

# Wave-induced motion

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I believe that only one 20<sup>th</sup> century scientist understood the real problems in quantum and atomic theories: Dr. Albert Einstein. In 1926, Einstein wrote to Max Born, “*Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing.*” Of the *photon*, Einstein told Philipp Frank in 1932, “*A good joke should not be repeated too often.*” Einstein, who started the *photon* concept, told his co-author, Leopold Infeld, “*Yes, I may have started it, but I regarded these ideas as temporary, I never thought that others would take them so much more seriously than I did.*” The *others* shunned the master, but he worked on indeterminacy and causality to the end of his life. In 1944, Einstein wrote to Max Born, “*I firmly believe, but I hope that someone will discover a more realistic way, or rather a more tangible basis than it has been my lot to do.*” My wave-induced-motion-models (which everyone can build and test) give real, tangible, touchable and corporeal evidence.

Ali F. AbuTaha

## **ABSTRACT**

*Self-motion* denotes the motions produced from within the moving body. The author discovered that self-motion is produced by *modulation* of harmonic waves *in the moving body*. The harmonic waves, clearly seen in electromyograms, result from the disturbances induced in muscles by the familiar trains of nervous impulses, or action potentials. The author developed a similar process to produce linear, smooth, repeatable and controlled motions of objects made of different materials and shapes. It is shown how harmonic disturbances applied to any body can be used to produce *almost harmonic (or almost monochromatic) amplitude-modulated waves* in the body. It is also shown *how* the resulting modulations produce the reported motions. By *phase-locking* the input harmonics, the author produced the first-ever, hitherto impossible, *ideal low-pass filter* behavior, or near perfect stepping motion, in physical bodies. The mathematics, physics and mechanics of the phenomena, and the steps to reproduce the results, are described in this paper.

The study led to sweeping conclusions. It is shown how Planck overlooked quantization in the *classical wave theory* and how Einstein placed the *modulations* in the exciting, rather than the excited, system in the *photoelectric effect*. It was Bohr who first proposed the *modulations* or *coupling mechanism* to explain the mysterious quantum and atomic effects. This author uses *real working motion models* and vivid natural examples to explain the *modulation* process. The dramatic conclusion (which really should not be dramatic) is reached: Waves are waves, and particles are particles; and confusion over this point should be over.

Whereas quantum theories ran smack against reality, causality and common sense, the author shows that *quantization and discontinuities* are natural. For example, the *modulating* waves can be continuous but the *modulated* waves are always quantized and discontinuous. This work is the first synthesis ever to combine the quantum and atomic effects, Maxwell's equations, and Newton's mechanics in one clear picture that restores reality and causality. The paper should be of interest to all schools of medicine, science and engineering and to many schools of liberal arts. The motion mechanism (patent pending) will find applications in many areas, including, medicine, transportation, robotics, aeronautics, various industrial applications, toys and others.

## 1. Introduction

*Self-motion*, or *natural motion*, was a central subject in *Aristotelian physics*, but the subject has been neglected for centuries. After hairsplitting analysis, Aristotle attributed the motions to *soul*, as can be found in his numerous books. Sir Isaac Newton attributed the same motions to *a most subtle spirit*, and he ventured the guess, in the last paragraph of the *Principia*, that *vibrations* somehow produce the motions. That was a wild guess for his time, and the author is not aware of any further development of the concept by Newton. In the 20<sup>th</sup> Century, many attempts to describe self-motion in classical, electromagnetic, quantum and, even, relativity terms were not successful. Modern science has developed a clear portrait of the structure and the function of the neurons, axons and musculoskeletal systems. Yet, how the neural activity turns into nervous impulses that move a body remains a mystery. The *mechanism* that turns any one of these activities into the other, e.g., impulses to motion, is the subject of this paper. The author produced motions by *dynamic coupling* of waves trapped inside physical bodies. He tested the *mechanism* with simple motion models (blocks, spheres and other bodies made of different materials) and produced a variety of gaits and forms of motion, including linear, smooth, repeatable and controlled motions.

**In Section 2**, the author gives a step-by-step description of how to build and test the motion mechanism using different materials and shapes; and how to change parameters to produce specific motion features. Researchers and students will be able to reproduce the motions. The straightforward research or production programs will reveal quantum effects in physical bodies that can be easily *seen* by everyone. The reader will see how motion, force, momentum and energy can be a function of frequency and other wave parameters.

**In Section 3**, the author derives the *almost harmonic amplitude-modulated* waves responsible for the reported motions directly from the input harmonic disturbances, and then in reverse from the Fourier integral. A dramatic development here is to produce near *ideal low-pass filter* behavior in tangible bodies, which has not been done before at all. The *physics* and *mechanics* of the motion is then explained using real motion models and vivid natural examples that the reader can reproduce in a sink or a bathtub, e.g., the energy-carrying water *wavelets*. The reader will see how the *modulation*, *superposition* or *dynamic coupling* of waves trapped inside of a physical body can be used to produce a large variety of motions. Dramatic and sweeping conclusions are then derived from the motion concept. You will see how Planck placed the quantization in blackbody radiation in the *continuous*, and not in the *discontinuous*, frequency term, and how Einstein placed the modulations of the correct frequencies in the wrong system, i.e., the exciting instead of the excited system; two mistakes from which physics could not extricate itself for one hundred years. Ironically, Niels Bohr previously proposed the same *dynamic coupling* principle in 1921, but Bohr could not corroborate the concept without the motion models or the clear-cut water *wavelets* and other compelling examples described by this author.

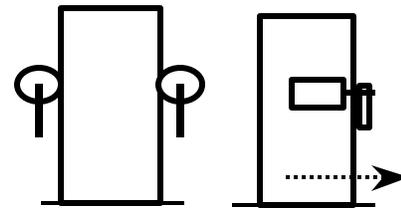
**In Section 4**, the reader will see the beginning of the avalanche of explanations of the mysterious quantum and atomic effects. Did Planck use the *frequency* of the electric wave, magnetic wave, or electromagnetic wave to describe the quantization in blackbody radiation? Think about it, two of these frequencies are *continuous*, but one is always *discontinuous*! Einstein placed the *cause* of the photoelectric effect in the light. Pebbles (exciting system) thrown into the water (excited system) produce waves that *modulate* to produce the energy-carrying *wavelets*. Is it the pebbles (as *balls*) that form the wavelets by impact forces? Are the *wavelets* the product of modulation, or of impact? Is it the exciting system, or the excited system, that modulates? **Section 4** is only the beginning of the avalanche.

And **in Section 5**, the author describes how he used the same wave-induced motion mechanism to induce his whole body to move mechanically, or robotically, without motion order from his mind! In these tests, the nervous feedback system operated correctly, by detecting the unexpected motion and issuing the correct balance orders to the rest of the body.

## 2. Self-motion Mechanism

I conducted extensive experimental and analytical research over a 20-year period to produce and control self-motion. My research comprised hundreds of thousands of tests, which produced many forms of motion and verified many characteristics of the phenomenon. It is impossible to report all of my results in one paper. Living motions in nature show infinite gaits and forms, which also cannot be fully described in even a volume. I will therefore limit this paper to the production of linear, repeatable and controllable motions.

Self-motion turned out to be the result of *dynamic coupling* of two or more wave trains traveling within a body. A common apparatus that can be effectively used to produce traveling waves in a body can be dc motors with rotating unbalanced masses, **Fig. 1** The continuous rotation of the unbalanced masses produce repeated surface disturbances, which send waves traveling within the body. The traveling waves will reflect at the boundaries of the body and from the base, and set up standing waves within the body. The standing waves, of course, occur at the normal modes.

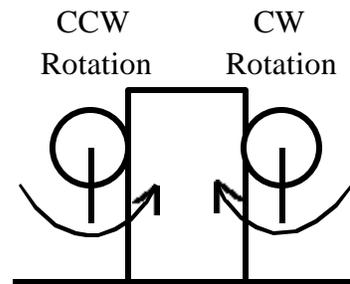


**Fig. 1** Wave-induced motion model

Note that the resulting motion will be *perpendicular* to the plane of rotation of the inertia elements, or in a direction orthogonal to the standing waves set up inside the body.

A snap shot of the waves traveling within the body will show a rather complicated state of affairs, including *reflected, refracted, standing, interfering, decaying* and other forms of waves. I will show later that the principle of superposition of waves can be used to develop the mathematical formulas that govern self-motion. For now, I will describe the specific steps to build, test and operate self-motion models.

To produce linear, smooth and repeatable motions, mount two motors firmly symmetrically on the sides, or on the top, of a body. The sense of rotation for each motor is shown in **Fig. 2**. It is recommended that simple geometrical shapes be first used, e.g., a simple wooden, metallic or plastic block or box. There is no limitation on material or shape, and researchers can vary these and other parameters. As a guide, the ratio of the mass of the rotating unbalanced element to the total mass of the motion model (block, motors, batteries, wires, etc.) can be between  $1/10^{\text{th}}$ - $1/100^{\text{th}}$ , but other ratios can be also be used. For starters, the recommended rate of rotation is between 300-3,000 rpm (or 5-50 cps), and other frequencies can be tried.



**Fig. 2** Rotation to produce smooth linear repeatable motion

I have tried the configuration described here successfully on many bodies made of metals, alloys, wood, plastic, rubber, composites and other materials. I also studied the response of different shapes to the self-motion mechanism, including spherical, triangular, square, rectangular and odd-shaped solid and hollow bodies. Additionally, I used the mechanism to induce my own body (75 kg, or 165 lbs) to move mechanically, which was a unique experience described later in this paper.

Let me next summarize: (1) Basic steps to build and test self-motion models, (2) suggestions to do advanced study or production programs, (3) basic features of the motion mechanism and (4) basic mathematical relationships that can be deduced from the previous programs.

## 2.1 Steps to build and test self-motion models

1. Mount 2 dc motors firmly symmetrically on the top, or the sides, of a body as shown in **Fig. 1**. Initially, use standard shapes, e.g., a wooden cube or a box
2. Cross-wire the motors to rotate the shafts in opposite directions; clockwise (CW) and counterclockwise (CCW), as shown in **Fig. 2**.
3. Attach equal unbalanced masses (inertia elements) to the shafts of the motors.
4. Connect the motors to a power supply, or a standard battery.
5. While motions can be produced with infinite combinations of pulse frequencies and amplitudes, in the initial trials, use the range of 300-3,000 rpm.
6. The mass of the inertia elements can be  $1/100^{\text{th}}$  the total mass, or even smaller.

## 2.2 Advanced study or production programs

1. Move the two motors laterally (sideways on top of the motion model) and axially (up and down on the sides of the model) and observe the resulting motions. Also try non-symmetric locations for the motors, but adjust the frequency of each motor to produce linear motion.
2. Mount the two motors symmetrically inside a hollow model, e.g., a box. Try the motors on the bottom, the sides and the inside-top surfaces.
3. Study the effect of changing the inertia of the rotating element. Use the amplitude,  $A$ , to verify mathematical equations.
4. Try the motion mechanism on bodies made of different materials and shapes.
5. Build a separate *drive module*, i.e., mount the two motors and battery on a separate strip of wood, plastic or metal, and attach the *drive module strip* on different models.
6. Fix the motion mechanism on belts for any toy that stands on one, two or more legs, secure the belt around the waist of the toy to produce different gaits.
7. Vary the input frequency and study the resulting motions at different frequencies. How fast can a given model move?
8. Emulate electromagnetic waveguide design by using rectangular blocks. Compare the resulting motions for different conditions and draw analogies to waveguide design and operation. For example, do you see the action of a Poynting vector?
9. To turn the motion models, deactivate one of the motors. You can turn on a dime by changing the frequency, amplitude, phase or other parameters. You can also move the bodies sideways by turning the two motors, or adding another motion mechanism to the model.
10. Try the same motion model on surfaces with different coefficients of friction.
11. Try specialized motions with the self-motion mechanism, e.g., pendulum, rocking, orbital, uphill and motion around joints.
12. Try to produce the *beat* effect (*beat* like in tuning forks beat sound). What kind of stepping motion do you get? Control the phase constant to produce near-perfect steps, i.e., *ideal low-pass filter-like* steps.
13. Add remote control to the motion model and operate remotely.

### 2.3 Experimental observations of basic characteristics

The experimenters should be able to produce smooth motions so that to the naked eye, no vibrations, pulsations or erratic motions are observed. Only by touching the model, will the pulsing action be perceived. Experts should be able to make the following observations from repeated tests.

1. The velocity,  $v$ , is constant for a given input frequency,  $f$ .
2. The kinetic energy,  $E$ , of linear motion is constant for the driving frequency,  $f$ .
3. Maximum linear velocity is reached nearly instantaneously.
4. There is a cutoff frequency,  $f_o$ , below which motion does not occur.
5. There is a frequency range ( $f_o < f < f_{max}$ ) within which the velocity,  $v$ , and kinetic energy  $E$  increase when the driving frequency is increased, and vice versa.
6. Beyond the maximum frequency  $f_{max}$ , the velocity,  $v$ , diminishes rapidly and the models stop.

### 2.4 Basic Mathematical Relationships from Experimental Observations

Careful tests of self-motion models reveal specific mathematical relationships. Other researchers can confirm, and supplement, my following observations:

1. Velocity,  $v$ , is proportional to frequency,  $f$ , in the operational frequency range ( $f_o < f < f_{max}$ ), or,

$$(2.1) \quad v \propto f$$

2. Velocity,  $v$ , is inversely proportional to the mass of the motion model,  $M$ , or,

$$(2.2) \quad v \propto \frac{1}{M}$$

3. Acceleration is proportional to the derivative of the frequency, in the operational frequency range,

$$(2.3) \quad a = \frac{dv}{dt} \propto \frac{df}{dt}$$

4. The kinetic energy of motion of the body,  $E$ , is proportional to the frequency,  $f$ , or,

$$(2.4) \quad E \propto f$$

It is clear that motions produced by dynamic coupling of waves traveling within a body do not obey Newton's Laws of Motion, which do not involve frequency, or wavelength, terms. It was strongly suggested by the above mathematical relationships that self-motion obeys quantum rules. I will describe the observed quantum effects and demonstrate that the simple rules of self-motion will supplant many unnecessarily complicated rules found in quantum, atomic and nuclear physics.

### 3. Wave-induced motions

*Wave-induced motion* is the technical term I selected to describe *natural motion* or *self-motion*. The selection will become apparent from the mathematical derivations of the experimentally induced motions. The reader should be able to verify all the derivations from his or her mathematics, physics or engineering textbooks.

#### 3.1 Mathematics of wave-induced motions

Mechanical pulse train disturbances generated by rotating unbalanced masses and deposited on the surface of a body produce wave trains that travel within the body. Consider the basic self-motion model of Fig. 1. The symmetric pulse trains applied on the surface produce wave trains that travel in the body and reflect from the boundaries. As a first approximation, let us take two wave trains of equal amplitude,  $A$ , which can be represented as simple harmonic motions of the form:

$$(3.1) \quad \mathbf{y}_1(t) = A \cos \mathbf{w}_1 t$$

$$(3.2) \quad \mathbf{y}_2(t) = A \cos \mathbf{w}_2 t$$

where  $A$  is the amplitude of the pulses and  $\omega_1$  and  $\omega_2$  are the in-phase frequencies of the pulses. The two wave trains travel in the body independent of one another, and the *superposition principle* can be used to derive the resultant wave. In this case, the resultant wave is the sum of the two equations, or,

$$(3.3) \quad \mathbf{y}(t) = \mathbf{y}_1(t) + \mathbf{y}_2(t) = A \cos \mathbf{w}_1 t + A \cos \mathbf{w}_2 t$$

From the trigonometric identity for the sum of cosines of two angles, or,

$$(3.4) \quad \cos \mathbf{a} + \cos \mathbf{b} = 2 \cos \frac{1}{2}(\mathbf{a} + \mathbf{b}) \cos \frac{1}{2}(\mathbf{a} - \mathbf{b})$$

The solution then takes the form,

$$(3.5) \quad \mathbf{y}(t) = 2A [\cos \frac{1}{2}(\mathbf{w}_1 + \mathbf{w}_2)t \cos \frac{1}{2}(\mathbf{w}_1 - \mathbf{w}_2)t]$$

Using standard steps, we define an average frequency  $\omega_{ave}$  and a modulation frequency  $\omega_{mod}$ ,

$$(3.6) \quad \mathbf{w}_{ave} = \frac{1}{2}(\mathbf{w}_1 + \mathbf{w}_2) \quad \mathbf{w}_{mod} = \frac{1}{2}(\mathbf{w}_1 - \mathbf{w}_2)$$

$$(3.7) \quad \mathbf{w}_1 = \mathbf{w}_{ave} + \mathbf{w}_{mod} \quad \mathbf{w}_2 = \mathbf{w}_{ave} - \mathbf{w}_{mod}$$

The final solution then takes the form,

$$(3.8) \quad \mathbf{y}(t) = [2A \cos \mathbf{w}_{mod} t] \cos \mathbf{w}_{ave} t$$

or,

$$(3.9) \quad \mathbf{y}(t) = A_{mod}(t) \cos \mathbf{w}_{ave} t$$

where,

$$(3.10) \quad A_{mod}(t) = 2A \cos \mathbf{w}_{mod} t$$

Equation (3.9) is the familiar *almost harmonic (or almost monochromatic) amplitude-modulated* wave with slowly varying amplitude  $A_{mod}(t)$  and with fast driving harmonic frequency  $\omega_{ave}$ . We arrived at

this solution for  $\mathbf{y}(t)$  by the superposition of two exactly harmonic traveling waves with two different fast harmonic frequencies  $\omega_1$  and  $\omega_2$ , or Equations (3.1) and (3.2). It is well established that if one begins with the *almost harmonic amplitude-modulated wave*  $\mathbf{y}(t)$ , as in Equations (3.5), (3.8), (3.9) or many other similar signals, then it is clear that the “modulation” consists of two exactly harmonic oscillations.

It is useful for the reader to begin to think of the other wave phenomena in nature. It will be important to clearly see the analogies that I will make and to think of the many other analogies that can be made between wave-induced motions and motions in mechanical, sound, water, electromagnetic and other waves. The exercise will lead us to resolve the central problematic issues that were encountered by the developers of the Quantum Theory in the 20<sup>th</sup> Century.

How do the above wave equations apply to the motions described earlier? In the case of living motions, the amplitude of the pulses is uncertain and the number of muscles and waves involved are prohibitive. Also, it was not clear in my experiments with living bodies whether the motions were the result of innervated muscles or the result of dynamic coupling of the waves in the skeletal system. The simple mechanical motion models that I built and tested made it possible to check out the application of the above, and similar, wave solutions. Some salient features of self-motion or wave-induced motion are discussed next.

When the two motors are operated at the same rpm, then,

$$(3.11) \quad \mathbf{w}_1 = \mathbf{w}_2 = \mathbf{w}_{ave}, \text{ and } \mathbf{w}_{mod} = 0$$

$$(3.12) \quad A_{mod}(t) = 2A \cos \mathbf{w}_{mod}t = 2A \cos 0 = 2A$$

$$(3.13) \quad \mathbf{y}(t) = 2A \cos \mathbf{w}_{ave}t$$

Here, the motion models move at a constant speed marked by small steps at the “fast” frequency,  $\omega_{ave}$ . Increasing the driving frequencies,  $\omega_1$  and  $\omega_2$ , increases the velocity of the motion model, and decreasing the frequencies, decreases the velocity, as shown in Fig. 3.

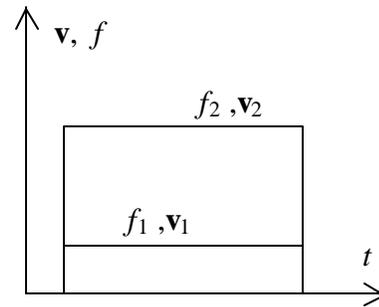


Fig. 3 Velocity increases as driving frequency increases.

One of the unusual observations I noticed was that the motion start-up was always sudden. Whether the terminal speed of the motion model was 3 cm/sec or 30 cm/sec, the model began to move nearly instantly at the terminal maximum speed. I tried to measure the rise-time to maximum speed with a stopwatch, but to no avail. Relating the wave-induced motions to wave characteristics provided the explanation. The rise time,  $t_r$ , for modulated signals of the above form can be approximated by:<sup>1</sup>

$$(3.14) \quad t_r = \frac{P}{\mathbf{w}_1}$$

Since  $\omega_1$  is known, it was possible to estimate the rise time. The frequencies that I worked with ranged from 5 to 50 cps. For these frequencies, the rise-time was in the rage of 10-100 milliseconds, which of course is difficult to measure with a crude instrument as an old stopwatch.

When the input pulse frequency in the motion model is increased, the speed of the model increases. When the input frequency is decreased, the speed decreases. This behavior is restricted to a

<sup>1</sup> Van Valkenburg, M. E., *Network Analysis*, Prentice-Hall, Inc. Englewood Cliffs, N.J., 1964, pp. 451.

band of frequencies, which depends on the properties of the motion model. Using smaller inertia elements, hence smaller pulse amplitude, and greater pulse frequency produces uniform and smooth motion. In these cases, the presence of pulsations or oscillations or vibration in the motion model could only be detected by actually touching the model. To the eye, the motion appears deceptively smooth.

More dramatic results occurred when I varied the rpm of the two motors, especially, when  $\omega_1$  and  $\omega_2$  were nearly equal. In this case, the modulation frequency is much smaller than the driving frequency, or,

$$(3.15) \quad \omega_1 \approx \omega_2, \text{ and} \quad \omega_{\text{mod}} \ll \omega_{\text{ave}}$$

The motion models exhibited distinct stepping motion at a low frequency! I recognized this as the *beat* phenomenon, e.g., sound *beats*. The motion is now governed by Eq., (3.9), or,

$$(3.9) \quad \mathbf{y}(t) = A_{\text{mod}}(t) \cos \omega_{\text{ave}} t$$

Here,  $\mathbf{y}(t)$  represents an oscillation at the angular frequency  $\omega_{\text{ave}}$ , with amplitude  $A_{\text{mod}}$  that is not constant but varies slowly with time according to Equation (3.10).

The derivations given above are the simplest wave-modulation equations, but these are sufficient to describe many features of *dynamic coupling* and *modulations* that I encountered with the motion models. Let us look at a well-known example, sound beats, and see how it compares with the wave-induced motions characteristics, particularly the stepping motion. I must first correct a wrong concept.

Suppose you strike two tuning forks, or two piano notes. You will hear the two notes, say,  $\mathbf{y}_1$  and  $\mathbf{y}_2$ . If the frequencies of the two notes are nearly equal, i.e.,  $\omega_1 \approx \omega_2$ , then you will hear a *single* pitch sound  $\mathbf{y}(t)$  of frequency  $\omega_{\text{ave}}$  and with a slowly varying amplitude  $A_{\text{mod}}$ , which are usually described as in Equations 3.9 and 3.10. This is the *beat effect*, which is encountered in acoustic, water, light and other waves. At two times during a modulation cycle, there is no sound, and the beat is heard between the silences. There are then two beats in one modulation cycle of two frequencies  $\omega_1$  and  $\omega_2$ , or,

$$(3.16) \quad \omega_{\text{beat}} = 2\omega_{\text{mod}} = \omega_1 - \omega_2$$

A simple rendition of the beat effect is shown in Fig. 4. The two musical notes  $\omega_1$  and  $\omega_2$  are shown in (a), and the beat is shown in (b). The beats are generally sketched in all physics textbooks as waves varying between +1 and -1, as shown in (b).

I had shown before that the rendition in textbooks is simply wrong. In preparation for releasing this work on wave-induced motion, I had written several papers for publication on related matters, e.g., “*Harmonic Oscillations in Force Fields*.”<sup>2</sup> While my papers were not published, it should be an easy matter to show the reader that the widely used Sketch (b) is wrong. Sketch (b) is the trace of a Simple Harmonic Motion (SHM). The simplest example to demonstrate the mistake is to use a slinky hanging from the ceiling. The professor gently suspends a weight from the slinky until the spring reaches the *equilibrium* position. The slinky is

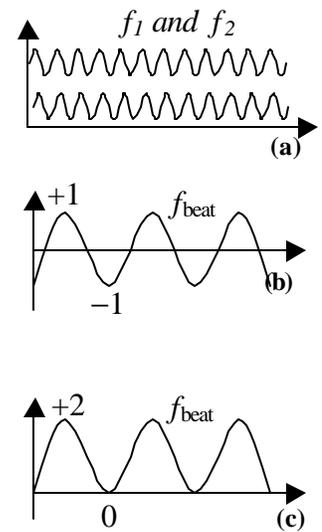


Fig. 4

<sup>2</sup> AbuTaha, A. F., “*Harmonic Oscillations in Force Fields*,” July 29, 1992. Submitted to and rejected by the *Physical Review Letters* (PRL Paper No. SV4501L, August 4, 1992).

now half-stretched. The weight is then displaced from the *equilibrium position* and released (by the professor), and the spring executes SHM motion, Sketch (b). It is true that *this spring* will oscillate between +1 and -1. But, nature does not work this way. Think about it. Hang the slinky from the ceiling so that the spring is in its natural non-stretched shape. If the weight is added and suddenly released from the starting point, nature will not first gently stretch the spring to the *equilibrium position* (like the professor does) and only then apply a pulse to cause SHM. Rather, nature will instantly jump on the spring and cause it to oscillate between the 0 position and +2 position, as I show in Sketch (c) – positive direction is down. This is so self evident that you do not even need to try it to believe it. Just think about it. This simple observation is crucial to the rest of this paper on wave-induced motion, and that is why I brought it up here. This Paper might require greater changes in physics textbooks, as you will see later, than my earlier unpublished preliminary papers.

Musicians are familiar with the beat phenomenon, and they use it to tune their instruments. The *beat* is a *third* sound produced by the modulation of *two* sound waves. The amplitude of the beat,  $A_{mod}$ , varies slowly with “ $\cos w_{beat}t$ .” The peak of the cosine term, however, varies between +1 and -1, and the question arises: Are there positive beats and negative beats? If you ever heard musical beats, you know that there is only one kind of beat sound. There is a “loud beat,” then “no sound,” another “loud beat,” another “no sound,” another “loud beat,” and so on. The fact that there is sound, no sound, sound, no sound, and so on is primarily because the pressures associated with sounds act as “force fields” and cause the *beats* to behave as in my Sketch (c), and not as in the familiar physics textbooks’ Sketch (b). As musicians know, there is no such thing as positive beat, negative beat. The beats then are a feature of wave mechanics, and not the product of ear-brain circuitry, basilar membrane resonance, non-linearity in the eardrum, or other anatomical or biological guesses that you find in some physics textbooks.

My concern here was not with the sound beats, but rather with the dramatic behavior of the wave-induced motion models. In applying the *almost harmonic amplitude-modulated* traveling wave solution of Equations 3.9 and 3.10 to the models’ motions, I had to ask the question: why didn’t the models move a step forward, a step backward, a step forward, and so on? The cosine term is there. Why do the wave-induced motion models move smoothly forward, and forward and forward in almost perfect steps? The answers are developed below. For now, I will include the *Abstract* and a concluding sentence from my 1992 paper mentioned above:

“ABSTRACT: *The common practice of referring oscillations to the position of equilibrium has masked the most important features of harmonic motion in gravitational, electric and nuclear force fields. We show that oscillations in force fields are distinctly different from simple harmonic motion ... Whereas simple harmonic motion is strictly the result of an externally applied force-pulse, or impulse, of short duration, force-field-harmonic-motion is strictly the result of a series of force pulses supplied by the field itself. Field forces sustain oscillations in the fields, and it is therefore incorrect to cancel the effect of these forces by modeling symmetric motion about the equilibrium position,*” and from the conclusion, “*we have presented basic concepts and models in “motion” which are indispensable tools to classical, quantum, and relativity physics.*”

Let us continue with wave-induced motion. A peculiar characteristic of the stepped motion is shown in Fig. 5 where the steps approximate nearly perfect square-edged steps. The motion model reaches terminal speed nearly instantaneously, moves steadily the width of the step, and then nearly instantaneously come to a complete stop, and so on. I could adjust the periods of the steps to be relatively long, in the order of 1 to 2 seconds, which made it easy to observe the

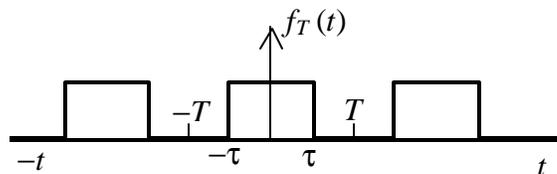


Fig. 5 Steps of wave-induced motion

phenomenon. The vertical rise-time lines will require only minor corrections (or rounding) at the corners.

The steps of the wave-induced motion models can be described by a waveform of a periodic pulse of magnitude  $f_T(t)$  and duration  $2\tau$ , as given by the following mathematical function:

$$(3.17) \quad f_T(t) = \begin{cases} y_0 & -t < t < t \\ 0 & -T < t < -t, \quad t < t < T \end{cases}$$

This is the familiar *delta function*. In our case, it is an even function, and its Fourier expansion contains only cosine terms. The Fourier expansion of  $f(T)$  can be written as follows:

$$(3.18) \quad f_T(t) = \frac{a_0}{2} + a_1 \cos \frac{pt}{T} + a_2 \cos \frac{2pt}{T} + \dots + a_n \cos \frac{npt}{T} + \dots$$

The coefficients  $a_0$  and  $a_n$  can be found from the following relationships<sup>3</sup>

$$(3.19) \quad a_0 = \frac{1}{T} \int_0^t f(t) dt$$

$$a_n = \frac{1}{T} \int_0^t f(t) \cos \frac{npt}{T} dt$$

Let the steps be defined as shown in Fig. 6, where the amplitude of  $f_T(t)$ , i.e., the magnitude of each step be a unity, or 1, and the period of the function,  $2T$ , is equal to 4, then,

$$(3.20) \quad a_0 = \frac{2}{T} \int_0^1 1 \cdot dt = \frac{2}{T}$$

$$(3.21) \quad a_n = \frac{2}{T} \int_0^1 1 \cdot \cos \frac{npt}{T} dt = \frac{2}{T} \cdot \left. \frac{\sin(npt/T)}{np/T} \right|_0^1 = \frac{2}{T} \cdot \frac{\sin(np/T)}{np/T}$$

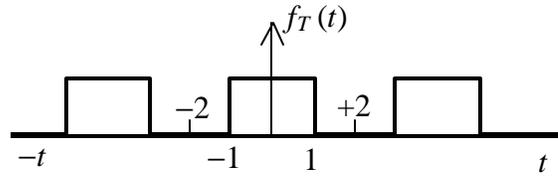


Fig. 6 Representative period of motion steps,  
 i.e.,  $2T = 4\tau = 4$ .

An approximate frequency spectrum of the function  $f_T(t)$  is sketched in Fig. 7. The spectrum is a plot of  $a_n$  as a function of the frequency  $w_n$ . The values of  $a_n$  are the y-ordinates of the curve, introduced in the definition of the step function in Equation 3.17, i.e.,  $y_0$ . The natural frequency  $w_n$  has its normal definition as follows,

<sup>3</sup> Wylie, C.R., Jr., *Advanced Engineering Mathematics*, McGraw-Hill Book Company, New York, 1966, pp. 182-184 and 211-214.

$$(3.22) \quad \mathbf{w}_n = \frac{n\mathbf{p}}{T} \text{ rad/unit time}$$

We now substitute  $\mathbf{w}_n$  in Equation 3.21 to express the coefficient  $a_n$  in frequency terms as shown next. Note that the successive values of  $n$  correspond to values of  $\mathbf{w}_n$  which differ by a constant amount  $\Delta\mathbf{w}$ , or,

$$(3.23) \quad a_n = \frac{2}{T} \cdot \frac{\sin \mathbf{w}_n}{\mathbf{w}_n}$$

$$(3.24) \quad \Delta\mathbf{w} = \frac{(n+1)\mathbf{p}}{T} - \frac{n\mathbf{p}}{T} = \frac{\mathbf{p}}{T}$$

$$(3.25) \quad a_n = \frac{2}{T} \cdot \frac{\sin \mathbf{w}}{\mathbf{w}} = \frac{2}{\mathbf{p}} \cdot \frac{\sin \mathbf{w}}{\mathbf{w}} \Delta\mathbf{w}$$

Can the Fourier coefficient  $a_n$  be the modulating factor in the *almost harmonic amplitude-modulated wave* of Equation 3.9? Or, can Equation 3.9 for  $\mathbf{y}(t)$  be written as shown next, where the expression in brackets is the modulating factor?

$$(3.26) \quad \mathbf{y}(t) = \left[ \frac{2}{\mathbf{p}} \cdot \frac{\sin \mathbf{w}}{\mathbf{w}} \Delta\mathbf{w} \right] \cos \mathbf{w}_n$$

I asked these questions because if Equation 3.26 represents a solution to the superposition of the two harmonic disturbances that are produced by the two motors on the wave-induced motion models, then it is likely that the observed stepping motion is the result of frequency superposition or modulation of the waves  $\mathbf{w}_1$  and  $\mathbf{w}_2$  in Eqs. 3.1 and 3.2. When the Fourier integral of the function in Eq. 3.26 is developed, then the function  $\mathbf{y}(t)$  can be estimated over frequencies less than  $\mathbf{w}_n$ , or in our case,  $\omega_{ave}$ , and the approximation would look graphically<sup>4</sup> as shown in Fig. 8. From top to bottom, the sketches in Fig. 8 correspond to  $\mathbf{w}_o = 4, 8,$  and  $16$  rad/sec. These curves represent ideal low-pass filter<sup>5</sup> behavior, where when  $\mathbf{w}_o = 16$ , the motion function has the shape of nearly a perfect step. In the case of my wave-induced stepping-motion models,  $\mathbf{w}_o$  is generally greater than 30 rad/sec, thus explaining the observed nearly perfect steps that I described earlier, e.g., Figs. 5 and 6. The nearly perfect steps allowed me to make greater leaps forward, as described later.

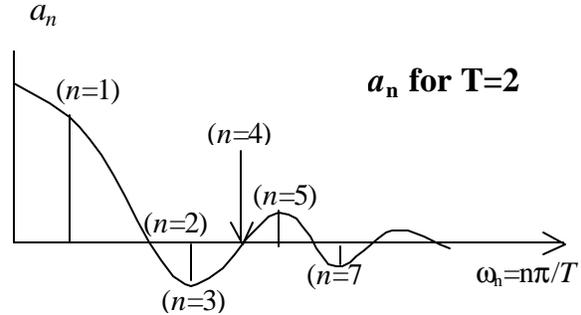


Fig. 7 Behavior of the Fourier coefficient  $a_n$  for a finite period.

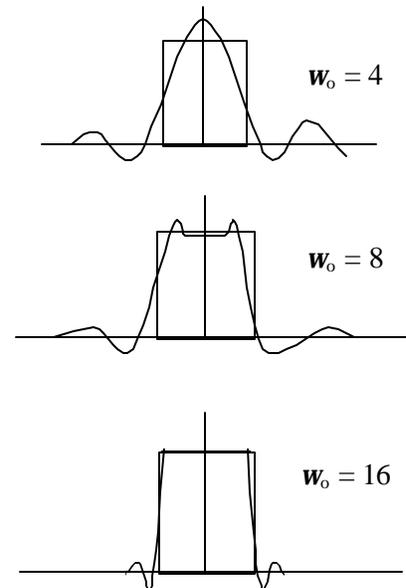


Fig. 8 Approximate  $\mathbf{y}(t)$  by Fourier integral

<sup>4</sup> Wylie, C.R., Jr., *Advanced Engineering Mathematics*, McGraw-Hill Book Company, New York, 1966, p. 219.

<sup>5</sup> *Ibid*

Backward analysis in wave mechanics is not unusual, where visualizability is not easy, and sometimes, impossible. The behavior of the ideal *bandpass* filters is not an exception. Consider the two harmonic disturbances produced by the two motors in my motion models, of Eqs. 3.1 and 3.2. I said that distinct stepping motions are produced when the driving harmonics are nearly equal,  $w_1 \approx w_2$ . Since the motors drive the two input harmonics, the driving torque of the motors produced a linear phase constant behavior, as in Fig. 9. In essence, I was able to “*phase lock*” the modulation of the waves. The stepping motion results were fascinating.

For a band limited system with the phase characteristic shown in Fig. 9(a), which is similar to the stepping mode of my wave-induced motion models, the magnitude of its output is the step of constant magnitude,<sup>6</sup> Fig. 9(b). The Fourier integral analysis of systems with this behavior can be found in the same, and other, references.

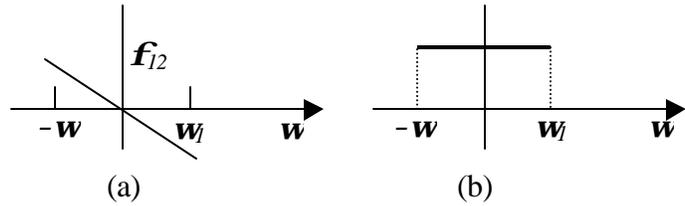


Fig. 9 (a) Phase characteristics of a band-limited system and (b) the magnitude.

In *Network Analysis*, Van Valkenburg points out that the “*ideal low-pass filter does not exist in nature,*” and he further comments on the Fourier analysis of Fig. 9 as follows:

“*The low-pass amplitude characteristic we have assumed (Fig. 9), is not realizable by physical components, and so it is not surprising that we should obtain a result which predicts effect before cause.*”<sup>7</sup>

I mention these things because my wave-induced motion models eventually turned out to be the *physical components* that will allow us to *see* characteristics of quantum, atomic and electromagnetic effects, which we have not been able to see or even *imagine* before.

Let me restate what we are trying to do here. Specifically, we are trying to firmly ascertain that the distinct stepping motion of my wave-induced motion models is the result of the superposition of the two exact harmonic disturbances produced by two motors and described in Eqs. 3.1 and 3.2. The process is analogous to recognizing that the *almost harmonic amplitude-modulated* traveling wave in AM radio transmission is the result of the superposition of two exactly harmonic waves,  $w_1$  and  $w_2$ . More importantly, that the AM radio signal is precisely the superposition of two exact waves, or, the carrier frequency,  $\omega_{ave}$ , and, say for the *lower sideband*, the harmonic wave “ $\omega_{ave} - w_{mod}$ .”<sup>8</sup> Some readers may *now* intuitively recognize the whole lengthy process in one step. But the reader must remember that no one has ever produced the motion characteristics that I describe here in physical objects and the mathematical foundation of the effects described here did not come on a silver platter.

Let us then complete the analysis of the wave-induced motion, especially, the observed distinct stepping motions. Our forcing input consists of the two harmonic disturbances  $w_1$  and  $w_2$ . We begin with the Fourier integral<sup>9</sup>, which you can also find in many textbooks.

<sup>6</sup> Van Valkenburg, M. E., *Network Analysis*, Prentice-Hall, Inc. Englewood Cliffs, N.J., 1964, pp. 438-449.

<sup>7</sup> *Ibid*, p. 449.

<sup>8</sup> Crawford, Frank S., Jr., “*Waves – Berkeley physics course – volume 3,*” McGraw-Hill Company, New York, 1968, pp. 274-275.

<sup>9</sup> Crawford, pp. 299-300. I strongly urge the reader to carefully study Crawford’s textbook and to appreciate the numerous well-thought out and wonderful examples of wave motions.

$$(3.27) \quad \mathbf{y}(t) = \int_0^{\infty} A(\mathbf{w}) \sin \mathbf{w}t d\mathbf{w} + \int_0^{\infty} B(\mathbf{w}) \cos \mathbf{w}t d\mathbf{w}$$

$$(3.28) \quad A(\mathbf{w}) = \frac{1}{P} \int_{-\infty}^{\infty} \mathbf{y}(t) \sin \mathbf{w}t dt$$

$$(3.29) \quad B(\mathbf{w}) = \frac{1}{P} \int_{-\infty}^{\infty} \mathbf{y}(t) \cos \mathbf{w}t dt$$

First, note that  $A(\mathbf{w})$  is zero for all  $\mathbf{w}$ , as our driving input consists of cosine terms. Second,  $B(\mathbf{w})$  is constant in the frequency range  $\mathbf{w}_1 > \mathbf{w} > \mathbf{w}_2$ , and is zero outside of the frequency range. Since  $B(\mathbf{w})$  is constant, the value of  $B$  can be selected so that the area of a plot of  $B(\mathbf{w})$  versus  $\mathbf{w}_1$  is unity. This is a good approximation of our motion output step. Then we have,

$$(3.30) \quad \begin{aligned} B(\mathbf{w}) &= \frac{1}{\Delta \mathbf{w}} \quad \text{for } \mathbf{w}_2 \leq \mathbf{w} \leq \mathbf{w}_1 = \mathbf{w}_2 + \Delta \mathbf{w} \\ B(\mathbf{w}) &= 0 \quad \text{elsewhere} \end{aligned}$$

The steps leading to the solution of  $\mathbf{y}(t)$ , as given by Crawford, and using my definition of  $\mathbf{w}_1$  and  $\mathbf{w}_2$  is given in the procedure in Eq. 3.31,

$$(3.31) \quad \begin{aligned} \mathbf{y}(t) &= \int_0^{\infty} A(\mathbf{w}) \sin \mathbf{w}t d\mathbf{w} + \int_0^{\infty} B(\mathbf{w}) \cos \mathbf{w}t d\mathbf{w} \\ &= 0 + \int_{\mathbf{w}_2}^{\mathbf{w}_1} \frac{1}{\Delta \mathbf{w}} \cos \mathbf{w}t d\mathbf{w} \\ &= \frac{1}{\Delta \mathbf{w}} \cdot \frac{\sin \mathbf{w}t}{t} \Big|_{\mathbf{w}=\mathbf{w}_2}^{\mathbf{w}=\mathbf{w}_1} \\ &= \frac{\sin \mathbf{w}_1 t - \sin \mathbf{w}_2 t}{\Delta \mathbf{w}} \\ &= \frac{\sin \mathbf{w}_1 t - \sin \mathbf{w}_2 t}{(\mathbf{w}_1 - \mathbf{w}_2)t} \end{aligned}$$

Note that “ $\mathbf{w}_1 - \mathbf{w}_2$ ” is twice the modulation frequency we defined in Eq. 3.16. The result in Eq. 3.31 can be written in the form of an “almost harmonic oscillation with average frequency”  $\mathbf{w}_{ave}$  “and with a slowly varying amplitude,” by noting the relationships developed in Eqs. 3.32 and 3.33. By simply substituting from these relationships in Eq. 3.31,  $\mathbf{y}(t)$  will then be described by Eq. 3.34, or,

$$(3.32) \quad \mathbf{w}_{\text{ave}} = \frac{1}{2}(\mathbf{w}_1 + \mathbf{w}_2)$$

$$\frac{1}{2}\Delta\mathbf{w} = \frac{1}{2}(\mathbf{w}_1 - \mathbf{w}_2)$$

$$(3.33) \quad \mathbf{w}_1 = \mathbf{w}_{\text{ave}} + \frac{1}{2}\Delta\mathbf{w}$$

$$\mathbf{w}_2 = \mathbf{w}_{\text{ave}} - \frac{1}{2}\Delta\mathbf{w}$$

$$(3.34) \quad \mathbf{y}(t) = \frac{\sin(\mathbf{w}_{\text{ave}} + \frac{1}{2}\Delta\mathbf{w})t - \sin(\mathbf{w}_{\text{ave}} - \frac{1}{2}\Delta\mathbf{w})t}{\Delta\mathbf{w}t}$$

Further simplifications give the following results:

$$(3.35) \quad \sin \mathbf{a} - \sin \mathbf{b} = 2 \cos \frac{1}{2}(\mathbf{a} + \mathbf{b}) \sin \frac{1}{2}(\mathbf{a} - \mathbf{b})$$

$$(3.36) \quad \mathbf{y}(t) = \frac{2 \cos \mathbf{w}_{\text{ave}}t \sin \frac{1}{2}\Delta\mathbf{w}t}{\Delta\mathbf{w}t}$$

$$= \frac{\sin \frac{1}{2}\Delta\mathbf{w}t}{\frac{1}{2}\Delta\mathbf{w}t} \cos \mathbf{w}_{\text{ave}}t$$

$$(3.37) \quad \mathbf{y}(t) = A(t) \cos_{\text{ave}} t$$

Where,  $A(t)$  is given by:

$$(3.38) \quad A(t) = \frac{\sin \frac{1}{2}\Delta\mathbf{w}t}{\frac{1}{2}\Delta\mathbf{w}t}$$

The solution  $\mathbf{y}(t)$  in Eq. 3.37 is for a large number  $N$  of harmonic oscillations having  $N$  uniformly distributed discrete frequencies. We finally reduce the last solution to our case, where we have only two driving harmonics,  $\mathbf{w}_1$  and  $\mathbf{w}_2$ , or  $N=2$ .

$$(3.39) \quad \frac{\sin \frac{1}{2}\Delta\mathbf{w}t}{\frac{1}{2}\Delta\mathbf{w}t} = NA \frac{\sin \frac{1}{2}N\mathbf{d}\mathbf{w}t}{N\frac{1}{2}\mathbf{d}\mathbf{w}t} = A \frac{\sin \mathbf{d}\mathbf{w}t}{\sin \frac{1}{2}\mathbf{d}\mathbf{w}t}$$

Using,

$$\sin 2\mathbf{a} = 2\sin \mathbf{a} \cos \mathbf{a}$$

$$\frac{\sin \frac{1}{2}\Delta\mathbf{w}t}{\frac{1}{2}\Delta\mathbf{w}t} = A \frac{2 \sin \frac{1}{2}\mathbf{d}\mathbf{w}t \cos \frac{1}{2}\mathbf{d}\mathbf{w}t}{\sin \frac{1}{2}\mathbf{d}\mathbf{w}t}$$

$$= 2A \cos \frac{1}{2}\mathbf{d}\mathbf{w}t$$

$$= 2A \cos \frac{1}{2}(\mathbf{w}_1 - \mathbf{w}_2)t$$

$$= 2A \cos_{\text{mod}} t$$

We now substitute the value of the Si function ( $\sin q / q$ ) that we developed in Eq. 3.39 into the solution of  $y(t)$  of Eq. 3.37 to obtain my original Eq. 3.9, or,

$$(3.9) \quad y(t) = A_{\text{mod}}(t) \cos w_{\text{ave}} t \quad \text{Q.E.D.}$$

Where,  $A_{\text{mod}}(t)$ , from Eq. 3.39, is also as defined in our original Eq. 3.10, or,

$$(3.10) \quad A_{\text{mod}}(t) = 2A \cos w_{\text{mod}} t$$

### 3.3.1 Discussion

Readers acquainted with wave and quantum mechanics will find my mathematics simple and familiar but my concepts strange. Actually, the mathematics is simple and should be familiar but the concepts should not be strange. Let me explain.

On the way to Schrödinger's complicated wave equation, students (and professors) usually begin with simple waves, particularly, waves in a string that is fixed at both ends to rigid walls, e.g., Fig. 10. The first natural mode of vibration is shown on the top, and the second mode on the bottom, and there are of course many higher modes.

What I am saying is as simple as it can ever get. Apply the waves to a freestanding physical body, as shown in the Figure. If this body is a block of wood and you strike it with a hammer on one side, the disturbance will send waves traveling through the body. Now, if the walls were separated by great distance, then traveling waves can be sent down the length of the rope. The same is true for a solid body. When an earthquake happens at one location, the disturbance sends waves that travel through the rigid body of the earth. It is that simple.

The same is true for standing waves. When you send waves down a string to a rigid connection, the waves reflect at the far end, reverse phase and return, forming standing waves in the process. Now, when you apply disturbances on the surface of the wooden block shown in the figures, the disturbances send waves in the physical body. When the waves reach the *boundaries* of the body, the waves reflect and standing waves can form in the physical body just like the case of the string. Einstein postulated and extensively used standing waves in physical bodies in the analysis of specific heats of solids.<sup>10</sup>

Mathematically, there is no difference between the two cases shown in these Figures. But conceptually, there is a very important difference that has been completely overlooked, even by the founders of the quantum theory. My freestanding physical body can move if internal *dynamic coupling* or *modulations of waves* prompted it to move. The string, fixed to rigid walls, is not going anywhere.

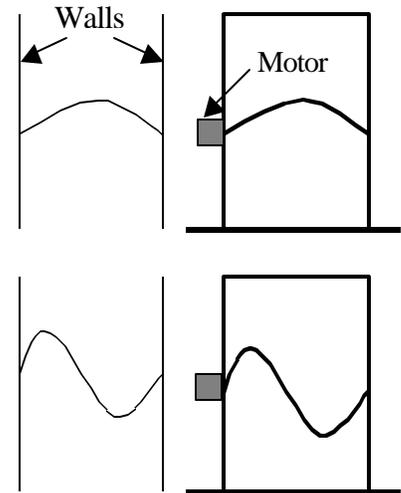


Fig. 10 The same analysis for ropes on rigid walls apply to freestanding physical bodies.

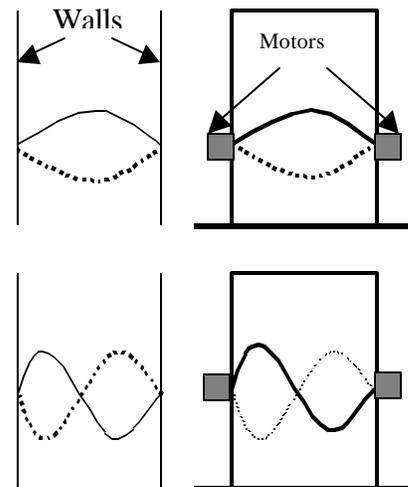


Fig. 11 The same analysis for ropes on rigid walls apply to freestanding physical bodies.

<sup>10</sup> Seitz, F., "The Modern Theory of Solids," Dover Publications, Inc., New York, 1987, p. 99. Einstein also "assumed that the allowed energy states of these oscillators (i.e., in solid crystals) are integer multiples of  $h\nu$ , where  $\nu$  is the frequency of oscillation and  $h$  is Planck's constant."

Pendulums, spring-mass and other oscillators fixed to rigid walls or ceilings or on laboratory benches will also not go anywhere, whether there is internal wave-modulation or not.

Consider the basic wave-induced motion model that I described in Section 2, Fig. 12. Two motors with unbalanced rotating masses produce the harmonic disturbances that we analyzed earlier. The *primary* harmonic waves are longitudinal compression and refraction waves. But if you think carefully about it, you will find that each motor produces *two* harmonic disturbances, i.e., a compression wave train on the front end of the motor and a refraction wave on the other end. This results from the bending moment actions, Fig. 13. If you think more about it, you will discover that the compression and refraction waves generated by each motor are out of phase. Does it matter? I evaluated these variations carefully, experimentally and mathematically, and I will describe some results here.

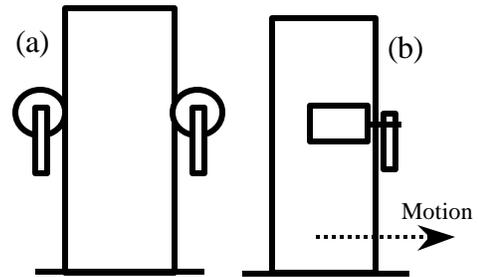


Fig. 12 Wave-induced motion model (a)

front view (b) side view. Note: Motion

variations carefully, experimentally and

Let us first consider the “number” of wave trains propagating in the body. It really does not matter how many waves propagate within the body and the mathematics remains the same. The most important thing is that there must be at least *two* waves in order to produce dynamic coupling, modulation, or superposition of the waves. If we have only one wave, then it will travel indefinitely in a medium, and to use the electromagnetic transmission analogy, the wave will carry no information! Mathematically, the superposition or modulation of 4, 16, or any large number of waves will follow the same basic steps used in the first 10 Equations in this Section.

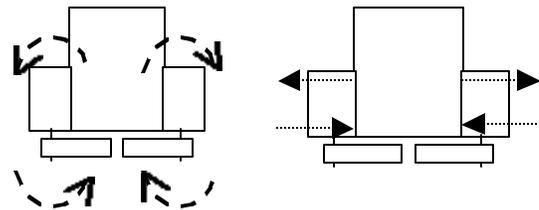


Fig. 13 Each motor produces compressive and refractive waves in the body

Take for example the case of transmitting one musical note on AM radio. We then need a carrier frequency, which is generated at the station, say our  $\omega_{ave}$ . The AM radio signal is completely defined in our Eqs. 3.9 and 3.10, where I substitute  $V(t)$  for  $y(t)$ , or,

$$(3.9) \quad V(t) = A_{mod}(t) \cos \mathbf{w}_{ave}t$$

$$(3.10) \quad A_{mod}(t) = 2A \cos \mathbf{w}_{mod}t$$

where,  $V(t)$  is the transmitter driving voltage. If the AM radio station is transmitting a concert, then there are great many modulation frequencies to handle, and not only the frequency of one musical note. In that case, the driving voltage  $V(t)$  is still described by Eq. 3.9, or,

$$(3.9) \quad V(t) = A_{mod}(t) \cos \mathbf{w}_{ave}t$$

But now,  $A_{mod}(t)$  is the sum of the frequencies of the sound waves, which, including phase constant, can be described as follows<sup>11</sup>.

$$(3.40) \quad A_{mod}(t) = A_o + \sum_{\mathbf{w}_{mod}} A(\mathbf{w}_{mod}) \cos[\mathbf{w}_{mod}t + \mathbf{j}(\mathbf{w}_{mod})]$$

$A_0$  is the amplitude of the driving voltage that keeps the channel open whether the music is present or not.

And so, the number of motors, waves, or sources of harmonic disturbances that is used in wave-induced motion will not alter the basic mathematical formulations that I presented earlier. Of course, the gait, form of motion, pace of motion and other motion characteristics will be altered by the content of the modulation terms when the number of wave trains is increased. I have produced a large variety of motion forms by altering the number of the modulations present in the body. I must remind the reader again that the primary restriction on the number of wave trains is that there must be at least *two* wave trains to facilitate the motion production by superposition, modulation, or dynamic coupling.

If you guessed that you could produce wave-induced motion with one motor, then you are right. Again, consider the primary wave disturbances produced by one motor, Fig. 14. There are compression and refraction waves on the front end and back end of the motor. The motor here is raised on spacers from the body. The practice is good for all the other configurations, as it accentuates the waves propagated within the body by concentrating the input disturbances. Here, two wave trains trapped within the body will modulate, or couple, to produce motion in a direction perpendicular to the plane of rotation of the rotors on the motor's shaft. But, the compression waves, for example, are completely out of phase with the refraction waves. Does the phase difference matter? Actual working models show that this configuration works just as good as the two, or more, motors cases. Remember, the requirement for wave-induced motion is *two or more wave trains*, and not two or more motors.

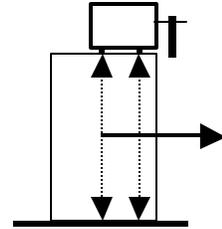


Fig. 14 Wave trains from one motor produce wave-induced motion (→)

The solution of the one motor configuration approximates that of the *standing wave equation*. Here is an example where the reflected wave (in a standing wave) is out of phase:<sup>12</sup>

$$(3.41) \quad \mathbf{y}_1(t) = A \sin(kx - \omega t)$$

$$\mathbf{y}_2(t) = A \sin(kx + \omega t)$$

$$\mathbf{y}(t) = \mathbf{y}_1(t) + \mathbf{y}_2(t) = A \sin(kx - \omega t) + B \sin(kx + \omega t)$$

$$\sin \mathbf{a} + \sin \mathbf{b} = 2 \sin \frac{1}{2}(\mathbf{a} + \mathbf{b}) \cos \frac{1}{2}(\mathbf{a} - \mathbf{b})$$

$$\mathbf{y}(t) = [2A \sin kx] \cos \omega t$$

Again, the solution is the *almost harmonic amplitude-modulated* traveling wave, or Eq. 3.9, or,

$$(3.9) \quad \mathbf{y}(t) = A_{\text{mod}}(t) \cos \omega_{\text{ave}} t$$

Where now,

$$(3.42) \quad A_{\text{mod}}(t) = 2A \sin kx$$

The one motor configuration is a special case of the two, or more, motors. While motion is easily produced by the same principle, it is more difficult to produce and maintain coherent waves within the body with one motor. This produces some limitations on the performance of the one-motor system. For

<sup>11</sup> Crawford, p. 274.

<sup>12</sup> Halliday, D. and Resnick, R., "Physics for Students of Science and Engineering," John Wiley & Sons, Inc., New York, 1965, eighth printing, p. 412.

example, superposition, or modulation, to produce linear motion is limited to one operational frequency. As a result, the linear speed cannot be increased or decreased by increasing or decreasing the single input driving frequency.

Fig. 15 shows numerous configurations that I have tested to produce smooth, linear, repeatable and controllable motions. Any two opposite, but not necessarily symmetric, harmonic disturbances can be used to produce linear motion. The same is true for two, or more, harmonic disturbances applied on the top of the shown body. Also, the freestanding body could be hollow shaped, made of wood, metal or other material(s). By selecting the appropriate dispersion relationship for the body, any two harmonic wave trains can be used to produce smooth linear motions.

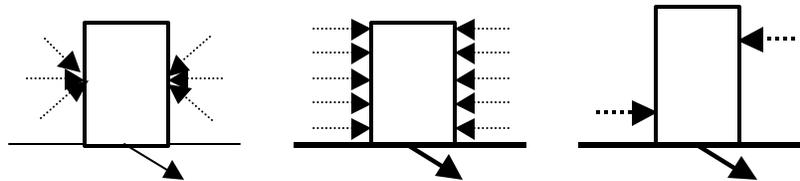


Fig. 15 A large number of paired harmonics can be used with any material or geometry.

As with any new and novel discovery or invention, the skeptics abound. The discovery and invention of wave-induced motion has not been an exception. Here is an example of an objection that is unchallenging mathematically or physically. Since the placement of the motors in my basic wave-induced motion models is horizontal, some experts think that the vertical rotation of the inertia elements provides a “lift” component which, combined with friction forces and Newton’s Laws of Motion, would explain the observed motions. After four years. I have not seen any of these experts produce one stepping model yet. The distinct stepping motion alone that I described earlier in this Section is sufficient to dismiss any notion that Newton’s Motion Laws could explain the observed effect. The lift from the rotors has nothing to do with the wave-induced motion. Consider the three Sketches in Fig. 16. When I orient the two motors vertically so that the inertia elements rotate in a horizontal plane, the body moves in the direction shown. The bending moment effect that I show in Sketch (a) has led some scientists to insist that there is “lift” in wave-induced motion. There isn’t. The bending moment *appears* to provide “lift,” but the motion is not the result of the lift effect. I had included the spacers shown in Sketch (b) in my experiments and varied the length and width of the spacers to reduce any “lift” effect. I had built and tested numerous

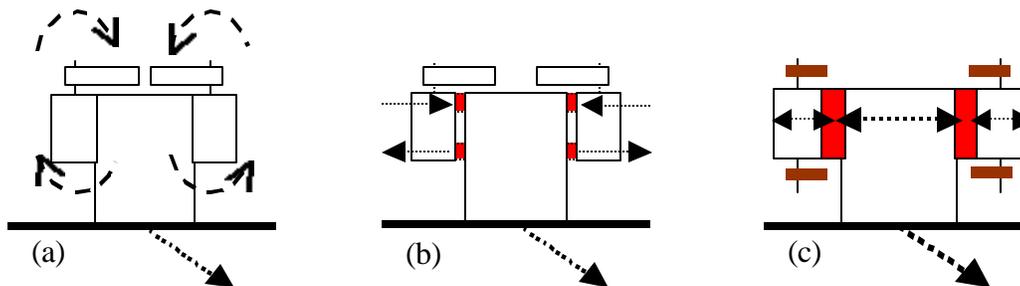


Fig. 16 Eliminating “lift” effects. In (c) Motion steps with the balanced harmonics give better approximation of the *ideal low-pass filter* behavior described earlier (Q.E.D.)

configurations where any “lift” effect was completely eliminated. The skeptics can use Sketch (c), to completely eliminate any bending moment by using two inertia elements on both sides of the motors’ shafts as shown. I will report here that the configuration in Sketch (c) produces more distinct steps than with the other configurations. The nearly *ideal low-pass filter* behavior with the balanced harmonic

disturbances, Fig. 16(c), further validates my thesis that self-induced motion is strictly the result of the *superposition, modulation or dynamic coupling* of harmonic waves traveling in a physical body.

The mathematical foundation of wave-induced motion is compelling. My use of the simplest case of superposition of waves, i.e., 2 harmonics, does not limit us from making sweeping generalizations. I gave specific examples to show that the number of harmonics, phase variations or change of other wave parameters will lead to the same basic conclusion, i.e., the *almost harmonic amplitude-modulated* traveling wave, Eq. 3.9. I purposely excluded consideration of material and geometric properties and dispersion characteristics so as not to clutter the analysis. My *picture* should be easy to grasp: The *superposition, modulation or dynamic coupling* of two, or more, wave trains in a physical body will impart energy to induce the body to move in a direction orthogonal to the plane of the waves. The founders of the quantum theory spent inordinate effort trying to explain quantum effects by the complicated dispersion laws and the properties of material, rather than concentrate their effort on the behavior of the waves themselves, as I have done here.

Let me conclude this Section on the Mathematics of wave-induced motion by pointing out the meaning of the analysis. In both Quantum Mechanics and in Wave-Induced Motions, the functions  $y_1(t)$  and  $y_2(t)$  have clear definite physical meanings. These are waves that the reader can create with a rope or a slinky, which he or she can study, analyze and see in space and time, e.g.,  $y_{1 \text{ or } 2}(x,y,z,t)$ . However, while the function  $y(t)$  has a clear definite physical meaning in wave-induced motion, it has a fuzzy uncertain or no meaning at all in quantum mechanics. In wave-induced motion,  $y(t)$  describes the motion resulting from the modulation of the two waves. I may not be able to pin down the motion model between  $-\tau$  and  $\tau$ , (Fig. 5) as the model is moving, but I know that it is moving. Between steps, the model is pinned down, and I know *where* it is. And so, I say that  $y(x,t)$  describes the modulated motion of  $y_1(t)$  and  $y_2(t)$  in the body in direction  $x$  at time  $t$ . And just as  $y(x,t)$  has definite physical meaning, so does its derivative  $\partial y(x,t)/\partial x \partial t$ , and its second derivative, as you will see under energy considerations.

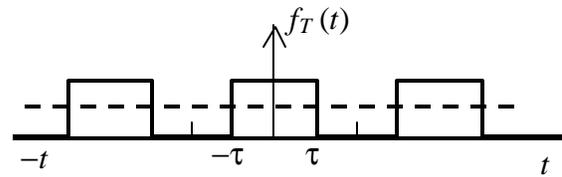


Fig. 5 Steps of wave-induced motion models described by a periodic function

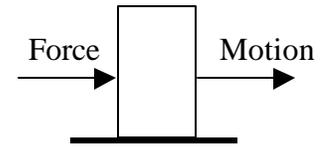
Max Born's interpretation of the quantity  $\psi^2$ , as being *a measure of some probability*, lacked the clear picture of  $\psi$  itself. It just happened that the numerical value of  $\psi^2$ , or its average value, is an easily measurable quantity and is directly related to the modulated steps. I added the dashed line in Fig. 5 to emphasize my point. Briefly, the wave-induced motion theory *sees* the steps in the real physical world; quantum mechanics *does not see the steps*.

But, how does the *dynamic coupling* of waves in a physical body induce a body to move? What does it mean to say that *dynamic coupling, superposition or modulation* of two or more waves induce motion in an orthogonal direction? How could simple mathematics, as I have developed above, modify the work of such great scientists as Planck, Einstein, Bohr and others? These great scientists overlooked fundamental features in the physics of waves, which my wave-induced motion theory and experimental programs elucidate with dramatic examples. The problem was not in *mathematics*, but in *physics*, our next topic.

### 3.2 Physics of wave-induced motion

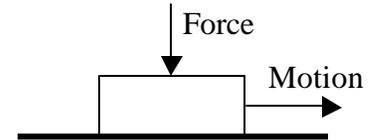
Just as the mathematics of wave-induced motion is straightforward, so is its physics. You might ask, how can the modulation of harmonic waves within a physical body induce the body to move? The phenomenon is so ubiquitous in our daily lives, but its workings have gone unnoticed for the longest time (since Adam?). My lengthy research has shown that the motions of our own bodies are the result of the type of superposition, modulation and dynamic coupling of harmonic waves, just as I described above. Yet we go on with life without the slightest notion of the dynamic coupling of the harmonic pulses that are produced by our nervous system and deposited on our musculoskeletal system, thus producing the variety of motions and gaits. My simple wave-induced motion models made of wooden, metal and plastic blocks and boxes made it easy to develop the underpinning mathematics of the phenomenon; and I will use the same models to explain the physical events that produce the mysterious living and quantum motions.

Let us begin with the prevailing view of motion. According to Sir Isaac Newton, bodies move only when external forces are applied to them, e.g., **Fig. 17**, and the bodies necessarily move in the direction of the applied force. If there are no external forces, there will be no motion.



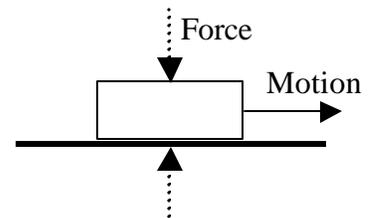
**Fig. 17** Newton's view of force and motion

Now, consider the old *Aristotelian* idea that the downward force of gravity is necessary to induce forward natural motion, **Fig. 18**. By the end of the 17<sup>th</sup> Century, many great ideas of Aristotle were considered crazy. How can a body move in a direction orthogonal to the applied force? According to Newton, the body in **Fig. 18** will go nowhere.



**Fig. 18** Aristotle's view of force and motion

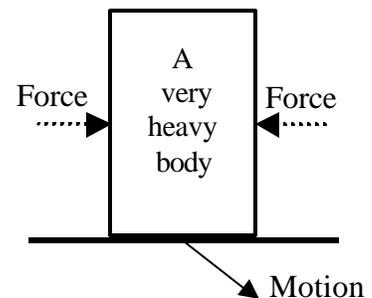
I was rather intrigued by Aristotle's idea, and I put it to test, and the reader can do the same. It turned out that any lightweight body could be moved horizontally when the right downward force is applied to it, but the force must be applied with the hands. Magicians have used this effect on television, in one case a group of people had to run with a table, which was gently touched with the hands of the people. A free-body diagram of this effect is shown in **Fig. 19**. *The action-reaction force pair must be a pulsing force pair*. I eventually discovered that any heavy body, e.g., a refrigerator, could be moved with this technique, **Fig. 20**. Try it with any heavy object around you. Remember that there is a built-in time delay that may require some practice.



**Fig. 19** A free-body diagram

My tangible wave-induced motion models took the contentious effects of psyche, psychology and physiology out of the picture and made the above mathematical analysis possible. The motion models also became invaluable tools in understanding the physics involved.

The question arises: How can pulsing forces in one or two directions produce motion in the third orthogonal direction? Can we find such effect in prior art or in nature? Let me rephrase it graphically, **Fig. 21**. Suppose we have forces acting in *y* and *z* directions, could **X** in the figure be the result of some interaction between *y* and *z*? If *y* and *z* were pulsing forces, could the force **X** be the result of the interaction? Note the stringent criterion in the question and the ramifications involved. As *y*, for example, oscillates back and forth, no net motion could result from



**Fig. 20** Natural motion

its action, and the same is true of  $\mathbf{z}$ . But  $\mathbf{X}$ , acting as shown, could be a  *motive force* . The reader might have seen this relationship in standard college physics textbooks. The Sketch we are looking at here is the well-known and well-recorded behavior of electromagnetic waves.

The electric vector  $\mathbf{E}$  oscillates in one direction, say  $\mathbf{y}$ , the magnetic vector  $\mathbf{B}$  oscillates in another direction,  $\mathbf{z}$ , and the resulting electromagnetic wave travels in the third orthogonal direction,  $\mathbf{X}$ , as illustrated in Fig. 22. One might argue that there is no connection whatsoever between my tangible and touchable motion models, on the one hand, and the intangible and ethereal electromagnetic waves. But, electromagnetic waves transport energy, measurable and calculable energy that moves orthogonal to the electric and the magnetic fields. Here, I am trying to show you the analogy between wave-induced motion and electromagnetic waves. One way to accomplish our goal is to use an electromagnetic cavity resonator, or a terminated waveguide. Actually, it is more fruitful if we think of the electromagnetic waveguide as being a wave-induced motion model!

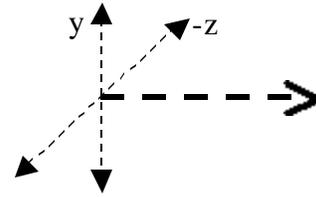


Fig. 21 Can the oscillating forces in  $\mathbf{y}$  and  $\mathbf{z}$  directions produce  $\mathbf{X}$ ?

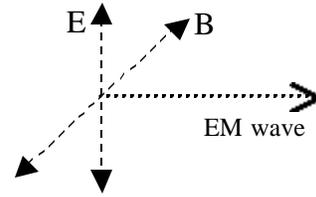


Fig. 22 EM wave propagates perpendicular to  $\mathbf{E}$  and  $\mathbf{B}$  vectors

The readers familiar with the electromagnetic theory know that the superposition of the oscillating  $\mathbf{E}$  and  $\mathbf{B}$  vectors produces the *Poynting* vector  $\mathbf{S}$ , which represents energy packets that travel orthogonal to the electric and magnetic waves, see Fig. 23. Both the energy and momentum of the  $\mathbf{S}$  vector have been measured experimentally. If the energy packets strike the vertical termination rod that I added in the sketch, then energy and momentum are imparted to the rod. And if the rod is rigidly attached to the waveguide, then the *absorbed* energy ( $U$ ) and momentum ( $U/c$ ), or the *reflected* energy ( $2U$ ) and momentum ( $2U/c$ ), are physically imparted to the waveguide body.<sup>13</sup> There is nothing in Maxwell's equations that require that the Poynting vector,  $\mathbf{S}$ , be the result of any Newtonian action-reaction forces! That is to say that the vector  $\mathbf{S}$  is not the result of some kicks applied on the left wall by  $\mathbf{E}$ ,  $\mathbf{B}$ ,  $\mathbf{S}$ , or any other agent. The Poynting vector is specifically the cross product of the electric and magnetic vectors, or

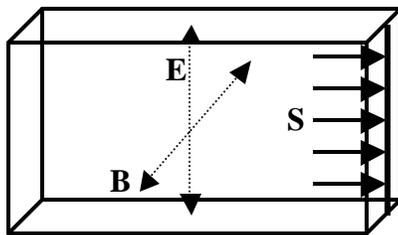


Fig. 23 A waveguide with Poynting vector  $\mathbf{S}$

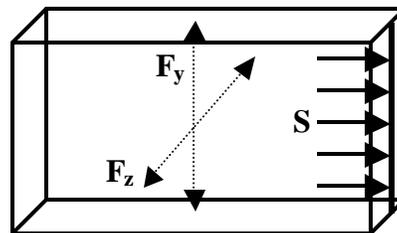


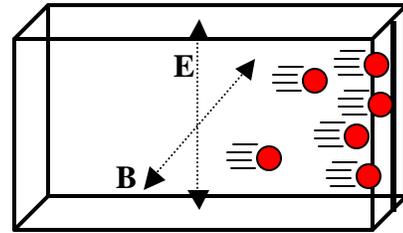
Fig. 24 Analogous wave-induced motion model

$(\mathbf{E} \times \mathbf{B})$ . My point should be abundantly clear. My rectangular wave-induced motion model is analogous to the waveguide example. The model on the right is not figment of imagination; you can build it and test it yourself. Here, the forces  $\mathbf{F}_y$  and  $\mathbf{F}_z$  in Fig. 24 oscillate perpendicular to each other. Or, more precisely, the waves generated by the pulsing forces on the surfaces of a wooden block travel and reflect within the block. When standing waves of specific wavelengths form inside the block, the waves modulate, couple

<sup>13</sup> See Halliday and Resnick, p. 903, or any physics textbook under *energy and momentum in electromagnetic waves*. Here,  $U$  is the energy carried by light waves, and  $c$  is the speed of light.

dynamically or superpose. Energy packets, not unlike the Poynting energy, then materialize within the wave-induced motion body acting to the right. It is the energy  $S$  in the modulated wave packets that move the wave-induced motion body to the right.

I added the termination rod on the right of the waveguide and the wave-induced motion model to help the reader to *visualize* what goes on inside these bodies. The energy and momentum in the waveguide can be derived from Maxwell's equations, and the electromagnetic radiation pressure was confirmed in torsion balance experiments with waves falling on mirrors in 1903. For later Sections, the reader should note the quantum version of events, which is shown in **Fig. 25**. Here, it is said that tiny red balls, or the photons, strike the termination rod on the right to impart their energy and momentum to the waveguide body. Whether scientist or not, the reader should know that the energy in electromagnetic waves may not move a waveguide or a microwave oven, but the energy is there; it heats the food. Also, the electromagnetic energy and momentum values derived by quantum techniques are equally derivable by classical methods.<sup>14</sup>

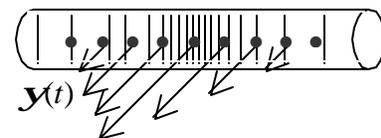


**Fig. 25** Quantum version of events – Can tiny balls, or photons, carry energy & momentum?

Waveguides are sensitive to dimensional tolerances. Researchers will be delighted to emulate and replicate the design, construction and test of electromagnetic waveguides with the wave-induced motion concept. I did thousands of tests with the simple -waveguide-like rectangular block or box-shaped motion models and watched carefully for correlations to waveguide behavior. Since we already know how to optimize the design of waveguides, for example for maximum group velocity or cutoff frequency, try the same principles with the wave-induced motion models. The similarities are amazing.

If you find my analogy with the electromagnetic waves farfetched, or if you are not familiar with the electromagnetic theory, then try sound waves. Sound travels in longitudinal waves in the air. I mentioned the sound beats in the previous Section in the mathematical derivations. Let us look at another aspect of sound waves. Can the energy in the longitudinal sound waves in the air be transformed into energy in a perpendicular, or transverse, direction? It seems that sound should not do that, but it does.

Consider the tube shown in **Fig. 26**. If one end of the tube is closed, then sound waves travel to the closed end, reflect, and set up standing waves in the tube. The compressions and rarefactions in the tube are shown with the vertical lines in the Sketch. Now, we saw in Eqs. 3.41 and 3.42 (from Halliday and Resnick physics textbook) that standing waves do modulate to produce a third wave. What is the third wave, or the modulated wave in the tube? As I said before, the modulation wave should be in a direction orthogonal to the component input waves. Consider the following example, also from Halliday and Resnick (pp. 429-430). When *regularly spaced small*



**Fig. 26** Longitudinal acoustic waves transformed into transverse waves

<sup>14</sup> Crawford, *Waves - Berkeley physics course*, pp. 362-364. Crawford writes, “The (quantum) derivation is short, and perhaps misleading. The fact that electromagnetic radiation turns out to be “quantized,” in the sense that it can only deliver energy in quantized “bits” ... really has nothing to do with radiation pressure ... Therefore we should be able to give a purely classical derivation ... without using the idea of photons or “particles,” and we shall now do that,” p. 362. Crawford then gives the straightforward derivation. My point is that waves transport energy, and in the case of the wave-induced motion models, there is really no need to resort to “quantum” explanations, including quantum mathematical derivations.

*openings*” are added along a tube filled with flammable gas, and resonance is set up inside the tube, “*the amplitude of the standing longitudinal waves becomes rather large,*” *Ibid.* Halliday and Resnick then point out how the height (the openings in their sketch are on the top) and width of the gas flames along the tube produce “*wave-like variation.*” The next remark about this experiment, which the authors describe as dramatic, in the renowned physics textbook is noteworthy:

*“It is as though standing longitudinal waves are transformed into a stationary transverse wave pattern,”* p. 430. My emphasis.

I show a rough sketch of the “*transverse modulation*” of the standing longitudinal waves with the arrow lines in **Fig. 26**. Notice, in particular, that I marked the “*modulation*” as  $\mathbf{y}(t)$ . Also, I do not use the preamble “*It is as though;*” rather I would directly say, “*standing longitudinal waves are transformed into a stationary transverse wave pattern.*” The transverse pattern resulting from the modulation of the standing waves *is* orthogonal to the component longitudinal waves. Furthermore, the *transverse “modulation”* wave carries energy that is generated by the modulation process, and not by kicking back on the far side of the tube.

In the previous Section, I pointed out that standing waves in ropes or strings attached to rigid walls are not going anywhere; even if the modulation, superposition or dynamic coupling of the waves wanted to take them somewhere. The boundary conditions of “*rigid walls*” take the whole wave-induced motion possibility out of the picture. The waves must be modulated in freestanding bodies and the bodies must be free to move, if they wished to do so. You can see a clearer picture of the physical meaning of the wave function  $\mathbf{y}(t)$ , which was easy to derive mathematically in the previous Section.

Some readers might still doubt the physical meaning that I give to the wave function  $\mathbf{y}(t)$ ; after all, electromagnetic waves are ethereal and sound waves are intangible. How about examples involving physical, material, tangible or corporeal bodies?

The similarities of waves are more striking than the differences. With many tests of my wave-induced motion models and the previous mathematical analysis, I was able to find a plethora of examples and analogies to confirm my thesis that physical bodies (and particles) can be induced to move by *dynamic coupling* of two or more traveling or standing waves in the body. With the collective physical community searching for answers to the quantum effects, including the reality of the *photon*, Neils Bohr used my same “*coupling mechanism*” “*to renounce the ‘so-called hypothesis of light quanta,’*” in 1921.<sup>15</sup> Again, using the “*coupling mechanism*” mathematics, Bohr avoided “*interpreting the results of Arthur Holly Compton’s experiments on the scattering of X-rays from atoms in terms of light quanta (1923).*”<sup>16</sup> The founders of quantum mechanics were greatly adept at the mathematics of wave mechanics, yet; somehow, no one could correlate the quantum effects to physical reality. Bohr’s idea of dynamic coupling is clearly demonstrated with my wave-induced motion models. The idea could be *gleaned, or imagined,* from my above examples of electromagnetic and sound waves. Yet, Bohr and his supporters could not produce *working models* (my wave-induced motion models) to demonstrate the *dynamic coupling* principle, nor did they produce palatable physical examples from nature. Here is a dramatic example.

Everyone is familiar with *water waves*. One can easily produce modulated or dynamically coupled *water waves* in a pond, bathtub, sink, tray, coffee can, or a card box.<sup>17</sup> Crawford describes everything I want to tell you about the water wave example in the brief introduction to Chapter 6 on

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<sup>15</sup> Miller A.I., “*Imagery in Scientific Thought,*” Birkhäuser Inc., Boston, 1984, pp. 135, 176.

<sup>16</sup> *Ibid.*, p. 135.

<sup>17</sup> Crawford, “*Waves – berkeley physics course.*” The reader will find in this textbook many delightful simple home experiments that he or she can do with water waves, and see the mathematical correlates of the phenomena.

“Modulations, Pulses, and Wave Packets,” (next two paragraphs). So rather than build up my own description, I will give you Crawford’s words. Please read the following quotations very carefully:

“We shall study beats in space as well as in time, and beats resulting from the superposition of many frequency components as well as from just two components. We shall also study how the beats (or more generally “modulations,” for more than two frequency components) propagate as traveling waves. It turns out that the modulations, called wave groups or wave packets, carry energy as they propagate and travel at the group velocity.<sup>18</sup> (my emphasis).

“The best way for you to obtain personal experience with wave packets is to pitch pebbles into ponds and watch the expanding circular wave packets. (Dropping water droplets into dishes also works very well.) It is obvious that these expanding circular wave packets carry energy – they can set a distant cork to bobbing when the wave packet arrives. If you look closely, you will see that the little wavelets that make up the wave packet do not maintain constant positions relative to the packet. For water wave packets with wavelet wavelengths of more than a few centimeters, the wavelets travel almost twice as fast as the packet. They are “born” at the rear of the packet, travel to the front, and dwindle away. (my emphasis). The wavelets travel at the phase velocity. The wave packet as a whole travels at the group velocity.” *Ibid.*

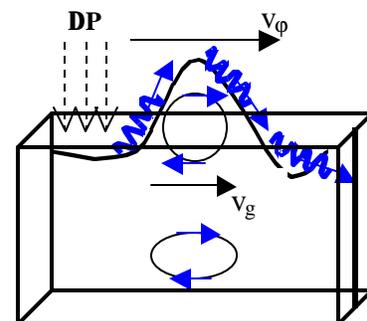
“With some practice, you can follow a packet with your eyes and watch individual wavelets grow at the back, pass through the packet, and “disappear” at the front.” (my emphasis), *Ibid.*, p. 293.

“After some practice, you should see that for these packets the phase velocity is greater than the group velocity. You will see little wavelets grow from zero at the rear end of the packet, travel through the packet, and disappear at the front. (It takes practice; the waves travel rather fast),” (my emphasis) *Ibid.*, p. 313.

Have you ever *seen* the small water wavelets? I have. The wavelets “carry energy.” From where do you suppose the energy come? The wavelets move rapidly through a wave packet and then disappear. Where do their momentum come from? You can literally *see* the wavelets *appear, travel* and *disappear*. Where does the energy, or momentum, in the wavelets go? Can you relate this action here to the waveguide model I described earlier? Can you relate it to Newtonian physics?

In the 1910’s-30’s, the King of Belgium and E. Solvay hosted the top scientists to discuss and solve the mysteries of the new sciences; quantum and atomic physics. In the 1927 Solvay Conference, everyone involved in developing quantum physics was there: Max Planck, Albert Einstein, Neils Bohr, Louis de Broglie, Werner Heisenberg, Erwin Schrödinger, Wolfgang Pauli, Arthur Compton, P.A.M. Dirac, and others. Do you remember the acrimonious remarks that Heisenberg and Schrödinger made about each other’s work in 1926? As Einstein and others said, the mathematics was simple; the difficulty was in the picture of reality. How can one justify the *photon* concept? Can light waves also be a shower of particles? There were many intriguing questions. The wavelets held many answers; but no one noticed.

Take a volume element of water and put it on a desk (add boundary condition forces), we get my waveguide example, **Fig. 27**. Overhead pressure,  $\Delta P$ , excites the water, creates waves, the waves modulate, the blue tiny wavelets on the top move from left to right, carrying energy. This is a legitimate fluid model. Now, let the wavelets strike the vertical termination rod on the right. The momentum of the wavelets is imparted to the rod and to the waveguide parallelepiped element, or my wave-induced motion

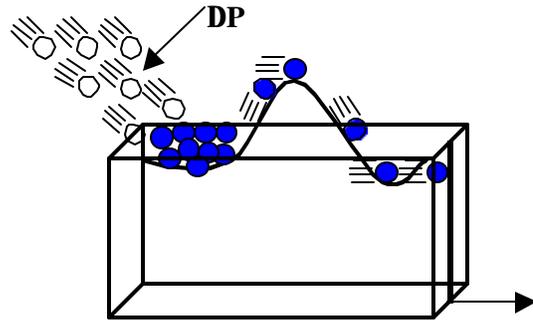


**Fig. 27** Wavelets appear in back and disappear in front of a wave group

<sup>18</sup> Crawford, “Waves – Berkeley physics course,” p. 268.

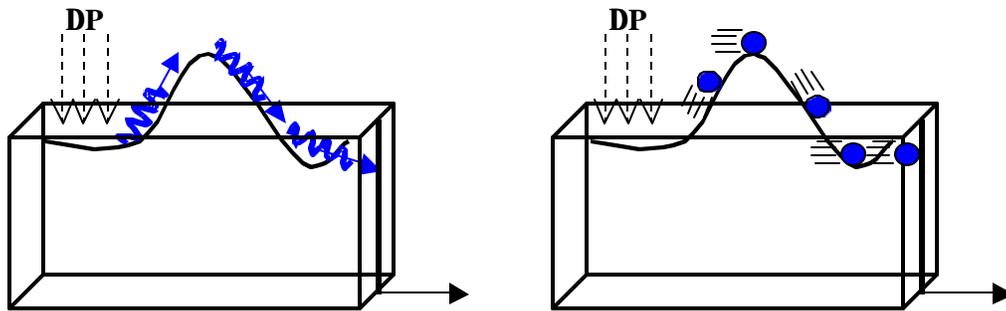
model. Figure 27 also shows the underwater circular, and elliptical, currents that are generated by the superposition, or modulation, or dynamic coupling of standing or traveling water waves. Near the shore, these circular flows break up to form the shore breakers. Einstein used the shore breakers to explain the *photon* concept, by comparing the breakers to a stream of bullets.

This model is dramatic because it shows that the *photon* concept is the wrong interpretation of wave events. Do you see it? The *wavelets*, or *wave packets*, in radiation are the result of modulation of the electric and magnetic waves, and the packets are the energy carrying agents. Now, you may imagine the wavelets to be balls, but you must not confuse the wavelets with the external, or exciting, agent. I must borrow a Figure from later in this paper to emphasize the point here (**Fig. 44**). Einstein's interpretation of the *photoelectric effect* was off the mark. It is perfectly valid to model the water packets as *wavelets* or *small balls*. But I take issue with you if you say that the *atmospheric pressure pulses* over Lake Geneva could be modeled as balls, which strike the water molecules and send the latter (wavelets or balls) to strike the vertical terminal rod at the end of the volume element. Take it one step at a time.



**Fig. 44** Photoelectric interpretation using water wavelets example

Water wavelets provide simple examples that are easy to perceive by everyone. On the left of Fig. 28, you see the wavelets, or look for them in a bathtub. On the right, you see *water balls* that can represent the *wavelets* on the left. There is an incredibly perplexing effect that is worthwhile examining.



**Fig. 28** Are wavelets matter or waves?

A legitimate model of water wavelets.

The effect, which I will describe later, was a central problem encountered in physics a century ago, but which no one realized. Waves and particles became so enigmatic then that no one could tell what is "wave" and what is "particle," e.g., Heisenberg described the severity of the problem in the following words,<sup>19</sup>

"What the words 'wave' or 'corpuscle' mean we know not any more." Heisenberg recalled of this period that "we couldn't doubt that [quantum mechanics] was the correct scheme but even then we didn't know how to talk about it . . . [these discussions left us in] a state of almost complete despair." Miller includes Heisenberg's 1970's *reminiscences* where Heisenberg "recalled the "uncertainty," "confusion," and "despair" of the period 1926-1927."

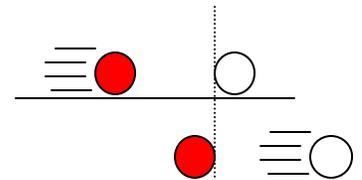
If we can hold the water volume element upright (like an ice block) with the correct boundary-condition forces, and excite the modulated group and wavelets in **Fig. 28**, the waveguide-like box should

<sup>19</sup> Miller, pp. 149-150, and 178. Letter from Heisenberg to Pauli, 23 November 1926.

move to the right as shown by the arrow; and as happens with my wave-induced motion models. The motive force is supplied by the energy of the water wavelets, as in Fig. 28, and not by atmospheric balls, or photons, as in Fig. 44. Remember, the wavelet packets on the left are strictly the result of the *superposition, modulation or dynamic coupling* of two or more waves. More importantly, remember that the exciting, or driving, force responsible for the component waves (that modulate) is orthogonal to the modulated wavelets. You might wonder, how about the effect of gravity, wind, earthquakes and ships on the volume-element we selected above. Let us say that the water element is extracted from Lake Geneva, or even an isolated pond, on a very calm day where the primary driving force is the overhead pressure variation; which can result in sizable *seiches* that travel along the lake. Also, remember that the energy in electromagnetic waves may not be conducive to move the waveguide, but it is strong enough to heat the termination rod, or the food in a microwave oven.

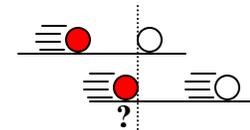
Let me formulate the fundamental problem as follows. Suppose I use a remote control to turn on my TV. We say that photons fly to the infrared detector in my unit, strike some hapless electrons and send the electrons flying to close a circuit. Let us reduce the photon concept to the classical billiard balls example. After all, every scientist in the 20<sup>th</sup> Century was well founded in the billiard balls examples of Huygens, Leibniz and Newton.

Look at the billiard balls in **Fig. 29**. The red ball moves to the right and strikes the white ball. The red ball comes to a stop, and the white ball takes off. In an ideal experiment, we say the momentum  $p_1$  of the red ball before collision is equal to the momentum  $p_2$  of the white ball after the collision. We can ask many questions about velocity, force, momentum, energy and other parameters of this interaction, and we have many answers from classical physics and engineering. The questions and answers are generally sensible.



**Fig. 29** Billiard balls

Now look at the *photon-electron* pair in **Fig. 30**. Here, it is said that the photon (the small red ball) strikes the electron, imparting momentum to the latter! What gets this model in trouble is the question about forces. For example, what was the cause of the red ball's motion in the first place? In the case of the billiard balls, we can say that I hit the ball with the cue. Now comes the crucial question, what was the *initial cause* of the photon's momentum in the first place? You might say that the photon came from a flashlight. This is not enough. Did the photon kick back (action-reaction) on the flashlight, or did I push the flashlight forward (also action-reaction) to send the photon on its way? This is like asking Aristotle's basic question, what is the "mechanical" *first mover* in the two interactions? What caused the red ball on the left to move in the first place? What caused the "photon" or the electromagnetic "wavelet" to move in the first place? The "photon" did not go through the rigorous scientific test. Let me explain.

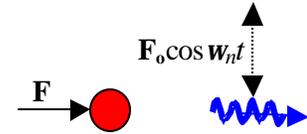


**Fig. 30** Photon-electron

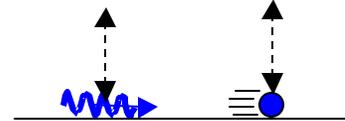
I hit the first billiard ball with a cue and the ball moves *in the direction of the applied force*. The picture is clear. Why is the electromagnetic wavelet fuzzy? Everyone knew what caused this wavelet, or photon, to move in the first place. It is the harmonic oscillation of the electric and magnetic fields. You can see the orientation of the electric, **E**, and magnetic, **B**, oscillations in **Fig. 22**. Let us look at two sketches that show the *first mover* for the two cases, or **Fig. 31**. Do you see the problem? The force vector for the billiard ball example is distinctly clear. What about the water wave packet? We all know that when two or more oscillations modulate, the resulting motion will occur in a direction orthogonal to the direction of the originating oscillations. If we allow the wavelet packet to become a particle "a water ball," then the untenable situation shown in **Fig. 32** arises.

Study Figures 31 and 32 very carefully, and try to distinguish between what is “wave” and what is “particle.” Also, try to clearly *see* the forces acting in each case.

The case of the billiard ball (left in **Fig. 31**) is very clear. Force **F** acts on, and moves, the ball. Of course, other parameters are involved including, friction, inertia, aerodynamic pressure, etc., but these are not relevant to our picture. The case of the up-down harmonic force (right in **Fig. 31**) should also be abundantly clear to every scientist and engineer. That the up down force  $F_o \cos w_n t$  produces orthogonal motion in waves is clear. When the wavelet was turned into a ball, troubles began (right in **Fig. 32**). How can the up-down force (but now acting on a solid particle) induce orthogonal motion? Other than my wave-induced motion models, there are not equally powerful examples of oscillatory forces acting in one or two directions to produce motion, force, momentum, energy or whatever you like in the third orthogonal direction in physical bodies or particles.



**Fig. 31** The first mover for billiard ball and wavelet



**Fig. 32** Do you see the basic problem with the *particles*?

Let me caution that I am trying to simplify the picture as far as I can, but that the reader should complicate the picture as far as he or she could. For example, begin with a rock or pebbles thrown into a pond, or sudden atmospheric pressure changes over one end of a lake or the ocean, or drops of water falling in a sink or a bathtub. These are exciting forces that belong to the exciting system. The exciting forces produce waves, e.g.,  $y_n$  where  $n = 1, 2, 3, \dots n$ . The exciting forces might produce millions of waves, such as the musical sounds of a concert. The final *modulation* product  $y$  is not any of the  $y_n$ 's, but rather it is the combination of the  $y_n$ 's. The next step is to look at different exciting systems. If you set water drops to fall into a sink at a regular rate, then you can measure a frequency and a wavelength for the constantly dripping water. The water drops from the faucet produce the water waves in the sink. Now you can measure the frequency and wavelength of the water waves in the sink. The frequencies and the wavelengths of the latter are not the same as the former. The energy-carrying wavelets in the sink are not the direct result of the water drops, rather they are produced by the *modulations* of the waves in the sink that are excited in the first place by the regular water drops. Water wavelets still appear with the wave groups halfway down a bathtub, far away from the exciting system, the water drops. If you carry these analogies further, you will discover the *ideal low-pass filter* behavior without doing any Fourier series, Laplace transforms or other advanced mathematical analyses.

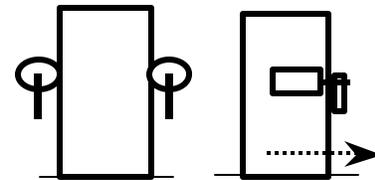
My extensive wave-induced motion research has made it abundantly clear that waves are waves and particles are particles. Quantum mechanics has been based on the wrong pictures.

The discussion has taken us back to the beginning of this Section, where I introduced the *Aristotelian* idea of a vertical force producing horizontal motion. That idea was clearly demonstrated by the Skylab astronauts in the early 1970's, i.e., running in zero gravity around the inner drum of Skylab! Aristotle had an equally dramatic, but *terrestrial*, example of the same phenomenon; I remember reading Aristotle's: *A man or a mouse cannot run swiftly on a heap of wheat* because of the absence of the vertical force. Sometimes, progress in physics is discontinuous.

### 3.3 Mechanics of wave-induced motion

Wave-induced motion produced by the *superposition, modulation or dynamic coupling* of wave trains trapped in the bulk revealed peculiar mechanical effects unnoticed before in engineering and physics. Energy conservation had to be found, momentum was a problem, and I detected, measured and analyzed two distinct forces, accelerating and non-accelerating. I said before that increasing the driving frequency increased the speed of the motion models. From simple mathematical projections, it seemed that by simply increasing the driving frequencies, very high speeds could be attained. It turned out that quantum effects govern wave-induced motion in more ways than I imagined. These and related observations are briefly discussed here.

Consider the basic wave-induced motion model, **Fig. 33**, and let me introduce a typical motion model as given in the following **Table-1**. The values shown are typical of many models that I tested. When the two eccentric masses are rotated at 100 rad/sec ( $\approx 16$  cps), the model moves at about 10 cm/s. Here, the motion model contains two energy terms, (1) the kinetic energy of rotation of the inertia elements, and (2) the kinetic energy of linear motion of the model itself. I will call these energy terms  $E_r$ , for rotation energy, and  $E_t$ , for translation energy, which can be written simply as,



**Fig. 33** Wave-induced motion model

$$(3.43) \quad E_t = \frac{1}{2} M \mathbf{v}^2$$

$$(3.44) \quad E_r = \frac{1}{2} I \boldsymbol{\omega}^2$$

Are the two energy terms  $E_r$  and  $E_t$  related, and how? If all the kinetic energy of rotation of both inertia elements were turned into linear energy, then the model would move at about 14 cm/s. This compares well with the measured speed. Just calculate the rotational energy of the two elements. The energy of rotation  $E_r$  is:

<b>Table-1</b>	
Parameter	Value
Total mass of model, M	$\approx 200$ gm (0.2 kg)
Mass of inertia elements, m	$\approx 2$ gm
Eccentricity, A	$\approx 0.01$ m
$\omega_{ave}$	$\approx 100$ rad/sec

$$(3.45) \quad E_r = m A^2 \boldsymbol{\omega}^2 = (.002 \text{ gm}) (0.01 \text{ m})^2 (100 \text{ rad/s})^2 = 0.002 \text{ Joule}$$

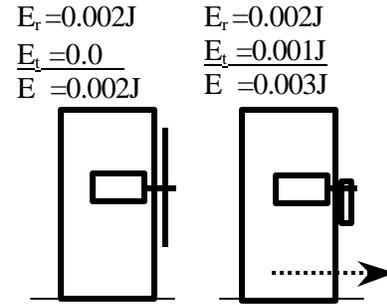
For the measured 10 cm/s speed, the kinetic energy of linear motion is:

$$(3.46) \quad E_t = \frac{1}{2} M \mathbf{v}^2 = \frac{1}{2} (0.2 \text{ kg}) (0.1 \text{ m})^2 = 0.001 \text{ J}$$

The reader should be careful as we proceed, primarily because this type of simple rotation and translation problem is not found in any physics or engineering textbook, even though the calculations appear to be straightforward. This is not the wheel of a bicycle rolling down the street.

When the motion model moves, it contains two energy terms, the rotation energy of the inertia elements,  $E_r$ , and the observed linear translation energy of the total motion model,  $E_t$ . In other words, the total mechanical energy of the moving system is 0.003 J.

From a purely mechanical viewpoint, the conservation of energy appears to be violated. I could balance the inertia elements so that the center of mass is at the same radius (A) as above, and then rotate the same *balanced* elements. This configuration produces no linear motion at all. It now appears that the total mechanical energy of the system is only 0.002 J. What happened here? The situation is presented graphically in **Fig. 34**. This appears to be a serious *mechanics* problem. The rotation energy in both cases is the same (0.002 joules), but in one case the motion model moves with a linear energy of 0.001 joules, and in the other case, the translation energy is zero. The potential problem is resolved by noting that the situation involves the energy derived from the power source, e.g., a battery (which is not shown in sketch). This is analogous to the energy; derived internally in the body from food and turned externally into motion, say, in our bodies. This is to say that the linear motion is derived from the excess energy expended by the battery when driving the unbalanced rotors, than when driving balanced rotors. This is one of many puzzling features that became apparent in testing the wave-induced motion models. For example, the rotation energy with the balanced rotors can be doubled or tripled, but without producing any motion. Even though the energy content of this body is then greater, it produces no motion at all.



**Fig. 34** Energy considerations

I said before that the models move faster when the driving frequency is increased. This behavior was tested with motion models ranging from 0.2 kg to more than 20 kg. The velocity,  $v$ , can be derived from energy considerations. Suppose all the rotational energy is transformed into motion energy, then,

$$(3.47) \quad E_t = E_r$$

$$(3.48) \quad \frac{1}{2} Mv^2 = \frac{1}{2} I\omega^2$$

$$(3.49) \quad v = 2 (m/M)^{1/2} A \omega$$

Generally, the calculated speed is always greater than the measured speed, which indicates that full conversion of the input energy into motion is not attained. This was great because I did not want to deal with *perpetual* machines. Defining  $C$  as the efficiency factor of energy conversion, and substituting  $N$  for  $(m/M)^{1/2}$ , then the velocity,  $v$ , is found to be,

$$(3.50) \quad v = CAN\omega$$

The following **Table-2** gives the calculated speeds for different driving frequencies:

<b>Table-2</b>		
Frequency (Hz)	Velocity (cm/s)	Velocity (cm/s)
	C=1	C=0.5
16	14.1	7
20	17.8	9
25	22.2	11
30	26.7	13
35	31.1	15

The above results are in general agreement with many measurements. I have shown many wave-induced motion models to experts and managers in the government, including the military, patent office,

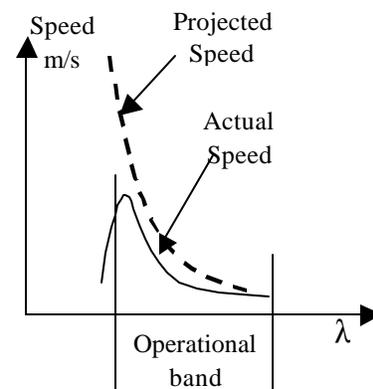
aerospace and think-tank companies and universities. I also prepared a 1-hour long videotape showing many motion features described in this paper, which I shared with others. Whenever there was feedback, it was filled with amazement. The president of my *alma mater*, the George Washington University, immediately referred the videotape and subject to a *physicist* vice president for action. To date, I produced speeds of up to 100 cm/s using the same wave-induced motion mechanism described here. I also built, under contract, several remotely controlled robots using the mechanism, which tested very successfully. Sadly, the experts familiar with my research have not grasped the true meaning of the wave-induced motion mechanism to date. Hopefully, this hurriedly prepared paper will remedy the situation.

During the development of the motion mechanism, it seemed natural to project the behavior in **Table-2** into higher frequency domains. The small 2-g eccentric elements could be rotated at 12,000 rpm with standard dc motors. This should produce speeds of up to 6 km/hr. The following **Table-3** gives some projected speeds, using Eq. 3.50, for very high driving frequencies:

Table-3	
Frequency (Hz)	Speed (km/hr) C=1
200	6
10,000	320
100,000	3,200

The optimistic projections are shown schematically in **Fig. 35**. All attempts to achieve the above projections were in vain. Long before the input frequency reaches 12,000 rpm (200 Hz), the typical motion model would stop moving altogether. More dangerously were my attempts to produce the phenomenal speeds with large steel rotors, of the order of 1 kg, which could have killed me several times when the heavy rotors would fly off like projectiles. All models that I tested, 0.2 kg to more than 20 kg, exhibit the *increased-frequency increased-speed* behavior in only a narrow frequency band, as illustrated in the Figure. No matter what parameters I changed, the incredible *projected* speeds could not be attained.

Does **Fig. 35** look familiar? It should. It is in most physics textbooks over the description, “*ultraviolet catastrophe.*” The classical radiation theory had predicted that atomic radiation energy at greater and greater frequencies, or smaller and smaller wavelengths, would increase indefinitely as shown by the dotted curve in **Fig. 35**. But experiments with *blackbody* radiation had shown that the actual radiation followed the solid line. The dotted curve was what I expected to achieve with wave-induced motion. In 1900, Max Planck demonstrated that the *solid line curve* was the result of *energy quantization*. I eventually realized that the dotted projection was unachievable, but also explainable. I dubbed that lengthy phase of my research, “*the mechanical catastrophe.*”

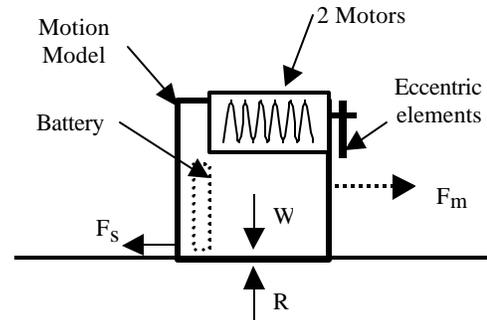


**Fig. 35** *Ultraviolet catastrophe in wave-induced motion*

The projected and actual curves in **Fig. 35** indicate that wave-induced motion is governed by quantum rules. This is just one item in a long list of features of wave-induced motion that I discovered to be directly analogous to the Century old quantum effects. But this time there was a big difference. Recognizing that wave-induced motion is induced by the *modulation* of the driving frequencies, it was easy for me to separate the waves from the particles. Finally, there is no confusion over what is wave and what is matter. There was no puzzlement over the *discontinuities, quantization or causality*. The distinct

steps of my wave-induced motion models, which I explained mathematically and physically earlier, gave clear answers. *Reality* remained intact, or more aptly, reality was regained.

The *forces* in wave-induced motion led to puzzling features, which pointed to serious problems in the prevailing understanding of the *nature of force*. Consider the free-body diagram of a typical wave-induced motion model shown in **Fig. 36**. In order for the motion model to move to the right, a *motive force* must be involved. The motive force,  $F_m$ , must be related to the wave function  $y(t)$ , as it (the force) is the result of the modulation of the driving harmonic disturbances. Common sense dictates that if there is motion, then there must be a force involved. Of course, when I activate the motors and the motion model moves, then another force is involved, and that is the friction force,  $F_s$ . There is also the action of gravity, or the total weight of the motion model  $W$ , and the equal and opposite reaction  $R$ . We learned how these forces interact in physics and engineering. But the behavior of the forces in wave-induced motion is nothing like we learned. By the way, aerodynamic forces are meager. Let us take a closer look.



**Fig. 36** A free-body diagram of wave-induced motion

All wave-induced motion models exhibit a *cutoff frequency*,  $f_o$ , below which motion does not occur. Many tests on surfaces of different coefficients of friction had shown that the *cutoff frequency* is related to the friction force,  $F_s$ . As in the case of energy, we can estimate the magnitude of the motive force,  $F_m$ , from the driving input, or the frequency of the rotating inertia elements. For the typical wave-induced motion model described in **Table-1** and for inertia elements rotating at 100 rad/s, the force can be estimated as follows (The 2 is because we have 2 rotating elements):

$$(3.51) \quad F_m = 2 m A \omega^2 = 0.4 \text{ N}$$

The static coefficient of friction,  $m_s$ , was measured at about 0.18, and that gives the following calculated friction force, which was also confirmed with measurements:

$$(3.52) \quad F_s = m_s W \approx 0.35 \text{ N}$$

The static friction force acts before the model begins to move, and the dynamic friction force acts during motion; but the two values are nearly equal.

It was established experimentally that the motive force,  $F_m$ , must be greater than the friction force,  $F_s$ , (or  $F_m > F_s$ ), in order for the wave-induced motion model to begin to move. This explains the *cutoff off* frequency behavior. For example, the inertia forces required to initiate the motion of 1, 5, and 10 kg motion models are approximately equal to the friction forces of 3, 15 and 30 N, where the coefficient of friction has the standard value of 0.3.

When you compare my **Fig. 36** with similar figures in your physics and engineering textbooks, you will notice a serious problem. Your textbook says the body is in equilibrium, the sum of the horizontal forces is zero, and the sum of the vertical forces is zero, and the body is at rest or moving uniformly. No motive force! I am saying the wave-induced motion models move uniformly under the action of a force. What's wrong? It has been the practice to use Galileo and Newton's law of inertia to eliminate the two vectors  $F_m$  and  $F_s$  from free-body diagrams, such as in the Figure, and to say that the

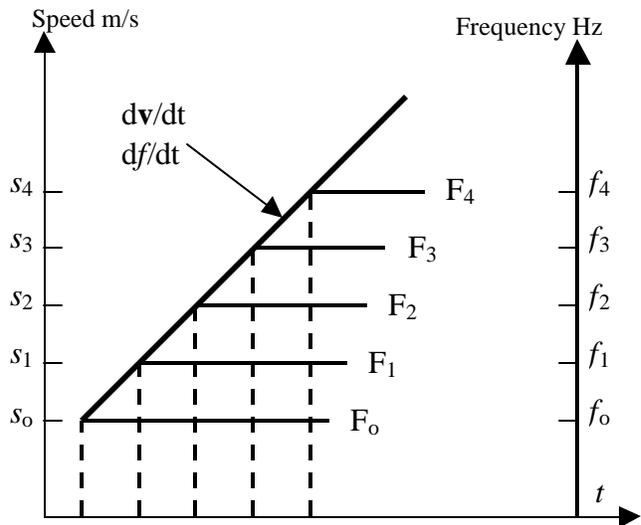
model moves with *zero net horizontal force* acting on it. But we cannot say here that  $F_m$  and  $F_s$  are equal during the constant motion. I measured the forces, and they are not equal, nor are their sum zero.

The wave-induced motion models exhibit the presence of a driving force, the motive force  $F_m$ . The motion models can push or pull weights equal to, or greater than, their own weight. The models move up inclined surfaces and pull weights up the inclined surfaces. At higher driving frequency, a motion model extends a fish scale farther than at low driving frequency. At higher frequency, the models push greater weights. At higher driving frequency, there appears to be a greater ‘*motive force*.’ I have estimated the motive forces for the typical motion model, in **Table-1**, from the rotational inertial forces. The results are given in **Table-4**, where I take the efficiency conversion coefficient at 0.5:

Table-4		
Frequency (Hz)	Velocity (cm/s) C=0.5	Force ( $F_m$ ) N
$f_0 = 16$	7	0.4
$f_1 = 20$	9	0.6
$f_2 = 25$	11	1.0
$f_3 = 30$	13	1.4
$f_4 = 35$	15	1.9

Let me first explain what the numbers tell us. When the frequency is increased from  $f_0$  to  $f_4$ , or from 16 to 35 Hz, the model accelerates from about 7 to 15 cm/s. At  $f_4$ , the force calculations, and measurements, indicate that a force of 1.9N is acting to move the model. The static friction force is less than 0.4 N, and during motion, the dynamic friction force should be smaller. There is a force difference of about 1.5N (or,  $1.9 - 0.4$ ). Using Newton’s  $F=ma$ , the motion model should accelerate at about  $7.5 \text{ m/s}^2$ ! But, at  $f_4$ , the model does not accelerate at all. The model moves at the constant speed  $s_4$ . The motion model also moves at constant speeds at  $f_1, f_2, f_3$ , and every other frequency between  $f_0$ , and  $f_4$ . You can see the above behavior in **Fig. 37**. The Figure reveals a hidden feature, namely, the presence of two forces!

There is the familiar acceleration force, which is evident from the velocity (speed) slope, or the acceleration. Associated with this acceleration is  $F=m(dv/dt)$ , or  $F=ma$ . But, there is a motive force at each operational frequency. The latter force produces only constant speed, with no acceleration, even though it manifests other properties of forces, e.g., pushing and pulling other objects. One must be careful here not to dismiss the issue as being trivial or obvious. Think very carefully about it.



**Fig. 37** Accelerating (Newtonian) and non-accelerating (Aristotelian) forces

Figure 37 and **Table-4** clarify some of the great debates about the nature of motion and force that raged over the centuries. Sir Isaac Newton saw the slope in the **Fig. 37**, and he derived the valuable mathematical relationship of force and rate of change of momentum, or force and acceleration. Constant force for constant speed was taught for a very long time before Newton. That was Aristotle’s concept, which was discarded after the 17<sup>th</sup> Century as being useless and silly. Wave-induced motions show the

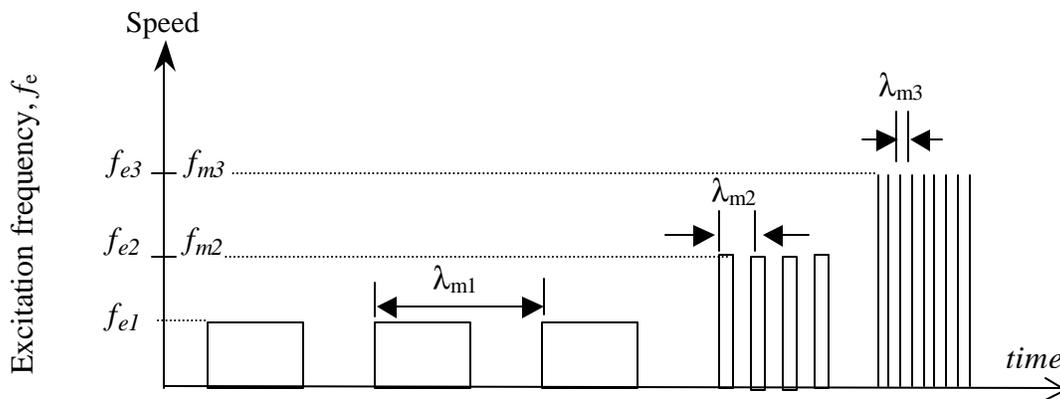
value of both opinions. If I seem to be mixing the old with the new, it is only because there is value in both.

Treating wave-induced motion using classical physics or mechanical methods seems to always run into trouble. There was the *ultraviolet catastrophe* behavior that happened with my motion models. My examples and experiments may explain the nature of the *uncertainty*, *confusion*, and *despair* during the 1926-1927 period that Heisenberg spoke about. Consider the conservation of momentum in wave-induced motion. Each disturbance applied to a motion model should propagate, reflect and set up equal but opposite reaction within the body. The sum of the forces generated by the disturbances and the reflections, according to the action-reaction law, must add up to zero. No motion whatever should result from the wave disturbances traveling in the body. The momentum should be zero, but it is not. Think about it. The most important law of conservation of linear momentum appears to be violated! These were the issues that puzzled Planck, Einstein, Bohr and the other great scientists of the 20<sup>th</sup> Century. One must be able to clearly visualize how modulating forces in one plane produce motion in an orthogonal direction to resolve the momentum problem, see last Section, Physics of wave-induced motion.

### 3.4 Modulated, quantized and discontinuous motions

The basic mathematics, physics and mechanics of wave-induced motion are finally at hand, as described above. A vital observation in wave-induced motion is the *low-pass filter* behavior that is clearly seen in the near-perfect stepping motion. This behavior alone differentiates wave-induced motion from any motions produced or taught to date. Wave-induced motion is strictly the result of *superposition, modulation or dynamic coupling* of two or more wave trains set up in a body.

In November 1997, I gave *Invited Talks* on the subject of this paper to international scientists (from the Americas, Europe, Asia, Africa and the Middle East) in Jordan.<sup>20</sup> In December 1997, I applied for a patent on the wave-induced motion mechanism. I also submitted several White Papers to different U.S. Agencies. In all these cases, I used the following diagram, **Fig. 38**, that summarizes the salient features of my wave-induced motion, including the quantum effects, as described in detail in this paper. The near ideal *low-pass filter behavior* is explicitly indicated in the distinct steps in this Figure, and in the other diagrams I used in 1997-98. That a Fourier expansion analysis is required should have been obvious to the scientists from the Figure. Other features, quantum or otherwise, are also clear in the diagram. Actually, this Paper is a translation into formal language of Figure 38 and my other 1997-98 diagrams. I will briefly discuss this early (1997) diagram here.



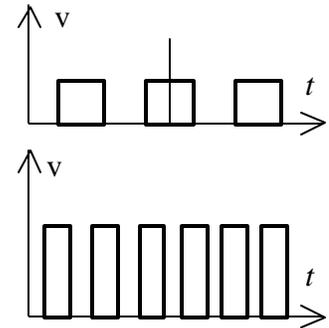
**Fig. 38** Summary of wave-induced motion characteristics, showing the **ideal low-pass filter** behavior with distinct motion steps.

The ordinate on the left shows the three primary parameters: (1) the speed of the motion model, (2) the excitation frequencies (i.e., the frequency of the pulses supplied by the two motors in the basic wave-induced motion configuration), and (3) the motion frequency of the model. At the excitation frequency  $f_{e1}$ , the *almost harmonic amplitude-modulated* wave solution of two or more nearly equal harmonics produces the three distinct steps shown on the left. The period of the steps can be made rather long and the steps are characterized by a distinct wavelength,  $\lambda_{m1}$ . If you use a stopwatch, you can easily measure the frequency of the steps, which I call the motion frequency,  $f_m$ . The middle four steps show another condition where the driving frequency is increased, the speed of the model is increased and the wavelength of the steps is decreased. But, the steps are still distinct, though of shorter period. This is a plain quantum effect, as was explained before and will be discussed further later. And it should be clear that the closely spaced lines on the right of the Figure represent the case where the wavelength of the

<sup>20</sup> AbuTaha, A. F., “*The Discovery of Self-motion, or Natural-Mechanical-Quantum-Motion,*” *Invited Talk*, The First Conference on Material Science (CMS1), **Mu’tah University, Jordan**, November 3, 1997. The talk followed the outline of this paper. Also, *Invited Talks*, with the same title, by **The Royal Scientific Society, Amman, Jordan**, and the **Physics Department, University of Jordan, Amman, Jordan**, November 1997.

steps, or  $\lambda_{m3}$ , is small, and the motion frequencies  $f_m$  are large. It is here that one can adjust the spacing of the steps, by modulation techniques, to produce smooth, and seemingly continuous, motion. While the smooth motion, and its associated motive force, will have many useful applications, the stepping motions will have great value in research.

The stepping motions *BETRAYED* the mysteries that confounded the founders of the quantum and atomic theories. That physical bodies can be induced to move by the superposition or modulation of 2 or more exactly harmonic oscillations was neither noted, nor developed, by those scientists, or anyone else. The case of modulation of two waves is the simplest amplitude-modulation example, but it is illustrative of all kinds of modulations. The reader should be able to see from the mathematical analysis in Section 3.1 that when the driving harmonics,  $w_1$  and  $w_2$ , have the same phase constant, then there is a time interval when  $y(t)$  is near its maximum value; and the stepped motion is the natural result. I also pointed out that when the nearly equal  $w_1$  and  $w_2$  are forcefully driven, e.g., with the motors' torque in a typical wave-induced motion model, then there is a very distinct and completely specified phase relationship between the two applied harmonics that make up the modulation. It can then be said that the *forced* superposition in the motion models produces a *coherent* condition. Some readers may try to make the one-to-one analogy with *coherent light lasers*.



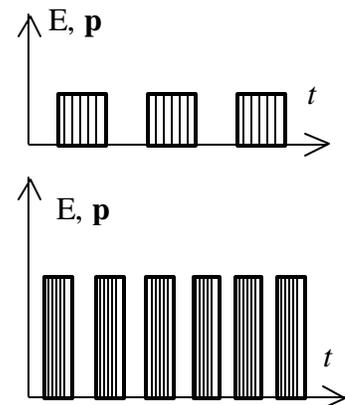
**Fig. 39** Distinct steps in wave-induced motion

Just as sound and light waves could be *superposed coherently* to produce the distinct *beat* effect so could the waves in the motion models be *superposed coherently* to produce the distinct stepping action. Maintaining a constant phase relationship between the driving frequencies produces the effect.

When sound waves and light waves are excited randomly, the *beat* effect is lost, but this does not mean that there is no modulation of the waves. You will still hear the modulation of the two forks, without the beat, and see the out-of-step light laser. In these cases, there is no time when the phase relationship of the driving waves is distinct, and the “*turn-on time*” is random or spread-out. The same behavior occurs in the motion phenomena, where the seemingly smooth continuous motion occurs.

Over a period of four years, the experts who studied my invention of wave-induced motion have had difficulties correlating the motion to quantum effects, or differentiating the invention from the well-known, but completely inapplicable, Newton's motion laws. It is my hope that this paper will elucidate the issues involved. Here are some more basic results.

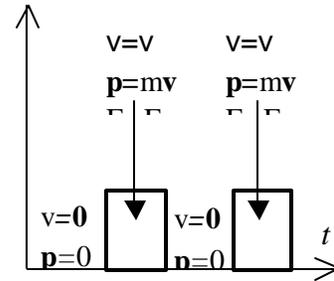
The distinct steps in wave-induced motion are the primary characteristic of the phenomenon. It differentiates the effect from the simple cases of dynamic *vibratory motions*. It allows clear physical explanation and interpretation of quantum effects. Let us look closely at the steps from **Fig. 38**. Turn on the harmonic disturbances, the resulting waves modulate, and the body executes the near *ideal low-pass filter* behavior in **Fig. 39**. As long as the power supply is constant, the model can move indefinitely as shown in the Figure. The body moves suddenly. It stops suddenly. It moves suddenly again. It stops again. And so on. This can be legitimately described as *discontinuous motion*. If we only consider the linear momentum  $p$  and energy  $E$  of the moving body, we see that the linear momentum and energy are turned on, turned off, on, off and so on, as in **Fig. 40**. *Energy is discontinuous*.



**Fig. 40** Energy bundles in wave-induced motion

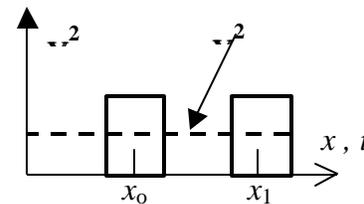
At the risk of being repetitive, but this is essential, I show the velocity, momentum and energy behavior again in **Fig. 41**. The motion model begins with zero velocity, momentum and energy. It then suddenly gains velocity,  $v$ , momentum,  $mv$ , and translation energy,  $\frac{1}{2}mv^2$ . Then it stops, then it moves, *discontinuously*. It is precisely the *discontinuities* in the behavior of particles that bothered Einstein, Planck and Bohr, even long after the quantum theory was set on its way.

Suppose you ask the question, where is the motion model some specific time  $\Delta t$  after the onset of motion? The model begins at  $x_0$  and it takes a step to position  $x_1$  in a definite period of time. You know how the model got from  $x_0$  to  $x_1$ ; by the *superposition* of the driving harmonic disturbances. You can solve this problem with a clear *vision* of everything involved. This is not the case in quantum mechanics.



**Fig. 41** E,  $p$  and  $v$  in wave-induced motion

No one should have trouble *seeing* that energy in stepping motion comes in bundles, bunches, packets or quanta! I can, and did, measure the energy quanta for the wave-induced motion models. You can too. I can also calculate the energy packets, and you can too. The wave function  $\psi^2$  has a clear meaning in wave-induced motion. It is not some probability that I might find the motion model at  $x_0, x_1$  or at any other location or region in space or time. Energy is proportional to  $A^2(t)$  – e.g., see Eq. 3.45. The *classical wave equation* takes on a physical and clear meaning. As noted before, I did not use the dispersion relationships in my mathematics so as not to clutter the picture and lose sight of what we were after; i.e., a clear understanding of the motions produced by the *superposition, modulation* or *dynamic coupling* of two or more harmonic disturbances. The *classical wave equation* for nondispersive waves in space and time is,



**Fig. 42**  $\psi^2$  regains its *real physical meaning*

$$(3.53) \quad \frac{\partial^2 \mathbf{y}(x,t)}{\partial t^2} = \mathbf{u}^2 \frac{\partial^2 \mathbf{y}(x,t)}{\partial x^2}$$

where  $v$  is the constant phase velocity. Here,  $\mathbf{y}(x,t)$  represents any one of the traveling harmonic waves in a *superposition* or a *modulation*, e.g., our  $\mathbf{w}_1$  and  $\mathbf{w}_2$  in Eqs. 3.1 through 3.10. Of course,  $\mathbf{w}_1$  and  $\mathbf{w}_2$  also satisfy Eq. 3.53, and so does the entire *modulation*. The reader would have noted that I have not used the *classical wave equation*, Schrödinger's *wave equation*, or any other complex wave equation to develop a clear picture of the motion, force, momentum, or energy concepts in wave-induced motions. And this is how it should be. Having a clear mental *picture* of events, I did not find it necessary to work out  $\mathbf{y}(t)$  backward from Eq. 3.53 or similar equations. The wave function  $\mathbf{y}(t)$  is completely defined in my Eq. 3.9. I will however write a follow-up paper that will deal with the wave equations, both classical and quantum, to show how the diametrically opposite subjects are anchored in the same world of reality and causality.

For those readers who are not familiar with quantum mechanics, let me describe a feature that could lead to considerable confusion if not anchored in the world of reality. We are naturally familiar with *continuous* mechanics, as were Planck, Einstein and Bohr. Suppose a car accelerates from 0 to 50 km/hr. We expect to look at the speedometer and see the needle making its way to 5, 10, 20, 30, 40, (and even 49), then 50 km/hr. Suppose you attach a speedometer to my wave-induced motion model shown in **Fig. 36** (also, look at **Fig. 37**) and you turn on the motors. What do you suppose will happen? If you look carefully at the speedometer, you will see 0, 50 km/hr, that's it. You will not see 10, 20, 30, 40, or any

number in between. If you were driving a wave-induced motion car, you would leave everyone behind in the dust at the traffic light. This is why the cheetah will beat any sports car in the first 3 to 5 seconds. The cheetah is up and running at terminal speed, while the sports car is accelerating to reach terminal speed. The features of wave-induced motion, and also quantum mechanics, are indeed problematic, but exciting. The experimental program and mathematical derivations that I describe in this paper should take the mystery out of many seemingly intractable features in quantum, atomic, biology and psychology theories.

Let us finally look at a central problem in quantum and atomic theories, and see how my wave-induced motion work resolves the matter. This is the quantization of energy. As you will see, there is nothing mysterious about it. This is extremely important because it was here that the 20<sup>th</sup> Century scientists mixed up the *cause* and *effect* and, as Planck and Einstein were concerned, *causality* was in trouble. Our starting point is Planck's energy equation,

$$(3.54) \quad E = n h f, \quad n = 1, 2, 3, \dots$$

where  $h$  is Planck's constant ( $6.626 \times 10^{-34}$  J.s),  $f$  the frequency of an oscillator and  $n$  a whole integer. This equation has roots in test results that *energy* is proportional to *frequency*. We saw that that was the case with the wave-induced motion models, e.g., my Eq. 2.4,

$$(2.4) \quad E \propto f$$

Let us introduce a constant of proportionality,  $a$ , in Eq. 2.4, or,

$$(3.55) \quad E = a f \quad \text{compared with } (E = h \nu)$$

This is the energy that results from the *modulation or dynamic coupling* process that I explained before. This energy also corresponds to a specific speed of the wave-induced motion model, for example,  $s_1$  in **Fig. 37**, which corresponds to the driving frequency  $f_1$ . When we increased the driving frequency,  $f$ , as you see in **Fig. 37**, the speed increased. Energy then increases with frequency.

Now Einstein's photoelectric equation includes the *work function*,  $W_o$ , which is necessary to loosen the electron from the surface of the metal, and is given as follows,

$$(3.56) \quad E_{\max} = h f - W_o$$

As you remember, I reported in Section 2.3 that "there is a *cutoff frequency*,  $f_o$ , below which *motion does not occur*," and you can try this behavior with your own motion models. I had also shown that one could measure and calculate the *motive force* required to overcome static friction to initiate motion in wave-induced motion. In plain language, the maximum energy of a wave-induced motion model is determined by including a *work function*, i.e., the energy required to overcome friction. Then, my Eq. 3.55 becomes,

$$(3.57) \quad E = a f - W_o$$

Now comes the quantization problem. My Eq. 3.55 should have been written in the first place in the same form as Planck's quantum equation, or,

$$(3.58) \quad E = n a f \quad n = 1, 2, 3, \dots$$

which is equivalent to the Planck's basic energy quantization Equation 3.54. While the Equations look alike (3.54 and 3.58), there is a big difference in the treatment of the two. In the quantum equation, the

quantization is in the wrong place. In wave-induced motions, it is easy to see where the *quantization* comes from. The *quantization must be placed in its rightful place*. Let us see how.

I began Section 3 by showing you how the *modulation, superposition* or *dynamic coupling* of two or more wave trains within a physical body can induce the body to move. I chose two wave trains,  $w_1$  and  $w_2$ . The *modulation* happens whenever  $w_1$  and  $w_2$  are in a characteristic, normal or eigen mode. This is a simple concept, which you know about from basic wave phenomena, such as sound beats. I also discussed earlier the analogy between the trapped string waves between two fixed walls and the trapped waves within the boundaries of a freestanding wave-induced motion body. The boundary conditions determine which modes are excited. The characteristic, or normal, modes in the string are excited when there are nodes at the walls. The same is true for the wave-induced motion body. Actually, the same is true of all waves confined in one, two or three dimensions. This simple and straightforward requirement dictates that the distance between any two adjacent nodes must be  $\lambda/2$ . In turn, the number of modes that can be excited between two fixed walls, or between the walls of the wave-induced motion body, can only be an integral number  $n$  of half wavelengths,  $\lambda/2$ ; where  $n = 1, 2, 3, \dots$ . The fundamental and second normal modes for a string between fixed walls and for the driving disturbances in a wave-induced motion model are shown in Fig. 43.

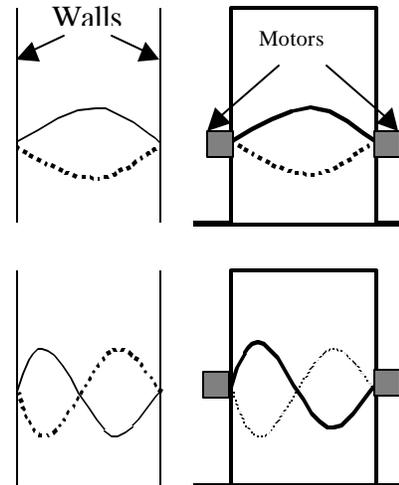


Fig. 43 Fundamental and second modes.

When the driving harmonics are in one of the natural modes, *superposition* occurs. This brings up two observations that have been overlooked in quantum mechanics. These are, (1) the number  $n$  relates to the excited system, and not to an external system or agent, and (2) the *modulation* at the normal modes produces the quantized results, even in the classical equations. What I mean by these statements should be self-evident. The wave trains  $w_1$  and  $w_2$  must be set up in a normal mode to *superpose* or to *couple dynamically*.

And when the *superposition* of the waves occurs, the result, e.g., the stepped motion, comes out in bundles, packets or quanta. How could these simple observations be the agonizing problem in quantum mechanics? In the photoelectric effect, the quantization was placed in an external agent, the impinging light, and not in the excited system, the metal. How is this wrong?

Einstein used water waves to explain the *photon*,<sup>21</sup> so let us use a water wave example. You saw how the change in (vertical) pressure on the surface of water could excite water waves. When the water waves modulate in one of the normal modes, the *modulation* produces wave packets, or wavelets, which I illustrated in Fig. 28, shown here again. There is no problem in modeling the water wavelets as “*small water balls*” as I show on the right, either to do mathematics or to understand, or explain, the physical events that transpire. But it should be clearly understood that it is strictly the *superposition, modulation, or dynamic coupling* of the water waves that produces the energy carrying wavelets. More specifically, the overhead *delta pressure* does not directly produce the wavelets. Do you see my point? The “*delta pressure*,” like a rock thrown into a pond, is the exciting force. The “*delta pressure*” itself does not *modulate*. *The rock does not modulate*. If you are producing and watching water *wavelets* in your kitchen sink with dripping water, *the water drops from the faucet do not superpose or modulate at any point in space or time from the faucet to the point of contact*. The exciting forces from any source (rock, water drops, air pressure) do not modulate. The system on which the exciting force *impinges* is where the

<sup>21</sup> Einstein, A. and Infeld, L., “*The Evolution of Physics*,” Simon & Schuster, Inc., New York, 1966 printing. For example, a section entitled, “*THE QUANTA OF LIGHT*,” begins with “*Let us consider a wall built along the seashore. The waves from the sea continually impinge on the wall, wash away some of its surface ...*” p. 257

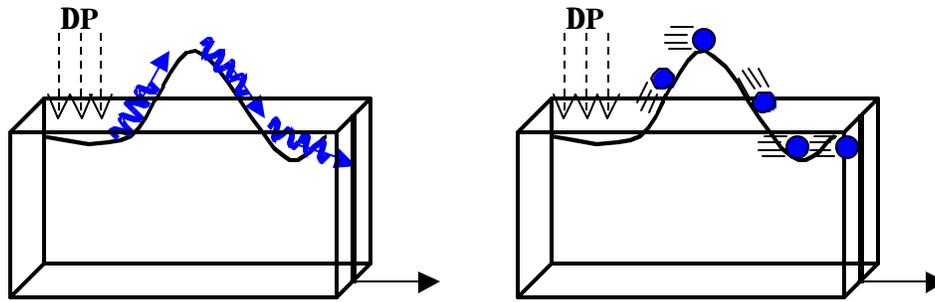


Fig. 28 Are the water wavelets waves? or, are the water wavelets matter (*photons*)?

modulation, superposition or dynamic coupling takes place. It is specifically the resulting waves in the water that modulate. To get a better picture yet, let us look at how Einstein handled the delta pressure and the wavelets. Read the following quotations from the same section in Einstein-Infeld book very carefully:

*"The light extracts electrons from the metal. The electrons are torn from the metal and a shower of them speeds along with a certain velocity. From the point of view of the energy principle we can say: the energy of light is partially transformed into the kinetic energy of expelled electrons."<sup>22</sup>*

*"The action between radiation and matter consists here (i.e., in the photoelectric effect) of very many single processes in which a photon impinges on the atom and tears out an electron."<sup>23</sup>*

Let us apply Einstein's sentences to the water example to clearly see the problem. The *quantization* in quantum mechanics is placed in the source of radiation, the light. This is like saying that the *quantization* in the case of the water wavelets is in the atmospheric pressure or the rock. Let me show you how this would look like schematically, **Fig. 44**. This is to say that the sudden change in air pressure over Lake Geneva is "*balls of energy*" (the white balls on the left), which fly into the water and expel the water wavelets (the blue balls). In this billiard ball like collision, the kinetic energy in the  $\Delta P$  balls expels the water wavelets! Do you see the confusion?

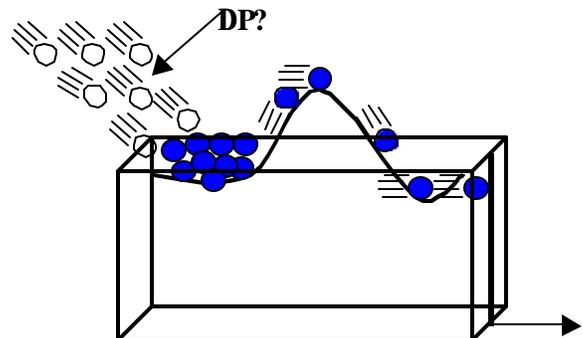


Fig. 44 Photoelectric interpretation using water wavelets example

The pressure change over the Lake need only be sudden. This produces a *unit-step-function* input, which you can solve using a Fourier series transform, just as we did in Section 3.1.<sup>24</sup> Obviously, the quantum problem was not formulated correctly from the start. By placing the quantization in the light waves, which is similar to placing it in the sudden pressure change, the particles and the waves got all mixed up. It is wonder that the founders of quantum mechanics managed to salvage the situation mathematically, as witnessed by the marvelous achievements of the quantum and atomic technologies.

We saw in Section 3.1 how the *unit-step-function* can be traced back to the *superposition or modulation* of two exactly harmonic oscillations, e.g., in the case of wave-induced motion,  $w_1$  and  $w_2$ . **In the case of the wave-induced motion models, you also saw that the resulting modulation occurs at**

<sup>22</sup> *Ibid*, p. 258.

<sup>23</sup> *Ibid*, pp. 260-261.

<sup>24</sup> Also, I had dealt extensively with the response of second-order transients of this sort before in space systems. For example see my web page "[shuttlefactor.com](http://shuttlefactor.com)."

the beat frequency ( $w_1 - w_2$ ), e.g., see Eq. 3.39. I should point out that the radiation of an electron in transition does not occur at just any frequency value. I must emphasize that the electron's radiation in transition does not occur at  $w_1$  or  $w_2$ . Instead, "*the radiation frequency is the beat frequency between the two stationary states involved in the "transition": ( $w_{rad} = w_2 - w_1$ ).*"<sup>25</sup> This is not accidental and the implications are far reaching.

Much has been made of Planck's constant. Did I check it? Yes. Is it related to my wave-induced motion? Yes. At the beginning of Section 3.3, I described a typical wave-induced motion model (see **Table-1**). Graduate researchers should be able to reproduce my results. I described above the quantized energy of the wave-induced motion as,

$$(3.55) \quad E = af$$

The constant of proportionality,  $a$ , for a typical motion model could be approximated as,

$$(3.56) \quad a = \frac{E}{f} = \frac{0.002 \text{ J}}{16 \text{ cps}} = 1.25 \times 10^{-4} \text{ J.s.}$$

Does my value have anything to do with Planck's constant ( $6.626 \times 10^{-34}$  J.s.)? It occurred to me that the *mass* in the energy expressions, e.g., kinetic, potential, etc., bears a linear relationship to energy. I asked, what if my wave-induced motion models were small electrons, and I mounted two tinier motors on the electrons and excited the small system at  $w_1$  and  $w_2$ , just as I described repeatedly in this paper? When the motors are turned on, the electron would jump into action, i.e., move suddenly, nearly instantaneously at their terminal constant speed. These and similar thoughts led me to scale my constant of proportionality,  $a$ , by the mass of my typical wave-induced motion model and the mass of the electron. I was astonished with the result. I suppose some researchers will have to replicate my typical wave-induced motion models (which should be easy to do) to confirm my results; and to then try to make sense of the following calculation. Here, the subscript *wim* stands for *wave-induced motion*, and *e* for the electron:

$$(3.57) \quad a_e = \frac{a_{wim} m_e}{M_{wim}} = \frac{(1.25 \times 10^{-4} \text{ J.s.})(9.11 \times 10^{-31} \text{ kg})}{0.2 \text{ kg}} = 5.69 \times 10^{-34} \text{ J.s.}$$

Is it a coincidence? I don't think so. You can get Planck's constant from my other equations.

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<sup>25</sup> Crawford, *Berkeley waves physics*, p. 558.

#### **4. The real quantum “picture”**

In “*Imagery in Scientific Thought*,”<sup>26</sup> Arthur I. Miller extends cognitive psychological theories to include the role of *mental imagery* in the construction of scientific concepts and the dynamics of creative scientific thinking. Miller evaluates “*Niels Bohr, Ludwig Boltzmann, Albert Einstein, Werner Heisenberg, and Henri Poincaré*.” Among other subjects, Miller describes the incredible roller coaster events that surrounded the development of the quantum and atomic theories. The theories are imageless. That aspect had bothered me since my youth for, in addition to being illogical, the theories ran contrary to the modern scientific method. Miller speaks of “*Visualizability Lost*,” and “*Visualizability Regained*.” How can light be at times wave, and at other times particle? How can the electron be at times particle, and at other times wave? These are daunting issues. Visualizability was not lost, for it was not there in the first place. Visualizability was not regained either, as I will further describe in this Section. The scientists mentioned were all Kantians, and Miller aptly includes Kant’s definition of the modern scientific method in one of the epigraphs to Chapter 4, “*Gedanken ohne Inhalt sind leer, Anschauungen ohne Begriffe sind blind*,”<sup>27</sup> or “concepts without percepts are empty, percepts without concepts are blind.”

Though wonderful in mathematical construction, the quantum and atomic theories are devoid of mental pictures, or *anschuliche bilden*. No one has a clear picture of events. My wave-induced motion models and theory finally give a clear picture of what happens in the quantum and atomic worlds. I repeatedly stated in this paper how the *dynamic coupling* mechanism is responsible for wave-induced motions. Ironically, Miller retells the same picture as painted by Bohr in the 1920’s. No one saw Bohr’s picture clearly, and the others dismissed it. Miller summarizes Bohr’s “*coupling mechanism*” as follows,

“Bohr proposed the “*coupling mechanism*,” according to which atoms responded to incident light like an ensemble of harmonic oscillators whose frequencies were those of the possible atomic transitions.”<sup>28</sup>

Look again at my last Figure of water wavelets and sudden atmospheric pressure change over Lake Geneva, Fig. 44. Bohr was simply saying that *dynamic-coupling, modulation or superposition* occurs in the system, i.e., in the water, and not in the external agent, the *delta pressure*. I might add that water responds *to incident pressure changes like an ensemble of harmonic oscillators* for water is precisely an ensemble of loosely bonded molecules that oscillate when disturbed. So, how does my work undrape the quantum “*picture*?”

#### **4.1 Visualizability**

There is a little psychology experiment I saw on educational television that tests the perceptual capacities of infants. A baby is placed in front of a table that has a hobby railroad track running across. The baby watches, and hears, an engine car running on the track. A board is then placed to obscure a part of the track. Now, the train appears from the right, disappears behind the board and reappears on the left. The babies are not aroused by the brief disappearance of the train. A heavy obstacle is then placed directly on the railroad track, and the board is raised so that the babies do not see the events behind the board. Now, the engine car comes from the right, disappears behind the board and *reappears* on the left. What happened! *Some* infants, without higher or lower education, are aroused. It seems as if the train did the impossible, it *tunneled* through the heavy obstacle.

I suppose the psychology experiment was inspired by Enrico Fermi’s<sup>29</sup> “*tunneling effect*,” e.g.,

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<sup>26</sup> Miller, Arthur I., “*Imagery in Scientific Thought - Creating 20<sup>th</sup>-Century Physics*,” Birkhäuser Inc., Boston, 1984.

<sup>27</sup> Miller, p. 125.

<sup>28</sup> Miller, p. 135.

“In the 1940’s Enrico Fermi, at the University of Chicago, demonstrated the phenomenon of tunneling with the following problem: Given a 1-ton automobile coasting very slowly toward a hill 100 ft long and 1 ft high, what is the probability that the car will tunnel under the hill? The answer came out  $10^{-38}$ .”

This is only one of many quantum effects that seem to confuse babies and adults alike. The tunneling probability is a tiny number. It is not as tiny as the answer I jotted down in one of my 1960’s textbooks. I scribbled, 0.0.

I was introduced to the strange quantum subject in the 1950’s, and I have had ½ a century to think about it. My science teacher in Jordan, who studied physics in Germany, introduced me to the strange subject. He was an enthusiast of the subject, and we talked at length about it. He was biased and strongly supported Bohr’s views over all others. My teacher’s higher education in Germany was not far removed from the rancor among the founders of quantum mechanics. For example, Heisenberg describing Schrödinger’s work as trash, in a letter to Wolfgang Pauli in 1926,

“What Schrödinger writes on visualizability [*Anschaulichkeit*] of his theory ... I consider trash.”<sup>30</sup>

Or, Schrödinger writing of Heisenberg’s theory, also in 1926,

“I knew of this theory, of course, but felt discouraged not to say repelled, by the methods of transcendental algebra, which appeared very difficult to me and by the lack of visualizability [*Anschaulichkeit*].”<sup>31</sup>

Notice that these two skilled mathematicians were more bothered by *visualizability* than by the complex mathematics of quantum mechanics. What is happening behind the veil?

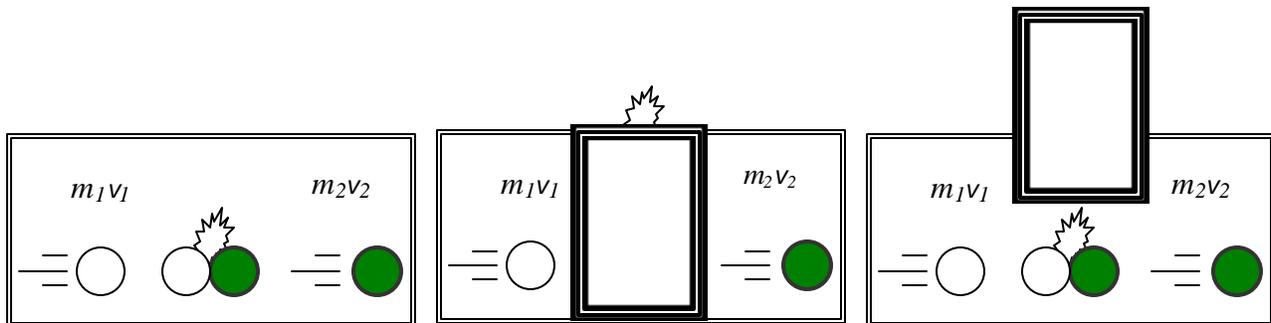


Fig. 45 A simple test with billiard balls

What happens behind the screen in my middle Sketch in Fig. 45? I suppose all of us would pass the simple test. But, what happened behind the board in the above psychology experiment? How are the babies to reason on what happened behind the board? Did the train really tunnel through the heavy obstacle? The psychology experiment is easy to explain. An assistant hides behind the table, and when the train engine comes across, she removes the obstacle, allowing the train to pass through; she then replaces

<sup>29</sup> Angrist, Stanley W., “Direct Energy Conversion,” Allyn and Bacon, Inc., Boston, 1965, p. 61.

<sup>30</sup> Miller, Arthur I., “Imagery in Scientific Thought - Creating 20<sup>th</sup>-Century Physics,” Birkhäuser Inc., Boston, 1984, p. 143. This is the best account of the development of quantum theory that I have read.

<sup>31</sup> *Ibid.*

the obstacle back on the track and hides behind the table. The babies do not see what happens behind the board and are deceived by the ploy.

The modern quantum theory deals with the actions and interactions between waves and particles. A board, as in the psychology experiment, has been placed permanently between the experimenters and the interactions. We could only see what goes in behind the board and what comes out at the other end of the board. Quantum theories are based on the experts' imagination and interpretations of the input and the output. My wave-induced motion experiments and analysis are the first ever to remove the board and allow direct observation of what happens in the mysterious quantum world. Planck and Einstein persisted that some classical explanation of the strange quantum effects might be out there. They labored for years to find it. They did not find it. As you will see next, the real explanation is not purely classical, nor is it purely quantum. It is a mixture of the two; a simple mixture that was overlooked by all.

## 4.2 Energy quantization (Max Planck)

In 1900, Max Planck proposed that energy packets, or quanta, could explain the peculiar behavior in blackbody radiation and the ultraviolet catastrophe. Discontinuous and bundled energy turned into a problem for science, for no one could find analogies for the effect in nature or in classical theories and no one could build real models to demonstrate the effect. The quantum effects ran smack against *reality, causality and* plain common sense. The quantum *effect* was real. The *cause* was not apparent.

I have built the wave-induced motion mechanism inside solid spherical balls, where all the elements are hidden from view. A remotely controlled wave-induced motion sphere is shown in Fig. 46. You point an *infrared* controller, just like the TV controller, at the model to turn on the two motors; and the model moves, say, to the right. From afar, you think it is a rolling ball. By tuning the input harmonics,  $w_1$  and  $w_2$ , the sphere can be made to move in distinct steps or smoothly as I described before.

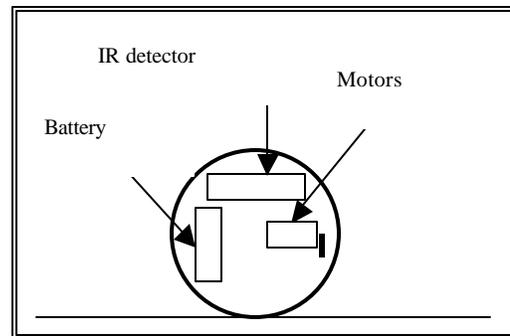


Fig. 46 A remotely controlled wave-induced motion model

What happens when we turn on the motors? Waves propagate in the body as a result of the harmonic disturbances,  $y_1(t)$  and  $y_2(t)$ , Eqs. 3.1 and 3.2. The waves *modulate* and produce, for example, the distinct stepping motion in Fig. 47, which you saw before. The modulation happens inside the body, and not in the infrared beam. The modulation energy in the body appears in discontinuous bundles, and there is nothing mysterious about it. I could control the size of the steps, or the speed of continuous smooth motion, by changing the motors' rpm.

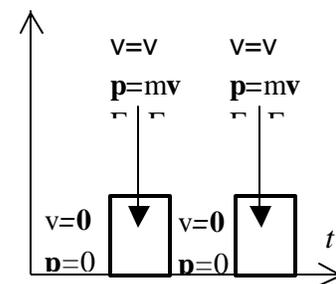


Fig. 47 E,  $p$  and  $v$  in wave-induced motion

The primary thing to observe here is that the motion energy of the models has nothing whatsoever to do with the *infrared* radiation from the controller. The IR beam simply turns the motors on or off. The concept is easy. To emphasize my point, think about a simple remotely controlled conventional toy car. The radiation from the remote control does not *push or move* the car; the motors in the car move it!

That energy is quantized in wave-induced stepping motion should be easy for everyone to see. You can think of it as a mechanical *beat* effect. The steps explain the discrete and discontinuous quantum predicament. You know *how* and *why* energy appears in discrete

bundles. A change of one parameter of the input waves (amplitude, phase, frequency, etc.) in the motion model itself changes the motion.

But there is a greater dilemma in the phenomenon. You might ask, how come Maxwell's electromagnetic theory did not explain the quantum effect. After all, Maxwell's equations worked so well in many areas. The answer lies in the fact that Maxwell's equations do not explicitly demand the *superposition, modulation or dynamic coupling* of oscillations. Maxwell recognized, and actually established, that light is an electric and a magnetic wave, and not an electric wave alone; or light is an electro-magnetic wave. But we have grown accustomed to think of electromagnetic things as being electric things. We buy electric appliances and pay electric bills when in reality we buy electromagnetic appliances and pay for electromagnetic services. To use Maxwell's equations effectively, one must keep the electric and the magnetic vectors in mind all the time. That was not done in the development of quantum mechanics.

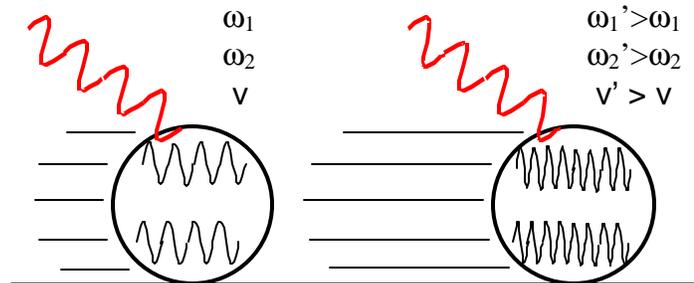


Fig. 48 IR signal intensity doesn't affect motions.  
 Motion is strictly the result of harmonics in body.

Fig. 48 shows two wave-induced motion models. In the first case, I send an IR signal that activates the motors at  $\omega_1$  and  $\omega_2$ , which induce the sphere to move at velocity  $v$ . In the second case, I send the same IR signal, which activates the motors to move the sphere at a faster velocity,  $v'$ . The same sphere moves at different speeds, not because different infrared signals are applied, but rather because of different *modulations* of the waves inside the body.

Now, it is imperative to note that even though the motion can be smooth, it (the motion) is strictly the result of the *modulation* of  $\omega_1$  and  $\omega_2$ , in one case, and  $\omega_1'$  and  $\omega_2'$ , in the other case. Consider a simple example. When  $\omega_1 = \omega_2$ , then modulation occurs at  $\omega_{ave}$ , which is equal to  $\omega_1$  or  $\omega_2$  ( $\omega_1 = \omega_2 = \omega_{ave}$ , Eq. 3.11). There is no way of telling that modulation is taking place. This is to say that if you did not know a priori that modulation is taking place, you could be easily deceived. Suppose we measure the pulsations on the surface of the sphere and determine that the sphere is pulsing at a given frequency  $f_{ave}$ . Since the three frequencies involved, i.e.,  $f_1$ ,  $f_2$ , and  $f_{ave}$  are equal, you could not discriminate between them. The same things can be said about the second model having  $\omega_1'$ ,  $\omega_2'$  and  $\omega_{ave}'$ . If you measure the numerical value of one, it is the same numerical value for the other two. You must be careful in deciding what is measured.

The Planck's quantum hypothesis states that an oscillator can only have energy of the multiples  $hf$ ,  $2hf$ ,  $3hf$ , and so on. The dilemma is in the limitation that  $f$ , the vibration, can occur only at the integer values 1, 2, 3, etc. But, what vibration? Planck picked the wrong *vibration*, and the quantum problem was born. The reader must forcefully note that  $f_1$  and  $f_2$  can be varied *continuously*, but that  $f_{ave}$  can only vary *discontinuously*.

Here is a numerical example. Suppose I operate motor #1 at 10 Hz, motor #2 at 10 Hz to move a wave-induced motion model. If I place a probe on motor #1, I will measure a vibration of 10 Hz, which is strictly due to the rpm setting of the motor. If I place a probe on motor #2, I will also measure 10 Hz, which is strictly due to the rpm setting of this motor. Now, if I place a probe on the surface of the sphere, I will also measure **10 Hz**, which is neither the vibration of motor #1, nor the vibration of motor #2. The vibration on the surface of the sphere is the result of the *modulation* of the other two frequencies. But, it,

the modulation frequency, has the same numerical value as the others. You can vary the vibration of motors #1 and #2 *continuously*. You can start a motor at, say, 3 cps and move on to 3.1, 3.5, 3.84, or any value between 0 and 10. But *Superposition, modulation or dynamic coupling* of the vibrations will only happen at the characteristic or normal frequencies, as explained earlier, e.g., in Section 3.4.

How can energy come in discrete bundles? A question asked over and over since Planck's hypothesis in 1900. The next time you throw a stone in a pond or watch water drips in a sink or a bathtub, look for the *discrete bundles, or water wavelets, or wave packets* that form by the *superposition* of two or more waves. You are then looking at the *discrete bundles of energy*. The "ideal low-pass filter-like" steps in wave-induced motion that I described and analyzed in this paper leave no room for doubt. If you build or buy a wave-induced motion model, then you will clearly *perceive the discrete energy bundles*. The *quantization* of radiation energy was always there in the classical wave equation, but Planck did not see it.

### 4.3 Photoelectric effect (Albert Einstein)

Einstein used Planck's quantum energy concept to explain another troublesome phenomenon, the *photoelectric effect*, in 1905. When light shines on the surface of metals, electrons fly off and their energy could be measured. The hallmark of almost all quantum effects is that they obey mathematical rules. Einstein's equation for the photoelectric effect, Eq. 3.56, works. But, what is the mechanism responsible for ejecting the electrons from the surface of the metal? The photoelectric effect produced more problems than could be imagined. Once Einstein placed the *cause* of quantization in the light, and not in the metal, there was no escape from the pursuing troubles.

Try to *visualize* the photoelectric effect as in Fig. 49. A light beam disappears behind the curtain on the left and an electron speeds out on the right. What happens behind the curtain?

In my previous Figure 48, you see that the spheres move as a result of modulation of internal waves. You can tell why the left sphere moves slowly, and the right ball moves faster. Suppose one of my motion models is behind the screen in Fig. 49, and we send an *IR* signal behind the screen and see the sphere *moving* out of the right side. What happened behind the screen? By now, the answer is obvious. The *IR* signal turned the motors on, which set up the waves that I sketched inside the ball. The left sphere in Fig. 48 moves slowly because of the slow modulating frequencies inside the sphere, and the right sphere in the same Figure moves faster because of the fast waves inside that sphere. Notice that the frequency of the *impinging infrared* signal in both cases is the same.

The electrons come out faster when higher frequency light goes behind the curtain. Why? The *photon* theory's answer is simple. The ultraviolet light wave is a bigger ball (compare Figs. 49 and 50). Many people have had difficulty *imagining* the transformation of waves of different frequencies into particles of different sizes. As hard as you try, it does not make sense. My wave-induced motion theory gives clear *images*.

Suppose we did not know about my wave-induced motion, how could we then explain what happens behind the screens? If we think in Newtonian terms, then we must find an *external* force to move the ball. We all learned by heart that "a body at rest remains at rest and a body in constant motion remains in constant motion unless acted on by an external force." "The wave

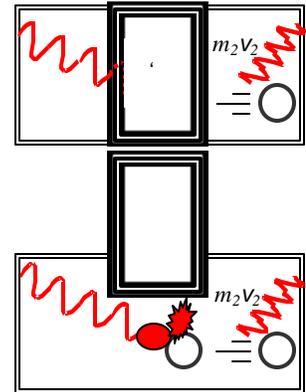


Fig. 49 Light strikes electrons fly out

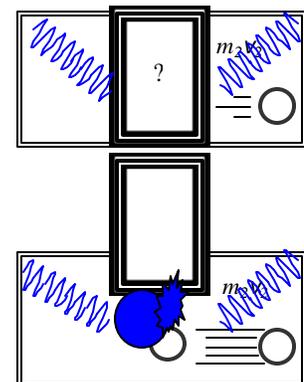


Fig. 50 Blue light strikes faster electrons

kicked the ball” just does not sound reasonable. But, what other choices do we have? Einstein’s solution was the bundled light energy packet, the *photon*. Behind the screen, the wave turns into a small ball with energy and momentum. The photon then strikes the electron, just like one billiard ball strikes and moves another billiard ball. In essence, Einstein sidestepped the *Aristotelian mechanical-first-mover* problem, which did not yield to Aristotle’s hairsplitting analysis a long time ago.

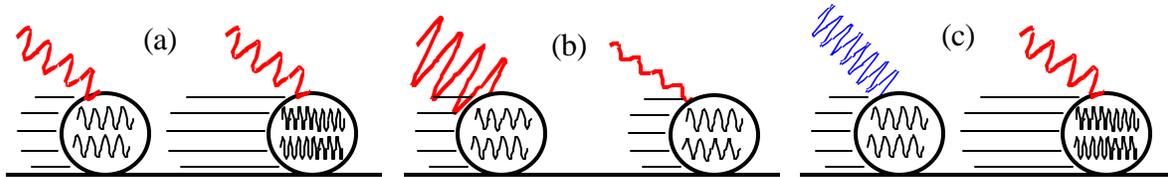


Fig. 51: Modulated-waves inside body *cause* different motions. (a) same *IR* intensity produces different speeds, (b) *IR* intensity doesn’t affect motions, (c) blue light produces slower motion

First note that waves modulating inside of a body can induce the body to move in a variety of ways. I show some real cases in Fig. 51. In (a), you see a body moves at different speeds even when the input *infrared* signals (the shining light) have the same frequency and amplitude. In (b), you see that the intensity of the *infrared* signal does not change the velocity of the body. Finally in (c), you can send a high frequency signal to move a sphere at slow speed, or send a low frequency signal to move the same sphere at higher speed. These are real possibilities that I have tested thousands of times. The input wave need not become a ball, or a bundle of energy, to set up a Newtonian external force to cause motion.

The wavelets example will help us to *see* the *causality* problem encountered in the photoelectric effect. The wavelets result from vertical disturbances. The wavelets move sideways. This is self-evident. But notice the subtlety in what happens. Let the disturbances be pebbles falling at a constant rate on water. Traveling and reflected waves lead to standing waves, which modulate to produce the wavelets. Even if the frequency of the pebbles matches the frequency of the standing waves, it does not mean that the pebbles directly produce the wavelets. The *mechanical-first-mover* is an up-and-down harmonic disturbance, while the resultant momentum and energy carry in an orthogonal direction. Neither the old classical wave theory, nor the new photoelectric theory recognize nor utilize the straightforward effect in their constructions. Wave-induced motion gives stark evidence of these points. Einstein wrote extensively about the *causality* dilemma in the photoelectric effect. We are familiar with the simple causal action: **momentum of body 1 ® momentum of body 2** (*cause-effect*). Do you see the *causality* dilemma in the *photoelectric effect*? **Is it “light photos ® electron motion”?** Let me exaggerate the *causal process*, described in this paragraph and elsewhere in this paper, as follows:

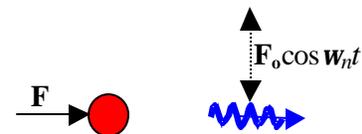


Fig. 31 The first mover for billiard ball and wavelet

**Pebbles ® disturbances ® traveling waves ® reflected waves ® standing waves ® modulations ® motion.**

This is the strangest *cause-effect* sequence that I have ever seen. It looks like a chemical reaction and, perhaps, chemists would grasp it quickly. The invention of the *photon* bypassed the *real* intermediate steps. The *photons* kick the electron is like saying the pebbles kick and move the water wavelets! The student should think these things carefully. The impulse-train running down a nervous axon is like the pebbles (constant frequency and amplitude). The nervous impulses do not *directly* produce motion. The impulses disturb the muscles to form waves that modulate to produce motion. Planck and Einstein did not consider the evident causal sequence that I describe here, and this is the root of the *causality* dilemma that the founders of quantum and atomic theories grappled with, but did not solve.

#### 4.4 Dynamic coupling (Niels Bohr)

I was mesmerized by Bohr's planetary model of the atom in the 1950's, and I tried to cling to it for years. That did not set well with my professors in the 1960's. The words of my high school science teacher in Jordan still ring in my head, nearly ½ a century later, that "*Bohr understood it best.*" And so, as the years went by, I tried to digest Bohr's words and analysis, and the rewards have been great. I repeatedly mentioned in this Paper Bohr's idea that the observed quantum and atomic effects could be explained by *dynamic coupling* when waves impinge on the oscillators. I also mentioned how the water molecules are "*an ensemble of harmonic oscillators,*" an ensemble that produces the water wave packets.

Bohr began with the "*correspondence principle*" where he tried to extend the classical wave theory of light to explain quantum and atomic phenomena. Maxwell's equations implicitly contained the *modulation* or *dynamic coupling* of oscillating waves to produce orthogonal effects, the electromagnetic waves themselves. But, as Bohr moved from the *correspondence principle* to the *coupling mechanism*, the conservation of momentum and energy and other basic features of reality went out the window. You can see this in Fig. 32. The simple *sum of the vertical, or horizontal, forces* does not work out. The conservation laws hold in all cases of collisions of billiard balls. You can see why the conservation laws are in trouble in the wavelet example. The forces of the exciting disturbances are in the vertical direction, but the results are in an orthogonal direction! I discussed the conservation of momentum and energy in Section 3.4 (Mechanics of wave-induced motion). Bohr used the *coupling mechanism* to dismiss the *photon* concept and Compton's results of the scattering of X-rays and to explain the spectral lines and atomic structure. Without the water wavelets example or my wave-induced motion models, the task could not be done.

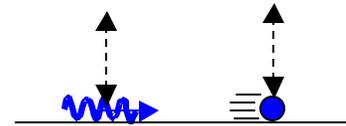


Fig. 32 Do you see the basic problem with the *particles*?

The *correspondence principle* and other Bohr's works were very influential in developing my wave-induced motion theory. Over the years, I went from my working models, to Maxwell's equations, back to the models, to the wave theory, back to the models, to my aerospace work, to the models, and so on. Along the way, I must admit that I was caught in a quagmire trying to develop and include the complicated dispersion laws for my wave-induced motion models into the mathematical analysis. That was what Bohr and his supporters tried to do with the "*virtual oscillators*" in the early 1920's. It was in simplifying the problem that I was able to see the straightforward mathematical process (Section 3.1). I hope that scientists and engineers will now undertake to expand the analysis.

Bohr proposed the *coupling mechanism* in 1921. After lengthy discussions with Heisenberg over a period of five years, Heisenberg said, "***I just wanted to forget about the wave packets and the waves.***"<sup>32</sup> We must not. Bohr was obviously pushing the correct solution. The *wave packets and the waves* hold the answers. Heisenberg was deeply engrossed in the *quantum* picture, for example the Sketch on the right in Fig. 32. It is not directly evident that vertical forces on a physical body could induce the body to move horizontally. It should be evident that vertical disturbances on water produce the water *wavelets, or the energy carrying wave packets*, that move sideways. Of course my wave-induced motion models give clear-cut evidence.

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<sup>32</sup> Miller, p. 149.

### 4.5 Particle-waves (Louis de Broglie)

I have tried the wave-induced motion concept on many perplexing quantum, atomic and nuclear effects, and just about all of them fell nicely into place, both conceptually and perceptually. I will describe some of these esoteric subjects in future papers or talks. For now, here is another basic example. In 1923, de Broglie proposed the mirror image of Einstein's concept, i.e., particles may be treated as waves. You can look up de Broglie's wavelength equation, derive the wavelength from the stepping motion in my previous analysis, and compare the two. Just as Planck and Einstein's equations are identical to those derived in my wave-induced motion analysis, so is de Broglie's. I want to discuss here the *visualizability* of the particle-wave concept, which we are told in every physics class, is impossible.

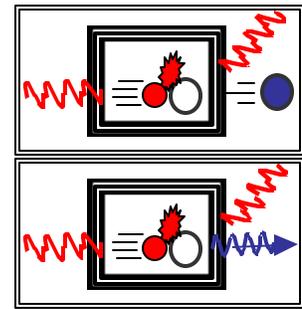


Fig. 52 From Einstein to de Broglie

Einstein's photoelectric effect explanation is shown on the top in Fig. 52. Light waves go behind the screen, and electrons speed out. Behind the screen a *photon* kicks an electron. A reasonable picture of de Broglie's particle-wave duality is shown in the bottom Sketch. Here, the light waves go behind the screen, turn into *photons*, kick the electrons, and the *electron* comes out of the right side a *wave*! For more details, see any physics textbook.

My wave-induced motion theory gives a clear picture of events, Fig. 53. An electromagnetic signal goes behind the screen, the signal activates disturbances in the body, the resulting waves *modulate* within the body, and the *modulations* induce the body to move out the right side. When you see it with your eyes with my wave-induced motion models, you will discover that nothing could be simpler to *visualize*.

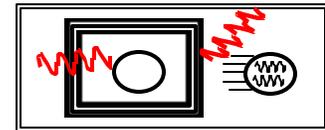


Fig. 53 modulation of internal waves moves body

The de Broglie concept becomes extremely difficult to visualize when you apply it to Bohr's atomic model or other atomic phenomena. Now, you have an assortment of waves and particles, or particles and waves, and you cannot clearly differentiate which is which. Let me illustrate the difficulty and how it is completely overcome rationally in wave-induced motion. Consider Fig. 54 from Section 3.4. Here, I added to the diagram what the wave-induced motion models do in stepping motion. On top of each step, you can visualize the ball moving at its constant speed. The balls are completely at rest in the bottom. The vertical lines in the steps are the "fast" frequency in the *almost harmonic amplitude-modulated* stepping motion solution. The fast frequency has specific wavelength, period and wave numbers. The reader should easily make out that the stepping motion itself has its specific frequency, wavelength, period and wave numbers. The picture is not cluttered nor confused. It is clear, simple and, above all, correct.

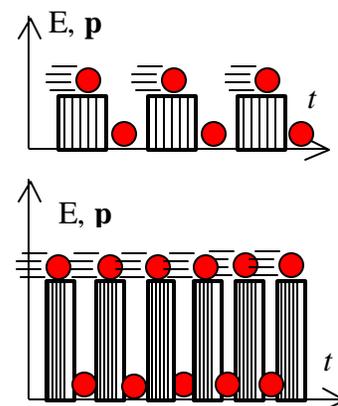


Fig. 54 Energy bundles in wave-induced motion

I don't want to leave any ambiguity in the reader's mind about my point here. Let us place a screen in front a wave-induced motion body, as in Fig. 55, that covers the events behind the screen. We have equipment to sense the events. What happens behind the screen? The student should not feel intimidated here. The top quantum experts freely admit that we do not have a clear picture. I remember reading the following by David Bohm, "*quantum mechanics is the subject where we do not know what we are talking about,*" (I don't have the reference now, but you can look it up). Let me use Fig. 55 to drive the point home.

Let us say that the motion model is any of my spheres in Fig. 51. With our equipment, we sense the infrared signal going in, and coming out, the frequencies of the motors and other things. Let us concentrate on one measurement that we can easily make, and that is the stepping motion of the sphere. We see on an oscilloscope a wave representing the steps of the motion model. The steps have distinct frequency  $f_m$  and distinct wavelength  $\lambda_m$ , those are as shown in Fig. 38. Remember that we do not see the sphere moving behind the screen, we only see a waveform on the oscilloscope, as in Fig. 55. Now, let us try to *imagine* what is going on behind the screen. With our knowledge of the wave-induced motion theory, we say that the sphere is moving in discrete steps as a result of the modulation of two or more harmonics within its body. The spherical ball moves with a distinct frequency and a distinct wavelength. That *frequency and wavelength* are properties of waves does not bother us, and it should not. We must not wonder for an instant that the moving ball may be a *wave*.

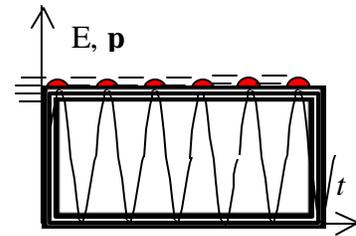


Fig. 55 Waves behind screen

The most important observation to make from these Sketches is that the wave-induced motion model moves in distinct steps with a given frequency and an associated wavelength. The wave-induced motion *spherical ball* is not now a body and now a wave. It is a *body* all the time. It is a tangible physical real body when standing still, and equally when moving (Fig. 54). Because the stepping motion is *wavelike*, it does not mean that the *spherical ball* may, at any time, be considered a *wave*.

The de Broglie duality does not see the ball, it sees only the waves, and it says in perplexed language that there is “*a wave*” behind the screen. It asks in wonderment, how can a *body* be a *wave*? It does not realize that the body is simply executing *modulated* harmonic motion.

Some readers who are not acquainted with quantum mechanics may complain that my lengthy discussion is plain banter. We know that the sphere is tangible, that it moves in steps, and that that might appear as a wave, etc. Is it necessary to repeat the details? Let me assure those readers that these matters are vital, as one can easily gather from similar considerations by Einstein himself. In “*The Evolution of Physics*,”<sup>33</sup> Einstein and Infeld try to explain de Broglie’s idea. They used the same string waves between fixed walls, as I did in Section 3.3.1. Einstein evaluated those same waves in solid bodies, but he did not apply the waves to freestanding bodies as I did. Einstein was looking for clues, which he described as guesses. Einstein was trying to justify de Broglie’s idea; I am explaining it. Here is a review of how Einstein and Infeld tried to explain the photon and de Broglie’s particle-wave duality.

1. To Einstein, the detailed description of de Broglie’s *idea* was crucial and not banter.  
“*thought and ideas, not formulae, are the beginning of every physical theory.*”
2. The clues to de Broglie’s idea, as Einstein saw them included,  
“*Electron moving uniformly @waves of a definite length,*” and, “*The principal guess is that the uniformly moving electron will behave, in some phenomena, like a wave.*”
3. Einstein fell into the trap of Newton’s inertia law. In the next quotation, I underline Newton’s words used by Einstein. I had shown you that *force is involved in the uniform motion* of the wave-induced motion bodies and, even, in the water wavelets in a lake or a bathtub. Einstein does not realize that *Aristotelian forces* can be involved in motion, (Section 3.4).  
“*In our material world, nothing can be simpler than an electron, an elementary particle, on which no forces are acting, that is, an electron at rest or in uniform motion,*” (my emphasis).

<sup>33</sup> Einstein, A. and Infeld, L., “*The Evolution of Physics*,” Ch. IV, *QUANTA*, p. 249.

3. My mathematical analysis in Section 3.1 is perhaps one of the simplest that I have ever done. It was straightforward. Einstein knew that the problem was not in the mathematics, but in the physical interpretation of events,  
*“The mathematics dealing with the problem of waves of matter is extremely simple and elementary but the fundamental ideas are deep and far-reaching.”*
4. Einstein ties his photon idea with de Broglie’s idea,  
*“in the case of light waves and photons, it was shown that every statement formulated in the wave language can be translated into the language of photons or light corpuscles. The same is true for electronic waves.”*
5. The basic questions are asked with wonderment. The questions and remarks I have heard from students over the years express greater disbelief.  
*“We asked before: what is light? Is it a shower of corpuscles or a wave? We now ask: what is matter, what is an electron? Is it a particle or a wave? The electron behaves like a particle when moving in an external electric or magnetic field. It behaves like a wave when diffracted by a crystal.”*
6. Years after de Broglie proposed his idea, Einstein described it as *strange and incomprehensible*.  
*“If there is any truth in de Broglie’s idea, then there must be some phenomena in which matter reveals its wave-like character. At first, this conclusion, reached by the acoustical analogy, seems strange and incomprehensible. How can a moving corpuscle have anything to do with a wave?”*
7. Einstein was keenly aware of the contradictions in the proposed explanations.  
*“One of the most fundamental questions raised by recent advance in science is how to reconcile the two contradictory views of matter and wave.”*
8. And finally, Einstein concludes that his wave-particle idea and de Broglie’s particle-wave idea may not stand the test of time:  
*“The future must decide whether the solution suggested by modern physics is enduring or temporary.”*

The solutions suggested by modern physics are not enduring; and this paper shows that those solutions have indeed been *temporary*. This paper, however, deals only with the most basic aspects of quantum and atomic theories. I have made many other observations and deductions from my research, which I will describe in following papers and talks.

The author hopes that other scientists and engineers will expand on the basic features described in this paper, and apply them to the most advanced modern physical theories. For example, consider the following case from *elementary particle physics*:

The atomic family has multiplied greatly in number. Understanding the basic tenet of wave-induced motion theory might reduce the family to a meaningful number. Hundreds of subatomic particles have been discovered, classified and named, and it is possible that, down the road, thousands more will be discovered, classified and named, or given a *strangeness quantum number*. The names of the initial strangers are indeed strange; *Up, Down, Strange, Charmed, Bottom and Top*. The wave-induced motion concept introduces an incredible possibility that might have not been considered before, and that is that different strange particles with different names may actually be the same particle doing different things.

For example, I can easily construct (which I did) a wave-induced motion sphere that can do, say, three things, as shown Fig. 56. I can set the sphere to move leisurely as in (a), then *phase lock* the input signals to set the same ball to move in distinct steps as in (b) and finally increase the input frequency to

move the very same sphere swiftly as in (c). The last case indicates a body with considerable momentum, compared with the other two cases, though it is the same body. If the three events are only seen from behind the screen, as in Fig. 55, then it is possible that the same ball might be named *Leisurely* in (a), *Stepper* in (b) and *Giant* in (c). But notice that *Leisurely*, *Stepper*, and *Giant* are the same fellow that does not need three social security numbers to identify it. If I add *spin* and other features with the modulation scheme of the input harmonics, then the picture will be cluttered. The screen in Fig. 55 must be taken down.

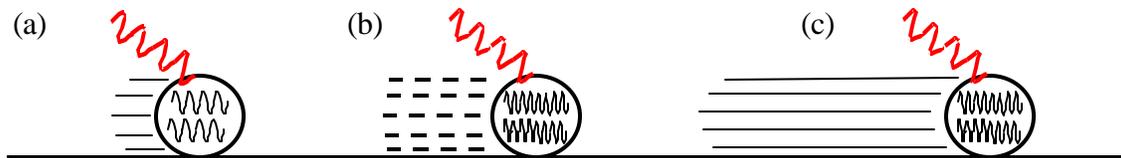


Fig. 56: Danger lurks in assigning the same particle different names, or quantum numbers.  
*Leisurely* in (a), *Stepper* in (b), and *Giant* in (c), are the same body!

Let me summarize:

*Dynamic coupling* occurs in the excited system and not in the exciting system. When the excited harmonics in a body *dynamically couple*, *modulate* or *superpose*, the *effect* is registered in the behavior of that body. The *input* and the *output* are two distinct entities that must be mentally separated. That energy can be discontinuous and quantized is natural. A great number of modulations can be so finely tuned to produce seemingly smooth motions, but underlying the smooth motions are the many magical modulations that make the discontinuous appear continuous, just as the motion of a living body or its parts.

## **5. Living motions**

The most dramatic experiments of the self-motion mechanism have been to induce motion of the human body or its parts by the *mechanical* means of wave-induced motion. I used the basic configuration shown in **Fig. 1** to move my hands or my arms. The motions were distinct, clearly recognized by my mind. It seemed natural to try the mechanism to move my whole body of 75 kg (165 lbs).

The basic components of the living motion engine are the muscles and the nervous system. It has been known for a long time that muscles contract in length and increase in diameter when activated. Modern biology has shown that the telescoping action of the *actin* and *myosin* rods is responsible for the axial contraction and radial expansion of muscle bundles. Living motions require the action of the nervous system on the muscles. The action of the nervous system consists of electrical-like signals, the action potentials or nerve impulses. The impulses travel rapidly from sensory neurons to axon synaptic terminals to excite the muscles. Throughout the pre-synaptic journey, the nerve signals maintain constant, non-decaying, amplitude. This is called by biologists the *all-or-none* property, i.e., trains of impulses of constant amplitude are either present or not (compare with our  $w_1$  and  $w_2$  in Eqs. 3.1 and 3.2). It is also known that the amplitude of the impulses is independent of the stimulus magnitude. For example, the difference between running and walking is that only the frequency of the impulses, or action potentials, or pulses, changes, but the amplitude of the impulses does not change (compare with the behavior of  $y(t)$  as function of  $w_1$ ,  $w_2$ ,  $w_3$  ...  $w_n$ ). Biomechanics has not been able to relate living motions to either classical or quantum effects. Again, my research provides the correct mathematical steps and the clear pictures of motion for medicine, biology, biomechanics, psychology, physiology and related fields.

Generally, a living motor unit consists of one *motoneuron* and all the muscle fibers that are activated by its signals. The nervous impulse trains produce recognizable response in the muscle fibers, as recorded in electromyograms.

The above basic summary of living motions lacks a vital ingredient. How are the pulses turned into motion? What is the specific mechanical causal mechanism that turns the nervous harmonic pulses into musculoskeletal motion, and how does it do that? These, and similar, questions have not been answered before this study, see previous Sections.

Over the years, I tried the wave-induced motion mechanism on my hands and arms, which induced a variety of motions and effects. I finally tried to move my whole body with the basic mechanism of two motors with rotating unbalanced masses, just as described in this paper. It seemed logical to try the two motors symmetrically on my shoulders, torso, waist or hip joints, which I tried many times. I examined many electromyograms of muscle responses in humans and animals to determine possible combinations of pulse *frequency* and *amplitude* that might induce my body to move. The artificial pulses generated by the motors, e.g.,  $w_1$  and  $w_2$ , were interacting in my body. A five-minutes test run would fatigue my muscles completely. It was as if the actin and myosin rods were completely locked by the artificially generated pulses, and I needed hours of rest before I could do another test. Years later, I still feel the effects of those experiments in my muscles. I finally arrived at a frequency range of 5-9Hz and rotating inertia elements of less than 30gm, or a fraction of an ounce, to produce the motion I longed for. Here is a description of the first successful experiment:

“I placed two small dc motors on a belt, which I wore so the motors were above my hip joints, simulating two giant *motoneurons*. I was apprehensive. Could the test harm my mind or my body? As always, I held the battery pack loosely in my hand so that if something went wrong, the battery would disconnect. I had tried this 100s of times before. It never worked. I finally touched the wire to the batteries. The two unbalanced masses rotated. I felt the pulses travel in my body. I changed the frequency, but nothing happened. I waited. Suddenly, my whole body began to lurch

forward. In a split second, many thoughts crossed my mind. I felt as if *two* entities within me communicated about the unexpected events. It was as if my mind said, “*we are moving,*” which I knew; and another entity within me responded, “*I know.*” Then the distinct thought crossed my mind, “*We are going to fall,*” and I thought, “*I know.*” *Unprepared for success,* my feet were still planted on the floor. I almost let go of the batteries. It was scary. Suddenly, my mind tersely ordered, “*lift the right leg,*” which I did, “*lift the left,*” which I did, “*lift the right,*” which I did. I moved like a mechanical robot to the end of the room. I stopped the test. It was unbelievable. That was the first time ever a person used mechanical means to induce his body to move.”

I established repeatability of the effect with a handful of tests, and with no medical supervision available, I discontinued the tests.

When I say, “*I moved like a mechanical robot*” I mean exactly that. Throughout the motions (about 12 steps in each test), my mind was continually expressing amazement that my body was moving forward without *its* specific motion command. My nervous feedback system seemed to be unduly in a hurry to keep me in balance. The best I can describe the feeling to others is to liken the experience to those very first steps (in your life) that you take on an escalator, especially fast moving escalators. It might take 1-3 seconds to adjust to the motion, even though your mind sees the escalator’s motion before you step on it. The difference was that I had the same feeling for the full 9-12 seconds during which the robotic motion was happening. This should lead to fertile research in neuroscience, psychology, medicine, physiology and related fields to study the mind-body interactions.

What happened to induce my whole body to move? There are two possible explanations. First, the two motors over my hip joints acted as two giant motoneurons depositing trains of pulses on the muscles responsible for forward motions, and innervating those muscles into action. This is to say that the artificially generated mechanical pulses mimicked the working of my nervous system and bypassed that system to act directly on my muscles. The second possibility is that the waves traveling in my body, and produced by the pulses from the motors, acted directly on my musculoskeletal structure, which, then, induced my body to move. In this case, I was simply a wave-induced motion model, just like the spheres, blocks and boxes described in this paper. Either way, the nervous feedback system worked well, as I was aware of the onset of motion, the strangeness of the motion, and the necessary balance commands were continually correctly issued and executed.

In other tests, I replicated features of the motions of fish, birds and other animals. In all cases, I confirmed the many tests that I had done with simple physical bodies, such as blocks, boxes and spheres. Two or more wave trains traveling within a body dynamically couple to induce living motions.

*Wave-induced motion* will find utility in great many areas. For example, neuroscientists will finally be able to use *mathematics* to evaluate motor disorder diseases and other important medical conditions. No one has been able to pin down the precise mechanical mechanism that turns neural activity into pulse-trains into outward musculoskeletal motion. Newton’s Laws of motion do not explain the full process. Maxwell’s equations do not explain it. Quantum mechanics does not see the process. In the important field of neuroscience, as in all fields of medicine, the experts could only patch and bandage pieces from the three great mathematical formulations. My wave-induced motion shows exactly how to integrate the three mathematical constructions and to *see* the meaning of the mathematics in the physical world. *Dynamic coupling*, first proposed by Bohr, goes beyond the title I gave it, *wave-induced motion*; it is *natural motion*.

## 6. Conclusion

I have demonstrated with real working models, evident natural examples, and straightforward mathematical, physical and mechanical analyses that *dynamic coupling, modulation or superposition* of two or more harmonic wave trains trapped in a body can move the body, whatever the material or shape. In the *almost harmonic amplitude-modulated* wave solution of the motion, it is shown how major mistakes could be made when failing to recognize that the input modulating frequencies are *continuous* and that the output modulated frequency is *discontinuous*. ***Producing and controlling the ideal low-pass filter behavior in physical bodies, by phase-locking the input, is irrefutable evidence of the novelty of wave-induced motion over any known mechanical means of motion.*** I have also shown that changing the frequency, number, phase or other parameters of the modulating harmonic waves does not affect the basic mathematical results. By simplifying the problem to include the least number of variables, Bohr's 1921 idea of the *coupling mechanism* finally came to fruition.

This paper has been prepared hurriedly, and it may contain errors, but the errors, if any, should not affect the overall premise or conclusions of the author. The paper is intended for the widest possible audience, particularly, the students of science and engineering, but it does not exclude readers from the liberal arts who are interested in, acquainted with or work in scientific and technological areas. Some readers may skip the mathematical formulas, but still grasp the overall picture from the description of the physical and mechanical phenomena. After all, the paper deals with reality, causality and other basic philosophical principles that are normally of interest to many non-scientists. As to style, I found out from my short advanced continuing engineering courses<sup>34</sup> that attendees, whether students or working experts, prefer the casual approach to complex technical issues and the use of relevant examples and analogies. This paper purposely departs from the formal scientific paper format, language and other restrictions.

The wave-induced motion mechanism (patent pending – Now, Patent No. 6,826,449) will find applications in many areas, including, medicine, transportation, robotics, industrial movers, aeronautics and toys. In medicine, the mechanism can supplant erratic or dead nerves, which produce erratic or no impulses, to activate living muscles, or to act independently to activate artificial limbs. The motion mechanism will be invaluable in the study and the treatment of motor disorder diseases, as the mechanism mimics the nervous-muscle system. In both cases, pulse trains produce diverse motions, not by pulleys or ropes, but by converting the pulses into motion. Other applications in biology, neuroscience, biomechanics and physiology are too numerous to mention here.

Combining the wheel with the wave-induced motion mechanism will open up possibilities never imagined before. The *natural motion mechanism* can supplement existing vehicles with additional motive power to reduce fuel consumption. Experts will recognize the greater efficiency of the motion mechanism over other modes of transportation from the analysis in this paper. For example, wave-induced motion converts energy into motion in one step; and the mechanism does not require gears, shafts, clutches, or other intermediate steps that normally reduce the efficiency at every step.

To date, no robots move naturally. Legged robots are clumsy and robots-on-wheels are not true robots. Progress in robotics decelerated rapidly in the 1980's, not because of limitations in artificial intelligence as witnessed by the quantum leaps in computer technology, but because the mechanism of *natural motion* is not implemented in the robots.

The power plant in self-motion is a small fraction of the total weight of the moving system, see the numerical examples in Section 3.3. The structures and the payloads can be made to contribute to the

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<sup>34</sup> AbuTaha, A. F., "Anatomy of Failure Mechanisms in Modern Systems." On-campus at the George Washington University, and at public, private and military centers at home and abroad, 1989-1992.

momentum, than to merely retard the motion. Let me explain. An empty industrial container can be moved by applying the appropriate input harmonics to induce motion. Modulation of the harmonic waves in the container's body is what produces motion. Many payloads could withstand the input disturbances or the modulation can be set up to produce smooth motion, in which case the payload itself becomes part of momentum production. The wave-induced motion mechanism will be ideal for use in warehouses, ships, airports, manufacturing facilities, and nuclear waste handling areas. Moving inordinately heavy masses and moving sideways are other unique features of the motion mechanism.

I purposely mentioned the psychology experiment that tests the perceptual capacities of infants in Section 4. If the strange "tunneling effect" is real, then it is well to introduce the strange concept to the infants. Children should be introduced to natural reality so that when they grow up, they would be better prepared for life. The author has applied the motion mechanism to hundreds of toys that are familiar to children and adults. The mechanism operates successfully when built directly on the surface of the toy, or hidden inside the body of the toy, or placed independently on a belt that is wrapped snugly around the waist. Children and adults would be delighted to see familiar toys sprint, scurry, ski, skate, slide and glide like pets. The toys appear to come to life moving directly on their bare feet or original shoes, boots, skis, or skates without mechanical linkages. And when advanced modulation principles are applied, then the toys can be made to emulate walking, stepping, striding, strolling and meandering. Working models of all the features described in this paragraph are available for review.

The list of applications for the mechanism of *natural motion* cannot be exhausted or fully described in this Conclusion. The above samples give clear pictures of the possibilities.

I also did not mention Aristotle's old concepts thoughtlessly. The quantum and atomic problems had roots in history. Aristotle's definition of motion, "*actualization of potentiality*," held a key to the perplexing quantum effects, but the useful definition was discarded after the 17<sup>th</sup> century. Aristotle had placed the *cause* of some motions in the moving body. The view has become anathema that, in my experience, senior scientists and engineers, who are amazed by the demonstration of my motion models, have been greatly skeptical about my invoking *causal* arguments, which directly lead to tying my invention to quantum and atomic effects. This paper shows that the connection is direct and natural.

Aristotle placed inherent activity in matter, which appears to our senses to be lifeless and dead. Today, we know that *all* matter vibrates, oscillates and is constantly in a state of continuous agitation. The forced structured agitations in my motion models produce the motions; this is a crude description of the action of the harmonic modulations described in this paper. Two vital points were thus missing from the vernacular of the founders of the quantum and atomic theories, (1) that matter is active, and (2) that the inherent invisible activity in matter can produce (self-) motion.

"What causes motion?" "What keeps matter in motion?" Descartes, Galileo, Gassindi, Leibniz, Newton and others asked these questions.<sup>35</sup> It was here that matter was stripped of inner active potential. Descartes and Galileo would show that bodies do not need motive force to continue in motion, hence, Newton's First Law of Motion. With the law of inertia went Aristotle's valuable classification system of motion, for example, read the following conclusion by the Mechanical Philosophy scientists:

*"Since matter is by definition inert stuff consciously pruned of active principles, it is obvious that matter cannot be the cause of its own motion," ibid.*

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<sup>35</sup> Westfall, R. S., "*The Construction of Modern Science, Mechanisms and Mechanics*," Cambridge University Press, Cambridge, 1977, p. 33. First published by John Wiley & Sons, Inc., 1971.

Well, if matter cannot cause its own motion, then how does matter (self-) move? Externally applied forces, answered Newton. Planck and Einstein looked for the cause of the quantum motions in externally applied forces, when the cause was really in internally generated forces, see Section 3.3, *Mechanics of wave-induced motion*. Aristotle struggled with the causes, including the cause of local motion, or locomotion. The Mechanical Philosophy scientists shunned the causes. Galileo called the study of causes “‘fantasies’ which it is ‘not really worthwhile’ for the scientist to examine.”<sup>36</sup> Newton considered the causes to be occult, mystical undertaking. In Query 31, Newton writes of force and motion, “*For these are manifest Qualities, and their Causes only are occult.*”<sup>37</sup> Newton then categorically states that he was not interested in finding out the causes of motion,

*“And therefore I scruple not to propose the Principles of Motion above-mentioned, they being of very general Extent, and leave their Causes to be found out,”* *ibid.*

The view against the study of Causes would harden with time. David Hume would insist that “*all causes are hidden,*”<sup>38</sup> and John Locke would write, “*we will always remain ‘ignorant of the several powers, efficacies, and ways of operation, whereby the effects, which we daily see, are produced.’*”<sup>39</sup> My effort to discover the cause of motion of the models I describe in this paper could be considered occult by modern science. It is not. One looks at my remotely controlled wave-induced motion black box. It is made of inert matter. It moves under the actions of the internally generated modulations. The skeptics say that the black box requires external force to move it. It must be pushing back against the floor to move. Well, the rank and file in science and engineering should be able to pass judgment on the basis of this paper. Of course, seeing or testing the wave-induced motion models would greatly help.

I might add that the philosophers should be as keen to read this paper. Westfall writes,<sup>40</sup>

*“In the 17<sup>th</sup> century, everyone agreed that the origin of motion lay with God. In the beginning, He created matter and set it in motion.”*

The Mechanical Philosophy saw the creation of motion as God imparting the total momentum to the universe in an act not unlike rolling a bowling ball; hence, determinism. In wave-induced motion, where the *modulations or dynamic couplings of harmonic waves* can produce incredibly vast variety of motions, the creation of motion appears to be more like God plucking the strings (like the harp strings) of the Universe, and all the wonderful motions with their many hidden modulations are simply playing God’s Grand Symphony.

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<sup>36</sup> Hutchins, R.M., “*Great Books of the Western World,*” Encyclopedia Britannica, Inc., Chicago, 1952, Vol. I, p. 161.

<sup>37</sup> Westfall, p. 158.

<sup>38</sup> Hutchins, *ibid.*

<sup>39</sup> Hutchins, Vol. II, p. 98.

<sup>40</sup> Westfall, p. 33.

### **Ali F. AbuTaha**

Ali F. AbuTaha is widely known in the aerospace communities for identifying and analyzing the critical liftoff and dynamic transient conditions in space systems, (see shuttlefactor.com). His independent investigation of the Challenger Accident was reported worldwide. He identified the heat mechanism in the cold fusion phenomenon (Journal of Fusion Energy, Vol. 9, nos. 3 and 4, 1990). His Continuing Engineering Education Program (CEEP), *"Anatomy of Failure Mechanisms in Modern Defense and Aerospace Systems,"* was highly praised by experts attending at the George Washington University, other campuses, and public, private and military centers at home and abroad. AbuTaha worked in satellite systems since 1969. As a consultant since 1980, he provided services in communications networks, television systems, computers, printed circuit manufacturing, metallurgy and failure mechanisms; and he was an invited lecturer on numerous subjects at home and abroad.

Mr. AbuTaha received a BSME degree from the George Washington University in 1972. Before attending GWU in 1964, he studied the complete works of Euclid, Aristotle, Ptolemy and other scientists in the Arabic Language, completed numerous courses of specialized studies, and tutored mathematics and physics in Jordan for a number of years. He is a Distinguished Life Member of the Armed Forces Communications and Electronics Association (AFCEA), and he received numerous acknowledgements for major works from leaders in the Administrations and the Congress.

The author says: *"I tried to gauge the reaction of the experts to the far-reaching ideas in this paper and I included some ideas in my course, "Anatomy of Failure Mechanisms," but without revealing the wave-induced motion mechanism itself. The following sample critique of the attending senior experts, submitted to the CEEP Administration of the George Washington University in 1989-90, demonstrate recognition and acceptance of the themes described in this paper. The experts wrote,*

***"Thought provoking course."***

***"I can't believe how much I understood."***

***"Excellent course for all ... engineering fields."***

***"Outstanding ... very rewarding."***

***"His presentation was fantastic."***

***"Content was very good but time was too short."***

***"Excellent – the use of other examples was outstanding."***

***"This was very informative and will influence critical thinking for sure."***

*I hope the rank and file in science and engineering will receive this paper with the same spirit, and I welcome their participation, critique and suggestions."*