The Fall and Rise of Resonance Science

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Abstract

The recent discovery of Einstein's hidden quantum variables has highlighted the importance of resonance as a fundamental physical phenomenon and a primary energy transformation process.[1,2] Although thermodynamics were developed in the 19th and 20th centuries, it is only now in the 21st century that the focused development of resonance dynamics is beginning to take place. This significant lag in the development of resonance dynamics can be attributed to three (3) factors: 1) in earlier millennia resonance phenomena were associated with Gnostic and pagan metaphysics which were later deemed heretical, and thus outside the bounds of allowable scientific inquiry; 2) the original experiments that gave rise to the first quantum concepts were exclusively thermodynamic and deliberately excluded resonant energies to accurately determine the thermodynamic equation being sought; and 3) early quantum pioneers were unable to agree on a solution to the "*resonance catastrophe*" and eventually excluded resonance, in large part, from quantum mechanics and dynamics.

Introduction

Resonance concepts and ideas have been considered by humans for thousands of years. Often incomplete, and frequently intertwined with religious and mystical philosophies, traces of those ideas can be found in ancient writings and oral traditions. Beyond those concepts and ideas however, it is also clear that actual resonance technologies have existed for thousands of years and can be found in ancient artifacts and architecture. It is only now, at the dawn of the 21st century, after millennia of false starts and stumbles attempting to unlock the secrets of resonance, that the real *science* of resonance is coming to the forefront of modern thought and technology.

We exist in a world of energy, with forces exerting their effects over distances as vast as galaxies and as minute as atoms and electrons. The energies teeming in our universe are transformed time and again, interconverted back and forth in many forms and guises including mechanical, chemical, electromagnetic, acoustic and electrical energies. These transformations can occur in orderly, synchronous processes that make use of uniform motions and forces, or they can occur in chaotic, entropic processes that make use of random, heterogeneous motions and forces. Much of 19th and 20th century physics was focused on the latter, and resulted in significant advances in the development of *thermo*dynamics. Recent recognition of the importance of resonant phenomena, especially as it relates to technology advancement, now portends a 21st century in which *resonance* dynamics will play a major role and undergo similar significant development.

This great leap in the understanding and use of resonance has revealed, in many respects, the single greatest and most important conceptual framework for the sciences. One tends to think of science as being traditionally divided into the primary fields of physics, chemistry and biology. It is being increasingly recognized however, that the most important primary fields in science are actually defined by the two (2) fundamental energy transformation processes: 1) resonance; and 2) thermal entropy. Everything else is secondary to this fundamental division in physical energy processes, particularly when considering the states of systems and the determinants of causality at work in our universe.

Thus, at its deepest, and yet most simple fundamental level, resonance is a physical process by which energy is absorbed, emitted, and transformed by objects. It is the "greener" of the two (2) primary energy processes - energy architecture at its finest. Thermal/entropic processes, by contrast, are the antithesis of resonance, scattering energy randomly and chaotically.

Resonance can occur where ever there is energy, motion, vibration, waves or frequency, and since all in our universe is in constant motion, from the spiraling of our galaxy to the oscillations of atoms and electrons, resonance can thus occur everywhere. So what is the nature of this energy transformation process called resonance? Let us begin with a simple example - imagine a ball of matter floating in a sea of energy, surrounded by heterogeneous waves (i.e., waves which do not match, and are not uniform in size with the size of the ball, Figure 1).

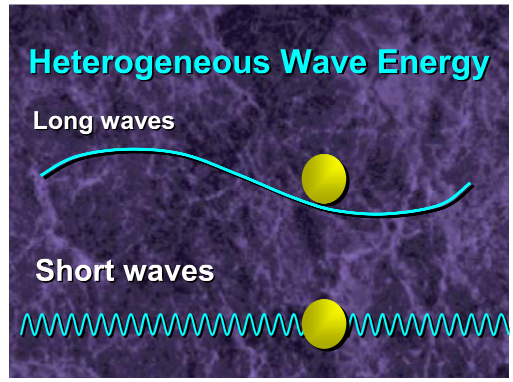

Figure 1. Examples of an object exposed to very long or very short heterogeneous waves.

In the case of waves much longer than the diameter of the ball, the ball will roll back and forth on the waves like a small rowboat bobbing on large ocean swells. And what of waves with very short wavelength? The ball will not be moved back and forth, or bob up and down. Instead, the waves will pass through the ball, or reflect from its surface. The dynamics of these heterogeneous waves are the thermodynamics of the 20th century.

Now, imagine that the ball and the waves are the same size (Figure 2, below). The wave passes into the ball, but when it reaches the opposite side of the ball it is reflected back, rather than passing through. When the wave reaches the first side of the ball it is reflected back again to the second side, and so on and so on into infinity. The wave energy stays inside the ball. If another homogeneous wave enters the ball, the energy of that wave will be completely absorbed by the ball as well. The waves and the ball are said to be in resonance. The wavelength of the energy matches the size of the ball and no energy is wasted or lost to the ball's surroundings.

When the wavelength of an energy matches the size of an object, i.e., they are uniform, then the energy is absorbed by the object, and this energy transformation process is called resonance. Resonance, is thus in its simplest terms, the process of energy transformation that occurs between matching or uniform energies and objects. Resonance is far more encompassing than matching just wavelength or size, however, because we live in a space/*time* continuum. Energies and objects can match in terms of time and synchronicity, just as they match in terms of space, wavelength or size. When energies and objects match in terms of time they are said to have matching frequencies, or "*resonant frequencies*". Because all in our universe is in constant motion there are many wavelengths and frequencies within and around us that can be subject to resonance processes. This is what makes the understanding of resonance such a powerful concept.

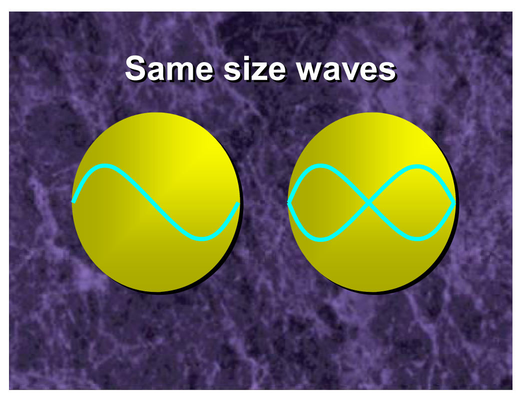

Figure 2. Example of an object exposed to homogeneous resonant waves.

When an object is exposed to a resonant energy, the energy is concentrated in the object and becomes available for the performance of useful work and the maintenance of order, far from the static equilibrium of a stochastic system. Other objects in the vicinity which do not resonate with that same frequency, do not transform and accumulate the energy resonantly, and remain at equilibrium with little change in their motion or dynamics. This renders the resonant transformation of energy a very precisely targeted and controllable process compared to the random processes of entropic energy transformation. Understanding this "targeting" concept allows one to precisely influence and control the *fundamental* interactions between energy and matter everywhere one looks, be it in physics, chemistry or biology.

The Historical Journey

How is it, one asks, that this most significant concept of science can be found in technology thousands of years old but was virtually omitted from modern science? The answer to that question is the story of the fall and rise of resonance science.

The Neolithic Age

The Neolithic age is well known for the construction of megalithic temples and structures involving the use of large, massive stones. The most familiar of these is undoubtedly the megalithic complex at Stonehenge, which was constructed around 2,500 BCE. Older Neolithic structures however, can be found on the Mediterranean island of Malta dating to as early as 4,000 BCE. Those structures exhibit a combination of construction techniques including the use of large stones, as well as the carving of underground rooms and chamber, including the spectacular Hypogeum of Paola, Malta (Figure 3, below).

In 1994 the Princeton Engineering Anomalies Research team examined the acoustic characteristics of several Neolithic structures in England, and found that the structures resonated in a narrow range of acoustic frequencies, from 95 - 120 Hz, despite major differences in shapes and sizes of the structures.[3] Subsequent studies of the Hypogeum also revealed a strong resonant acoustic frequency at 110 Hz.[4] The effects of acoustic frequencies from 90 -130 Hz on brainwave activity were recently studied in healthy volunteers.[5] Activity in the brain shifted from the left pre-frontal cortex to the right pre-frontal cortex. The neurophysiologists who conducted the study suggested that production of 90-130 Hz sounds were well within the vocal range of the adult male, and when produced in the megalithic structures may have caused a relative deactivation of language centers in the brain to allow other mental processes to become more prominent.

Figure 3. The Hypogeum of Paola, Malta

The Roman Iron Age

Thousands of years later at the beginning of the current era, traces of resonance concepts could be found in the metaphysical beliefs of at least three (3) major schools: the Egyptian Hermetecists, Hebrew mysticism and gnosticism, and the Greek Pythagorean school. All three (3) schools embodied concepts related to sound, light, and resonance/harmony as paths to an elevated consciousness, with particular emphasis on science and mathematics by the Pythagoreans.

A few hundred years later, those same concepts were an inherent part of Christian mysticism and Gnosticism, and therein lay the seeds for significant theological and political conflict. In 312 CE the Roman emperor Constantine adopted Christianity, and in short time the Roman government was gaining control of the Christian church, and with it the hearts and minds of the populace. By 325 CE Constantine convened the First Council of Nicaea which established a uniform Christian doctrine, and outlawed competing mystical and Gnostic doctrines, which emphasized the morality of the individual rather than any fixed rule of faith.[6] Resonance concepts and ideas, interwoven as they were with the religious Gnostic and mystical philosophies of the time, were driven underground into secrecy and hiding.

The Middle Ages

The religious-military Order of the Templars conducted extensive excavations under the Temple Mount in Jerusalem at the site of Solomon's Temple, around 1100 CE (just after the First Crusade). The Templars are rumored to have found technological artifacts from the earlier mystic and Gnostic schools that were associated with resonance concepts, however they too were driven underground. The wealthy Order had extended massive loans to King Phillip IV of France. In 1307 when the king found himself unable to repay those loans, he accused the Templars of heresy, seized all their properties, and burned several of the knights at the stake, including the Templar Grand Master – Jacques de Molay.[7]

Likewise, a Crusade had been declared against the Cathars - a peaceful sect of Christian Gnostics living in southern France, and tens of thousands of people were slaughtered or burned at the stake for adhering to Gnostic ideals. Persecution of the Cathars under the Inquisition continued until 1330, when it appears the Gnostic Cathar sect was finally extinguished.

The Age of Reason and the Enlightenment

In 1517 Martin Luther nailed his famous tract to the door of a church in Wittenberg, Saxony, and the protestant reformation had begun. By the 1600's the Church had lost its hold on the countries of northern Europe, but still exercised considerable power in the Italian peninsula, the home of Galileo Galilei (1564 – 1642). During the latter half of Galileo's life the Thirty Years' War raged between the Holy Roman Empire and the Protestant nobles of Europe. Galileo was denounced to the Inquisition in 1615 for his support of Copernicus' theory that the earth orbits the sun. The Church merely enjoined Galileo from discussing the Copernican theories either orally or in writing, and he thus escaped the more serious penalties of torture and death by burning at the stake, that had befallen his contemporary Giordano Bruno (1548 - 1600).[*]

Galileo persisted in fomenting the scientific revolution however, and in 1632 provided the first known written description of resonance in his *Dialogue Concerning the Two Chief World Systems*.[8] Regarding natural, resonant frequencies Galileo wrote, "*the Pendulum makes its vibrations with one*

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[*] Bruno not only espoused the Copernican theories but went further, asserting that the sun was one of only many stars in the universe, about which revolved "*an infinity of worlds of the same kind as our own.*" Bruno also taught conservation of energy and relativity, *"This entire globe, this star… dissolution and annihilation being impossible anywhere in Nature, from time to time renews itself by changing and altering all its parts. There is no absolute up or down, as Aristotle taught; no absolute position in space; but the position of a body is relative to that of other bodies. Everywhere there is incessant relative change in position throughout the universe, and the observer is always at the center of things." De la Causa, Principio et Uno,* circa 1592.

and the same frequency" and "*every Pendulum hath the Time of its Vibrations…pre-fixed…[and] it is impossible to make it move under any other Period, than that …which is natural unto it."* Galileo also described that: "*by blowing upon [the Pendulum one may] confer a Motion, and a Motion considerably great by reiterating the blasts, but only under the Time properly belonging to its Vibrations".* As to negative interference and resonant damping, Galileo taught that one should *"not [blow] when the Pendulum is coming towards us (for so we should impede; and not help the Motion)".*

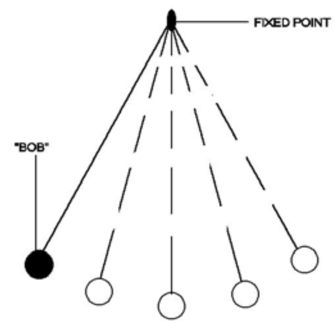

Figure 4. Resonance and oscillation amplitude as a function of time. Galileo discovered this phenomenon by giving small puffs of his breath to a pendulum, which matched the frequency of the pendulum's swings. The pendulum oscillations grew larger and larger, although the force of his breath was very slight.

The Church responded by trying and convicting Galileo of heresy, forced him to recant, and confined him to house arrest for the remaining ten (10) years of his life. Discussion of mathematical and resonance concepts, associated as they were with "pagan" beliefs, was still a dangerous endeavor.

This chilling atmosphere may explain in part, the secretiveness of French lawyer Pierre de Fermat (1601 – 1665), whose private avocation was mathematics. Fermat is thought to have developed the first resonance curve equation,[9] in the form of: $y = 1 / (1+x^2)$. Fermat published virtually nothing during his life, and his mathematical works were discovered only after his death, written in the margins of various books and treatises in his personal library.

Around the time of Fermat's death, Isaac Newton (1643 – 1727) wrote his famous "*Principia"* containing the three (3) laws of motion. Although working from the relative safety of England, Newton never-the-less waited another twenty (20) years to publish it.[10] Another resonance equation was later derived from his second law (force equals mass times acceleration):[11]

$$A = \frac{a}{\left| \nu^2 - \nu_o^2 \right|} \quad (1)$$

where "A" is the amplitude of the system's oscillations, "a" is the acceleration in the system's oscillation (caused in Galileo's case by the force of his small puffs of breath), "ν" is the resonant frequency of the system, and "ν_o" is the frequency of the outside force applied to the system. As the frequency of the outside force nears the resonant frequency of the system, the denominator in Eq. 1 becomes *very* small and produces a large amplitude (of theoretically infinite proportions when the outside frequency matches the resonant frequency of the system) (Figure 5. below).

By the mid-1700's the reception of new scientific and mathematical ideas had improved. In 1748, Italian mathematician Maria Agnesi organized the work of Fermat, Gregory, Euler, Newton, Leibnitz and Grandi in a very systematic manner, and compiled this work in a book on calculus and differential equations.[9,12] She also included a geometric description of the resonance curve as well as a

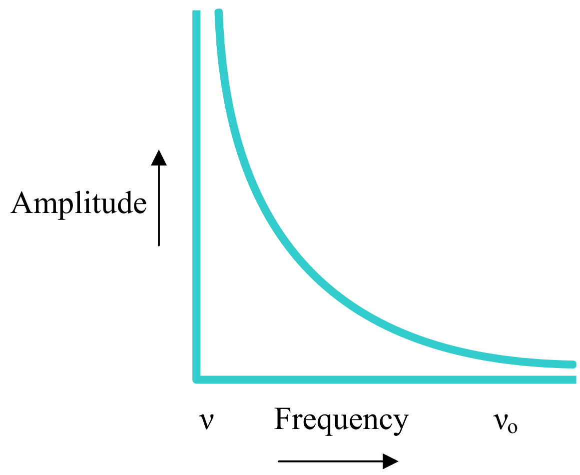

Figure 5. Amplitude plotted as a function of an applied resonant force. As the outside frequency "$ν_o$" approaches the resonant frequency "ν", the amplitude of the system's oscillations increases dramatically.

resonance equation, $y = ha^2 / a^2 + x^2$, where "h" is the height of the curve and "a" the half-width at half-maximum. The book was widely disseminated throughout Europe and caused such a sensation, that Pope Benedict XIV appointed her to the mathematics chair at the University of Bologna. Resonance and the mathematics to describe it, began to become widely known and accepted as a scientific principle. Unfortunately, due to an error in translation the resonance curve came to be known as the "Witch of Agnesi", harkening back to the earlier forbidden associations of resonance with Gnosticism and magic.

Taking an initially cautionary approach to resonance studies, Joseph Louis Lagrange (1736 – 1813) first explored the concepts of resonance by working with sound and music, which posed little threat to religious authorities.[13] Later in life, he fully developed his mechanical analysis of statics, dynamics and equilibrium, in which he considered resonance dynamics independent of the safe harbor of music.[14] Lagrange stated the mathematical function of a static system could be either a minimum (entropic) or maximum (resonant), and wrote, *"if this function is a minimum the equilibrium will be stable, so that the system, which is assumed in equilibrium and displaced by a small amount, will return to the configuration of equilibrium while making infinitesimal oscillation. On the contrary, in the case where the same function is a maximum, the equilibrium will not be stable and once disturbed the system will begin by performing fairly small oscillations but the amplitude of the oscillation will continually grow larger."*

Lagrange extended his minimum – maximum function analysis to rotating systems and dynamic systems. He devoted an entire section to the musical work of Chladni, Bernoulli, Sauveur and Rameau in regards to "*longitudinal*" and "*transverse vibrations", "harmonics [at the] nodes of vibration*", and *"the resonance of a sonorous body"*, as well as another section on the dynamics of pendulum motion and resonant oscillation. Throughout his book "*Méchanique Analytique"* of 1811, Lagrange interwove the conservation of energy concepts espoused by the ill-fated Bruno 200 years earlier, calling it *"Conservation des Forces Vives"*.

A generation later, Hermann von Helmholtz (1821-1894) organized the work of Lagrange, Joule, Carnot and others, and laid out the mathematical bases for conservation of energy in his famous treatise of 1847.[15] Helmholtz showed that heat was not a substance, as commonly believed at the time, but rather *"that heat itself is a motion, an internal invisible motion of the smallest elementary particles of bodies."*[16] Helmholtz described his ideas about energy in a simple mathematical form:

$$U = A + TS \quad (2)$$

where "U" is the total internal energy of a system, "A" is the energy available for orderly work (now known as "Helmholtz energy"), "T" is temperature (Kelvin) and "S" is entropy. He conceptualized all energy as involving motion, and differentiated between work and thermal energy based on whether the motion was orderly and uniform (work), or random and chaotic (heat).[†] His work energy was equivalent to Lagrange's maximum function, his thermal energy to the minimum function, and the sum of a mixed work/thermal system was equivalent to Lagrange's function when it lay *between* a minimum and maximum.

Helmholtz also wrote extensively on resonance, especially in regard to sound waves, the mechanics of the human ear, and the physics of music. Examples of Helmholtz's resonance work include, "*When these bodies are struck gently, but periodically, ...provided the periodic time of the gentle blows is precisely the same as the periodic time of the body's own vibrations, very large and powerful oscillations may result…Periodic impulses of this kind generally proceed from another body which is already vibrating regularly, and in this case the swings of the latter in the course of a little time, call into action the swings of the former. Under these circumstances we have the process called <u>sympathetic oscillation</u> or <u>sympathetic resonance</u>.*"[19]

Helmholtz went on to the highest physics seat in Germany, chairmanship of the physics department at the University of Berlin. There Helmholtz taught many students about conservation of energy, resonance, and thermodynamics. One of his most brilliant students - Heinrich Hertz (1857-1894) – proved the existence of Maxwell's theoretical electromagnetic waves in 1885, and by 1889 had shown that radio waves and visible light were both composed of the same sort of energy. Electromagnetic energy was thereafter referred to as "*resonant Hertzian waves*", reflecting the understanding that emission and absorption of electromagnetic energy was a resonance phenomenon.

After finishing his work on electromagnetic energy, Hertz undertook a complete analysis and update of mechanics, in regard to what he considered to be the most pressing issue of the day: the substance and nature of the medium through which the resonant electromagnetic waves propagated. Before he could finish editing his work on mechanics he died of pneumonia, however, in 1894. Helmholtz was asked to help finish editing Hertz's final work, and after spending a day correcting proofs remarked that *"he had discovered what he and many others before him had long been looking for"*.[20] Unfortunately, Helmholtz too was taken suddenly ill and died before he was able to write the matter out or present it to his colleagues.

The 20th Century

No one knows if Hertz and Helmholtz had discovered that orderly, uniform work performed by electromagnetic waves via sympathetic resonance is actually a form of Helmholtz work energy, however another of Helmholtz's brilliant students - Max Planck - made the connection a few years later. Planck (1858 – 1947) took up the theoretical study of the "*resonant Hertzian waves"* shortly after Hertz's death. Planck recognized that the emission and absorption of electromagnetic waves was

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[†] Ever mindful of recent history, Helmholtz remarked in his conservation of energy lectures on the treatment of 18th century robotics pioneer Pierre Jaquet-Droz (1721-1790), who "*being suspected of the black art, lay for a time in the Spanish Inquisition, and with difficulty obtained [his] freedom"*. The Church later pronounced that, *"Helmholtz's extension of the principle…[of Conservation of Energy]…is a hazardous leap from positive science into very speculative metaphysics."* See references 17 and 18

"*a resonance phenomenon in that the above-named oscillators [e.g., atoms] not only emit waves, but also are excited into oscillation by the incoming waves… These oscillators would emit waves because of their oscillations, and thus emit energy, but in turn would absorb selectively incident waves through resonance, thus amplifying their oscillation energy.*" [21] Planck also realized that the resonant electromagnetic waves were a form of work energy: "*If amplitude and phase [of the electromagnetic waves] both remained absolutely constant, which means completely homogeneous vibrations, no entropy could exist and the vibrational energy would have to be completely free to be converted into work*" (Lagrange's maximum function and Helmholtz's work variable, "A"). [22]

In the late 1890's, Planck began to focus on the thermodynamics of the black body radiation problem (i.e., the spectrum of electromagnetic energy emitted by an object purely as a result of being heated). He used experimental data from a device necessarily designed to exclude all resonant or Helmholtz work energy, so that only the emissions related to a change in temperature would be measured. Planck asserted that this experimental limitation created a "*loophole*" necessitating "*a special hypothesis*", namely that in the black body experiments "*the energy of the radiation is distributed in a totally irregular [entropic] manner*". When Planck eventually found the correct black body radiation equation in 1900, this special hypothesis allowed him to start with Helmholtz's internal energy equation "U = A + TS", set "A" equal to zero, and render total internal energy as simply, "U = TS". Planck then concluded that "*the entire matter [of black body radiation is] completely determined when one succeeds in calculating… dS/dU = 1/T*". From there he added his revolutionary concept of quantization of electromagnetic energy, and was then able to successfully derive his empirical black body radiation equation, which was published in 1901.

Four years later, the young Albert Einstein (1879 – 1955) used Planck's quantum hypothesis in his own work on the production and transformation of light, including an explanation of the photoelectric effect.[23] While there seems to have been little debate about Planck's resonance hypothesis (combining as it did, the well-accepted work of Hertz and Helmholtz) much debate ensued regarding the quantum and photoelectric hypotheses. In 1916, however, Robert Millikan (1868 – 1963) settled the matter with a definitive analysis corroborating Planck's constant "h" and Einstein's photoelectric equations, to the extent that both pertained to photoelectric phenomena.

Millikan first distinguished the photoelectric effect from thermal/entropic processes, noting "*that photoelectrons do not share in the energies of thermal agitation*". He then discussed several theories of photoemission, comparing them to his carefully obtained laboratory measurements. He noted the resonant nature of the photoelectric process, stating that the "*absorption [of electromagnetic energy] is due to resonance (and we know of no other way in which to conceive it…)*". Millikan reiterated what was well understood by all, that "*the phenomena of absorption and of emission show that…oscillators possess natural frequencies…and the characteristic waves which they emit are of these frequencies*". Millikan suggested that "*if any particular frequency is incident upon such a substance the oscillators in it which are in tune with the impressed waves may be assumed to absorb the incident waves*". In terms of his own meticulous experimental findings, Millikan stated, "*emission of [electrons] from the atom…takes place especially copiously when the impressed frequency coincides with a 'natural frequency'…*", thus indicating that the photoelectric effect is a resonance phenomenon.

Finally, although Millikan had initially been skeptical of Planck's quantum hypothesis, he concluded that it was indeed, correct. Millikan closed his landmark paper by stating that the photoelectric effect, with its resonant characteristics, differs from thermal/entropic processes and "*furnishes a proof which is quite independent of the facts of black-body radiation of the correctness of the fundamental assumption of the quantum theory, namely, the assumption of a discontinuous…energy absorbed by the electronic constituents of atoms from [electromagnetic] waves*".

The next generation of physicists to tackle Planck's quantum and resonance hypotheses included Erwin Schrödinger (1887 – 1961, who was a disciple of the Einstein school of wave/particle duality) and Werner Heisenberg (1901 – 1976, a disciple of the Niels Bohr school of discrete energy states and electron jumps). In 1925, Heisenberg spent a seven (7) month fellowship with Bohr, and a few months later wrote his famous paper on quantum matrix mechanics, in which he formulated the mechanical quantities of atoms and electrons (e.g. position and velocity) by abstract mathematical matrices rather than by ordinary numbers. Another paper on matrix mechanics and probabilities (in collaboration with his mentor Max Born) soon followed.

The next year (1926) Schrödinger – who had also been searching for an improvement to Bohr's orbit theory, based on resonant eigenvalues in atomic spectra - published the first of several papers describing his wave mechanics. Borrowing from resonant acoustic teachings of Chladni and others, Schrödinger asserted that the atom could be described by *"stationary proper vibrations",* i.e., as a standing waveform pattern. He proposed further that the energy associated with the stationary proper frequencies of the atoms was quite large, and that the electronic *"emission frequencies appear therefore as deep 'difference tones' of the proper vibrations themselves. It is quite conceivable that on the transition of energy from one to another of the normal vibrations, <u>something</u> – I mean the light wave – with a <u>frequency</u> allied to each frequency <u>difference</u>, should make its appearance. One only needs to imagine that the light wave is causally related to the <u>beats,</u> which necessarily arise at each point of space during the transition; and that the frequency of the light is defined by the number of times per second the intensity maximum of the beat-process repeats itself....It is hardly necessary to emphasize how much more congenial it would be to imagine that at a quantum transition the energy changes over from one form of vibration to another, than to think of a jumping electron."*

Many theorists, including Schrödinger and Heisenberg, struggled with the "*resonance catastrophe"*, i.e., the theoretically infinite oscillation amplitude produced when an outside frequency exactly matches a resonant frequency of the system. Schrödinger wrote in his fourth wave mechanics paper, *"I do not wish, however, to attempt to work out the calculation of the resonance case",* explaining that to do so would require a solution to the "*back-coupling…[of] the light wave…which is emitted by the system itself".*

In his final paper of the series Schrödinger summarized the exchange of energy according to wave mechanics and expressed his strong feelings about other quantum formulations: *"as soon as the conception of the 'terms' as discrete energy levels had been introduced, we were obliged to see a corroboration of that conception in every new [energy] exchange phenomenon discovered, even if there is really nothing present in nature beyond the resonance phenomenon…I do question whether it is not very much more to the point to push the idea of the frequency …instead of that of the 'kinetic energy of the single electron'. It is known that in passing through a potential difference these waves undergo just that change of frequency which corresponds to the acquired kinetic energy…I cannot help feeling that to admit the quantum postulates in addition to the resonance phenomenon is to accept two explanations for the same thing."*

As Schrödinger noted in his conclusion, however, Born had recently proposed that the wave equations which Schrödinger viewed as descriptive of real physical phenomena, should be thought of "*merely as probabilities…I am averse to this conception, not so much on account of its complexity as on account of the fact that a theory which demands our assent to an absolute primary probability as a law of Nature should at least repay us by freeing us from the old "ergodic difficulties" and enabling us to understand the one-way course of natural processes without further supplementary assumptions."*

By the 1930's it was generally acknowledged that the energy distribution of atomic spectral lines, including line widths, collision damping and Stark broadening, all fit the Fermat/Agnesi resonance curve, while the Doppler broadening due to thermal entropy (heat) fit the Gauss curve instead. The resonance theories of Schrödinger initially enjoyed support and interest, but - probably as a result of the uncertainty in quantum calculations created by the hidden quantum variables - the probabilistic theories of Heisenberg and Born eventually won out.

Meanwhile, at the same time Schrödinger's resonance theories were being slowly relegated to the dust bin, the flamboyant inventor Nikola Tesla, who had performed incredible technological miracles using resonance engineering, began to suffer credibility problems. Tesla (1846-1953) had demonstrated remote radio control of devices in 1893, just a few years after the announcement of "*resonant Hertzian wave*s". In 1896 his alternating current hydroelectric power plant based on resonant electrical concepts was installed at Niagara Falls and providing electrical power to thousands of households and businesses. By the late 1930's however, his Colorado Springs lab had been dismantled to pay debts, his subsequent lab at Wardenclyffe Tower was laughed at as "Tesla's million-dollar folly", and his eccentricities were leading to his reputation as a "mad scientist".

Neither the popular imagination nor academic fervor were fired by the study of resonance dynamics by the 1940's, and the fundamental concepts of this most primary of energy transformation processes slipped into oblivion. By the 1990's, a survey of a dozen college physics textbooks revealed that only two (2) even mentioned resonance. One book devoted a few paragraphs to the subject, while only "*The Mechanical Universe"*, gave a full 3-page exposition on the topic including a derivation of Eq. 1., from Newton's 2nd law of motion. So abject was the academic ignorance of resonance concepts, that the Chairman of the Department of Chemistry of a major U.S. university berated the instant author for referring to a resonance curve (Yes - that same resonance curve of Fermat, Agnesi, Helmholtz and Schrödinger) on the grounds that it violated the laws of physics!

The 21st Century

The recent discovery of Einstein's hidden variables heralds a new era in physics. The lag in the development of resonance dynamics can be traced to religious-political factors, absence of resonance in the original black-body experiments, and lack of a clear path forward in light of the *"resonance catastrophe"*. The issues with which both Schrödinger and Heisenberg struggled in regards to the third factor were in large extent a direct result of the previously hidden variables. Work in the new quantum physics has now contributed new variables and constants which greatly simplify the mathematics associated with electromagnetic energy, resonant phenomena, and resonance dynamics.

Planck's special case of "*completely homogeneous vibrations, [where] no entropy c[an] exist and the vibrational energy [is] completely free to be converted into work"* (i.e., Lagrange's maximum function, and its equivalent Helmholtz work variable, "A") are represented in resonance dynamics by a *resonance work variable*. For an entire system, the resonance work variable "A_r" is used, and when considering an element of a system (such as an atom or molecule) the work variable "r_A" is used:

$$U = A_r \quad [3] \qquad\qquad E = r_A \quad [4]$$

In the event the system under consideration is a mixed resonance/entropic system (which will be the case more often than not) the mathematics will appear thusly:

$$U = A_r + TS \quad [5] \qquad\qquad E = r_A + k_B T \quad [6]$$

with the values of "A_r" and "r_A" being determined as the difference between the total energy of the purely entropic system/element, and the total energy in the mixed resonant system/element, respectively. This construct has the advantage that inherent back-coupling is already accounted for in the total thermal/entropic energy, while back-coupling caused by the resonant energies are accounted for in the resonance work variable.

In certain dynamical and quantum considerations it will be more convenient to use a product rather than a sum, in which case a *resonance factor* (the ratio of total energy in a mixed resonance system/element, to purely thermal entropic energy of the system/element) may be employed:

$$U = A_f\,TS \qquad [7] \qquad\qquad E = r_f\,k_B T \qquad [8]$$

This formulation of the resonance factor allows its inclusion in quantum mechanical equations, and the accurate representation of real physical phenomena. For example instead of the purely thermal/entropic exponential function, "$e^{(\Delta E / k T)}$", derived by Planck, the resonance exponential function:

$$e^{\frac{\Delta E}{r_f\, k_B T}}$$

may be used to obtain a more realistic representation of resonance dynamic and quantum considerations, such as a resonant distribution weight, an equilibrium constant in a resonant chemical or material reaction, or a shift of equilibrium.

References

[1] J. Brooks (Mortenson), Einstein's Hidden Variables: Part A & Part B, *Proc. of MS&T 2009,* 2009, p. 573 - 597

[2] J. Brooks (Mortenson), Advance in the Foundations of Quantum Mechanics, Bull. Am. Phys. Soc., Vol 55 (No. 1), 2010, http://meetings.aps.org/link/BAPS.2010.APR.X14.9

[3] R. G. Jahn, P. Devereux, and M. Ibison, Acoustical Resonances of Assorted Ancient Structures, *J. Acoustical Society of America*, Vol 99 (No. 2), 1996, p 649-658

[4] R. Zahra, Personal communication, retrieved on June 24, 2010 from the Old Temples Study Foundation, http://www.otsf.org/Archaeoacoustics.htm#_edn6, January 2010

[5] I. A. Cook, S. K. Pajot, and A. F. Leuchter, Ancient Architectural Acoustic Resonance Patterns and Regional Brain Activity, *J Arch Cons & Cult*, Vol 1 (No. 1), 2008, p 95-104

[6] Irenaeus, *On the Detection and Overthrow of the So-Called Gnosis - Adversus Haereses,* 180.

[7] M. Maiorini, P. P. Piergentili, B. Frale, L. Becchetti, *Processus contra Templarios,* Archivio Segreto Vaticano, Exemplaria praetiosa, 3. Città del Vaticano, 2007

[8] G. Galilei, *Dialogue Concerning the Two Chief World Systems,* 1632 (English translation available at http://archimedes.mpiwg-berlin.mpg.de/cgi-bin/toc/toc.cgi? step=thumb&dir=galil_syste_065_en_1661)

[9] R. C. Spencer, Properties of the Witch of Agnesi – Application to Fitting the Shapes of Spectral Lines, *Journal of the Optical Society of America*, Vol 30, 1940, p 415 – 419

[10] I. Newton, *Philosophiae Naturalis Principia Mathematica,* Royal Society, London, 1686

[11] R. P. Olenick, T. M. Apostol, and D. L. Goodstein, *The Mechanical Universe*, Cambridge University Press, New York, NY, 1986

[12] M. G. Agnesi, *Instituzioni Analitiche,* Nella Regia-Ducal Corte, Milan, Italy, 1748

[13] J. L. Lagrange, *Mélanges de Turin,* Vol 1-4, 1759 – 1773.

[14] J. L. Lagrange, *Méchanique Analytique, novelle édition d' 1811,* Trans. A. Boissonnade and V. N. Vagliente, Kluwer Academic Publishers, Boston, 1997

[15] H. Helmholtz, *On the Conservation of Force, Ostwald's Klassiker der Exacten Wissenschaften,* Verlag von Wilhelm Engelmann, 1889

[16] H. Helmholtz, *Popular Lectures on Scientific Subjects*, Lecture VI. On the Conservation of Force, Trans. E. Atkinson, Longmans, Green and Col, New York NY, 1904, p 306

[17] W. R. Grove, H Helmholtz, J. R. Mayer, M. Faraday, J. Liebig and W. Carpenter, *The Correlation and Conservation of Forces*, D. Appleton and Company, New York, 1868., p 212

[18] Eds. C. G. Herbermann et al, *The Catholic Encyclopedia*, *The Law of Conservation of Energy,* Robert Appleton Company, New York, 1914

[19] H. Helmholtz. *On the Sensations of Tone.* Longmans, Green, and Co., New York, 1862.

[20] E. B. Wilson, Von Helmholtz, *Bull. Amer. Math. Soc.*, Vol 13 (No. 3), 1906, p. 112-119

[21] M. Planck, On Irreversible Radiation Processes, Ann. Phys., Vol 306 (1), 1900, p. 69-122

[22] M. Planck. On the Law of Distribution of Energy in the Normal Spectrum. Annalen der Physik, Vol. 4, 1901, p. 553

[23] A. Einstein. On a Heuristic Point of View Concerning the Production and Transformation of Light. Annalen der Physik, Vol 17, 1905, p 132-148

[24] R. A. Millikan, A Direct Photoelectric Determination of Planck's "h", *Phys Rev*, Vol 7 (No. 3), 1916, p 355 – 388

[25] W. Heisenberg, Ueber den anschaulichen Inhalt der quantentheoretischen Kinematik and Mechanik', *Zeitschrift für Physik*, 43, 1927, p. 172-198

[26] E. Schrödinger, *Collected Papers on Wave Mechanics*, Chelsea Publ. Co., New York, 1982