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Quantum Ripple Theory – Experimental & Model Based Discoveries

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Abstract

Aim/Purpose: The aim of this paper is to present the results of the conducted simulations for the proposed Quantum Ripple Theory (QRT).

Design/Methodology: The Quantum Ripple Theory and its conceptual model was described in a previous paper. Since the first paper, simulations were conducted, empirical data collected and analyzed, and the results and findings are presented in this second QRT paper.

Findings: QRT theory and conceptual model simulation results.

Conclusion: The simulation results support the legitimacy of QRT and its founding hypotheses. The results correspond to a simplified quantum Fourier transformation of phonons, also known as showing the quanta of the sound field. Hence, this research does have a link into the quantum world proposing a potential standing wave behaviour of quantum ripples. The probable standing wave behaviour should be further evaluated, as it could lead to new insights into the energy distribution of the cosmos. It is strongly believed that while simple sine and cosine waves basically depict infinity, standing waves do provide a form of order that it is trusted to theoretically be at the source of better understanding how the chaos in the cosmos can actually function when it comes to dispersing energy.

Limitation: Overall, approximately 8,000 experiments were conducted, varying the sound, distance, and angles of the sound sources. For approximately 86% of the experiments, a (close to a) standing wave pattern was observed between the waves of the two sources. In these cases, the mean correlation coefficient was measured at approximately -0.83, with a peak average of approximately -0.91. As the resources and equipment for this research have to be considered as rather limited, the results presented here only apply to the basic setup discussed in this paper. Nevertheless, the high number of experiments that point to a (close to) standing wave behaviour are significant and hence require further explanation.

Implication: The effects of the limited resources and equipment available for the experiments have to be taken into consideration when discussing the current state of the research.

Originality: Entirely new theory and model proposed.

Keywords: Quantum Ripple Theory (QRT), quantum mechanics, classical physics, unifying theories

Introduction

A previous paper (see pages 6-16) outlined the current view of the universe as being composed of more than the electrons, neutrons, protons, or photons (to name a few) of the visible (classical) universe. Hence, there is much more required to explain how different forces work or to evaluate the composition of fundamental elements. This all led to a discussion on Quantum Mechanics and the Standard Model, String Theory, Quantum Field Theory (QFT) and Loop Quantum Gravity (LQG), prior to describing the Quantum Ripple Theory (QRT).

Neutron Stars, Quantum Ripples, Standing Waves and Energy

A neutron star depicts the densest object astronomers can directly observe, crushing 500,000 times Earth's mass into a sphere about 12 miles across. Neutron stars are formed when a massive star runs out of fuel and collapses. The very central region of the star (the core) collapses, crushing together every proton and electron into a neutron. If the core of the collapsing star is between about 1 and 3 solar masses (1 solar mass equals to the mass of approximately 333,000 times the mass of Earth), these newly created neutrons can halt the collapse, leaving behind a neutron star. Stars with higher masses will continue to collapse into stellar mass black holes. This collapse leaves behind the densest object known to us, an object with the mass of the sun pinched down to the size of a smaller city. These stellar remains measure about 20 kilometers (12.5 miles) across. One sugar cube of neutron star material would weigh about 1 trillion kilograms (or 1 billion tons) on Earth.

Figure 1: Neutron Star

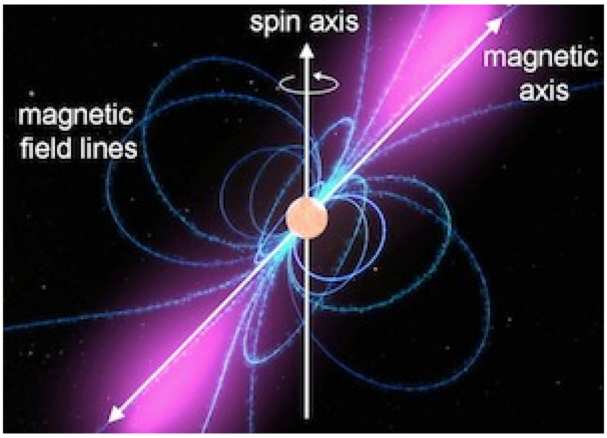


Figure courtesy of NASA

A pulsar has a strong magnetic field and a beam of light along the magnetic axis (see Figure 1). As the neutron star spins, the magnetic field spins with it, sweeping that beam through space. If that beam sweeps over Earth, one can observe it as a regular pulse of light. As neutron stars commence their existence as stars, they are discovered scattered throughout the galaxy in the same places where stars can be located. And like stars, they can be located as a single entity or in binary systems with a buddy.

Many neutron stars are probably untraceable, as they frankly do not emit enough radiation. However, under certain conditions, they can undoubtedly be observed. A handful of neutron stars have been located at the centres of supernova fragments silently emitting X-rays. More often though, neutron stars are detected spinning violently while disclosing extreme magnetic field conditions. In binary systems, some neutron stars can be encountered that are growing by accumulating materials from their companions, emitting electromagnetic radiation powered by the gravitational energy of the accreting material.

Most neutron stars are observed as pulsars. Pulsars depict rotating neutron stars examined to have pulses of radiation at very regular intervals that in general range from milliseconds to seconds. Pulsars have very strong magnetic fields that funnel jets of particles out along the two magnetic poles. These accelerated particles generate very powerful beams of light. Frequently, the magnetic field is not aligned with the spin axis, so those beams of particles and light are swept around as the star rotates. When the beam crosses the line-of-sight, one can observe a pulse in an on and off fashion as the beam sweeps over Earth. An analogy is that a pulsar is like a lighthouse. At night, a lighthouse emits a beam of light that sweeps across the sky. Even though the light is constantly on, one can only observe the beam when it is pointing directly in one's direction (see Figure 2).

Figure 2: Light Beam

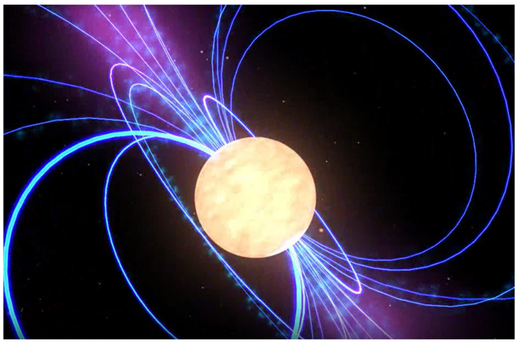


Figure courtesy of NASA

As discussed, a spinning pulsar has a strong magnetic field that is rotating along with it. Clouds of charged particles move along the field lines and their gamma-rays are beamed like a lighthouse beacon by the magnetic fields. As the line-of-sight moves into the beam, one can observe the pulsations once every rotation of the neutron star.

Another class of neutron star is termed a magnetar. In a typical neutron star, the magnetic field is trillions of times larger than Earth's magnetic field. With a magnetar, the magnetic field is an additional 1000 times stronger. In all neutron stars, the crust of the star is locked together via the magnetic field so that any change in one segment affects the other sections. The crust is under massive strain and just a minor movement of the crust can lead to an explosion. But as the crust and magnetic field are coupled, the explosion ripples through the magnetic field. With a magnetar and its gigantic magnetic field, movements in the crust cause the neutron star to release an immense amount of energy in the form of electromagnetic radiation. To illustrate, the SGR 1806−20 magnetar that was discovered in 1979 and was identified as a soft gamma repeater had a surge where in one-tenth of a second, it emitted more energy than the sun has released in the last 100,000 years.

Quantum Ripple Theory

The Quantum Ripple Theory was proposed in 2023 (Graham, 2023). The Quantum Ripple Theory depicts a new premise that was arrived at by looking at the problem of distance in measurement correlation for entanglement and identifying the potential implications of decoherence and interference (Graham, Heger 2024).

"Decoherence is the process by which bodies and quantum systems lose some of their unusual quantum properties (superposition or the ability to appear in various places simultaneously) as they interact with their surroundings. When a particle decoheres, its probability wave collapses, any quantum superpositions disappear, and it settles into its observed state under classical physics" (Heger, 2022, p.181).

"Interference is the ability of two waves passing through each other to mingle, reinforcing each other where peaks coincide and cancelling each other out where they correspond. This is similar to the way ripples in water interfere with each other" (Op. Cit,. 2022, p. 187).

This led to the following questions or hypotheses:

- Hypothesis 1: does Decoherence provide the link (possibly theory) between Classical Physics and Quantum Mechanics?
- Hypothesis 2: Is decoherence the result of interference?

In addition:

- What criteria are required for decoherence to happen?

The latter question was the basis for any simulation of these hypotheses.

Furthermore, Entanglement is stated to be:

"The property where two or more quantum objects in a system are correlated (or intrinsically linked). In such a scenario, the measurement of one entity changes the probable measurement outcome of the other in a correlated manner (2-qubit quantum system), regardless of how far apart the two objects are" (Op. Cit., 2022, p. 208).

In Quantum Ripple Theory, quantum ripples (light fields) are the result of the release of energy (light). Light is suggested because of its wave-particle and self-interference properties. If we consider the notion that every quantum object is part of a single looped wave (a quantum ripple) detectable due to decoherence (interference), this leads to a further set of questions and hypotheses:

- Hypothesis 3: Is detection a form of interference leading to decoherence, and does detection equate to observation?

Therefore:

- Hypothesis 4: Is entanglement correlation due to quantum ripple interference, with measured objects (particles) being measurements of the same quantum ripple, therefore they correlate independent of distance and require no information passing of any sort?

If a ripple is measured (or detected), this would also represent interference and its value observed. The value should be the same, independent of where on the ripple the measurement is taken, this would represent a solution for the entanglement correlation problem. No information passing is required at any speed (or transmission of information faster than the speed of light) as the same ripple is being measured and ripples could be massive.

These hypotheses would additionally be a part of any simulation.

Justification for Light as the Primary Energy Source

All conjectures appear to agree that the starting point for any theory, including the Standard Model, begins with energy. It is suggested that any candidate for the "original energy" must exhibit wave-particle duality, self-interference, and be capable of metamorphosing into other phenomena. Interference enabling the creation and binding of particles to other particles and matter.

Other potential candidates for which wave-particle duality and self-interference extends are electrons and fields. In the case of electrons:

“Pair production (Blackett, 1933) closely shows that we must describe light not only as being made of photons, but also in the context that photons can transform into other material particles, like electrons" (Heger, 2022, pp. 60-61).

In relation to Fields:

"What makes Compton scattering so important and motivating is that all this seems to suggest that we can again describe electromagnetic waves not as waves but rather as the light particles (photons) that bounce off other particles". And "pair production (opposite to annihilation) ... mysteriously, particles can appear from nowhere. Pair production and annihilation are examples of Einstein's mass-energy equivalence: E=mc2, where c = speed of light, m = rest mass of a particle" (Op. Cit., 2022, pp. 60-61).

In addition, “an atom can spontaneously emit light” (Op. Cit., 2022, p. 49). In consideration of the above, as well as its wave-particle duality and self-interference properties, light is therefore proposed as the primary or original energy.

QRT Simulation Description (notes in *italics*)

Considering QRT in a single plane:

- The simulation of quantum ripples in a single plane is *weakly analogous* to dropping a pebble into a pool of water.
- The pebble is equivalent to energy.
- The pebble *(energy)* is released at the origin, which will be at the centre of the ripples.
- The effect of the release of the pebble (the energy) is the forming of multiple ripples (quantum ripples).
- A ripple continues to spread outwards unless there is interference from another ripple (the result of another pebble of energy from the same point of origin, but of greater magnitude for a single plane).
- Both the size and frequency of the pebble (*energy*) would vary (*random probability*).

For each of the hypotheses above:

- *The simulation could determine if the interference results in different wave harmonics that would be akin to other phenomena.*
- *The model might identify a limited number of unique harmonic signatures, which might be associated with unique quantum phenomena.*

Extended QRT Simulation

The initial simulation acts in a single plane (a wavy disc), the second phase would have multiple planes. So, everything described above would need to be programmed for each plane (p), significantly adding to the complexity due to the increasing instances of interference.

A simpler, more abstract experiment is visualized in Figure 3, applying various angles and distances. A data collection and mathematical simulation application was required (had to be developed) to do this. This required adjustment of the frequency of the sound sources to simulate various potential configurations and ripples.

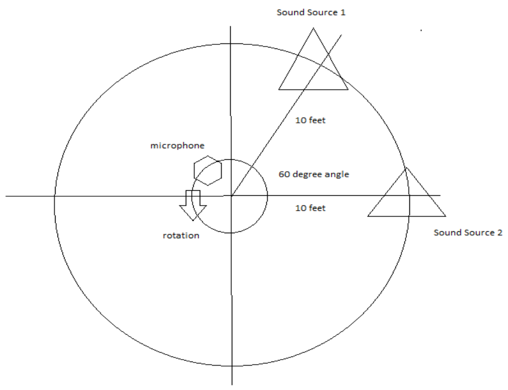


Figure 3: Quantum Ripple Theory (QRT) Extended Simulation/Experiment Diagram

QRT Initial Discussion

A constant release of energy could account for the continuous and increasing speed of the expansion of the universe. Newer, more powerful ripples push out "older" ripples, with new ripples resulting in more interference.

QRT Harmonics

If the point of origin of energy is constant, QRT may lead to a spherical, not flat, universe. The spherical case could be true in the first instance/energy release. The initial energy leads to the creation and spread of ripples in all directions from the origin. The implication for a full simulation is that there is significant interference and complexity from the outset, sufficient to lead to the creation of matter through QRT Harmonics and the classical universe. The (planes of) ripples radiate in all directions, with the origin at the centre, interference would occur at points/planes perpendicular (90 degrees) to one another, potentially leading to tensor fields with x, y, z coordinates.

If interference results in decoherence from the quantum to the classical universe, it could suggest that our reality; the classical universe, sits on top of this expanding sphere at the points of decoherence. Time equates to expansion and there is no real or separate concept of space. It is postulated that the result of numerous iterations of this simulation may result in an entangled spherical mesh of tensor fields. Einstein's description of a gravitational field is a tensor field. Tensor fields could be vital in the evolution of ripples to particles and matter.

To recap (Heger 2023); a tensor field portrays a function that inputs coordinates (x, y, z) and returns a tensor. Tensors are multi-dimensional arrays of numbers in a rectangular shape, and they can represent a lot more information than simple scalars or matrices. When these fields are provided with energy, they switch to higher energy states, a process that results in ripples. Importantly, these ripples are now labelled as particles. For instance, when ripples are fashioned in the electron field, electrons are formed, or when ripples are moulded in quark fields, quarks are formed. When these ripples turn silent, the corresponding particles disappear. The point where the energy is injected into these fields basically depicts where the particles are formed, and as the energy starts to spread across the field, the particles are moving. Depending on the field, various amounts of energy are needed to produce the particles. The primary factor that determines how much energy a field demands (to generate a particle) depends on the mass of the corresponding particle associated with that field.

In addition, waves have three characteristics: frequency, length, and amplitude. The product of the first two characteristics listed gives the speed. Wavelengths are also of interest to the harmonics of phenomena. Gamma rays have the shortest wavelengths of the electromagnetic spectrum, and the highest energies. Listing phenomena from the shortest to the longest wavelengths: gamma ray radiation, x-ray, ultraviolet, visible, infrared, microwave, radio. It was hoped that the running of sufficient simulations might demonstrate the creation or evolution of new wave harmonics, and their metamorphosis into other phenomena. Interference (tensor fields) and increasing wavelengths being possible proponents enabling the creation and binding of particles to other particles and matter.
Consequently, there are many new questions, including:

- Does interference increase wavelength?
- Or, do wavelengths increase due to expansion?
- Do increasing wavelengths impact the creation and binding of particles to other particles and matter?

QRT – Additional Discussion Points

In QRT, it was further suggested that light ripples are actually light fields, akin to gravitational fields. As mentioned previously, the classical physics universe may reside on the outermost “surface” at points of decoherence, the result of many interferences, so more complex. This classical universe is a small portion of the whole universe, the remainder is dark energy/matter. This was based on the notion that the initial “pool” is dark energy. This idea could be tested in the simulation. Looking at the projected ratio of light ("interference area") ripples, to dark energy (remaining “area”). The ratios should match those believed to exist for dark energy and dark matter, and energy and matter, the former estimated to be approximately 68% of the universe.

QRT starts with a spontaneous instance of light energy appearing within a dark energy universe. This primary energy is due to vacuum fluctuations of the electro -magnetic field which include the spontaneous emission of light. Strictly speaking, the term singularity is nonsensical. It has been suggested that dark energy may be a 5^{th} force missing from the Standard Model (BBC, 2023). Further questions, such as those pertaining to black holes, white holes, as well as thermodynamics, or the shape of the universe were not considered but may be directed by the simulation results.

Like Loop Quantum Gravity (LQG) theory (Rovelli, 2016), Quantum Ripple Theory (QRT) leads to the initial creation of the "Tensor Networks/Lattice" where time or space is an illusion, and there is no singularity. QRT also considers the current notion of a singularity to be wrong. However, unlike LQG, QRT implies that the universe is an expanding spherical lattice of ripples (initially at least), where interference (s) lead to decoherence into the classical universe. This allows for quantum and classical to coexist, and space to be deemed an illusion. Importantly, unlike LQG, QRT is a more testable theory.

In theory, for QRT, time can be replaced by distance (the radial value of the ripple in the simulation). The practical reality is, however, that this distance (space) is not measurable; space can be replaced by time in the same fashion. Likewise, a way of determining something similar to a universe horizon to prove that the universe may not be flat but a sphere, is not immediately apparent. Penrose’s Spin Networks look very much like Artificial Neural Networks (ANNs) with nodes and links. It was suggested that this could provide another means of simulation, or the current simulation model may result in something resembling these networks.

A further anecdote: an international consortium of astronomers has recently presented evidence that the fabric of the cosmos itself is constantly vibrating with light -year-long gravitational waves. The main result of the findings of the Pulsar Timing

Arrays (PTAs) collaboration, is that low-frequency gravitational waves exist in the Universe all around us (Mack, 2023). Finally, if QRT and hypotheses 1-4 are supported by the simulation data, a new look (from a different angle) at the Standard Model may be appropriate, assessing the possibility that QRT could be considered as a potential stage or precursor to the Standard Model and hence could be viewed as a prerequisite (or a valuable additional component) for it.

Quantum Ripples Research Project Methodology

The QRT research project methodology focused on the identification of potential quantum ripples that may have been part of the early cosmos (expansion). The idea was to simulate quantum ripples via an actual experiment conducted in the real world (based on our knowledge in 2024). The emphasis of the experiment was on addressing some of the theoretical "claims" that this research was making, by simulating quantum ripples via an actual experiment that uses a pulsar timing array. In this experiment, correlation methods were used to search for gravitational-wave signals in pulsar timing data. As a gravitational wave transits the line-of-sight between the Earth and an array of pulsars in our galaxy, it induces correlations in the measured timing residuals across pairs of pulsars in the array.

The set-up of the experiment was based on radio pulses from an array of pulsars that can be represented via two sound sources that are positioned at a distance and an angle from each other. The radio receiver in this experiment can be represented by a microphone (Figure 3). The passage of a gravitational wave in this experiment is simulated via the motion (circular rotation) of the microphone between the two sound sources. The motion of the microphone "doppler shifts" the received frequency of the sound source's pulses and that changes the arrival times of these pulses at the microphone. The objective was to understand the timing residuals for a pair of pulsars and how they are correlated as a function of the angular separation between the lines-of-sights to the two pulsars (sound sources).

For this research, a (mathematical) simulation software was developed that allowed recording of the sound waves, analysis of the generated data, and to have a visual representation of the residuals from the two sound sources that shows that they are shifted in phase relative to one another by an amount equal to their angular separation.

Utilizing our existing knowledge of when pulses should arrive, pulsar timing arrays use radio telescopes to measure fluctuations in the fabric of spacetime, that could signal the presence of gravitational waves caused by binary supermassive black holes that are orbiting each other or are positioned in the centres of other galaxies (Heger, 2024). That is the baseline for this research, analyzing the waves and quantifying the results in mathematical terms. The main aim was to learn as much as possible about the shape, form, and pattern of the waves. As a by-product of this research the following objectives were formulated and analyzed as well:

- Quantifying the pulse period and determining a source pulse profile based on consolidated data consisting of several pulse scenarios.
- Estimating the arrival times of the pulses by correlating the pulse profiles, as well as calculating the timing residuals.
- Demonstrating the actual correlation of the (timing) residuals for a pair of pulsars. The objective is to determine that the correlation is an artifact of the angular separation between the lines-of-sight of the two pulsars.

For a single sound source, it is rather straight forward to calculate the timing residuals by subtracting the expected arrival time from the measured arrival time of the pulses and hence, $\text{residual}(i) = \text{measured}(i) - \text{expected}(i)$. The expected arrival times are defined via an elementary timing model where $\text{expected}(i) = \text{measured}$

$(i_0) + (i - i_0)T_p$ (T_p depicts the pulse period). This all just reflects the measured arrival time of the pulse with the largest correlation plus the integer multiples of the pulse period T_p of the sound. The measured arrival times are obtained by correlating time-shifted pulse profiles with the actual data. The correlation function can be expressed as:

$$C_I(t) = \mathcal{N}_I \int_0^{f_{\mathrm{Nyq}}} df\, e^{i2\pi ft} \tilde{y}(f)\tilde{p}_I^*(f)\,, \qquad \mathcal{N}_I = \left[\int_0^{f_{\mathrm{Nyq}}} df\, |\tilde{p}_I^*(f)|^2\right]^{-1}$$ [1]

In Equation 1, $\tilde{y}(f)$ depicts the Fourier transform of the measured pulse data $y(t)$ while $\tilde{p}_I(f)$ represents the Fourier transform of the template pulse profiles $p_I(t)$ for the two sound sources ($I = 1, 2$). $C_I(t)$ shows a local maxima at the arrival times of the pulses. The normalization constant N_I is comprised so that the values of the correlation function (at the estimated arrival times) reflect estimates of the amplitudes of the pulses. The detrend residuals advance the estimate of the pulse period for a sound source by eliminating a linear trend from the timing residuals (if such a trend is observed). The detrending function has the potential to adjust the estimate of the pulse period by one to two microseconds.

For multiple sound sources, the objective is to record sound data from the two sources simultaneously. In this scenario, the analysis includes a process to simultaneously remove constant offsets allowing to map the calculated best-fit waves to the timing residuals of the two sounds sources. In order to accomplish that, initial estimates for the amplitude, frequency, phase of the waves, and the constant offset are used. The constant offset is an artifact of setting the randomness of the timing residual of the pulse with the highest correlation to zero. The correlation coefficient c alculates the time-averaged correlation coefficient between the best-fit waves for the two sets of timing residuals. If we denote the best-fit waves as $x(t)$ and $y(t)$, then:

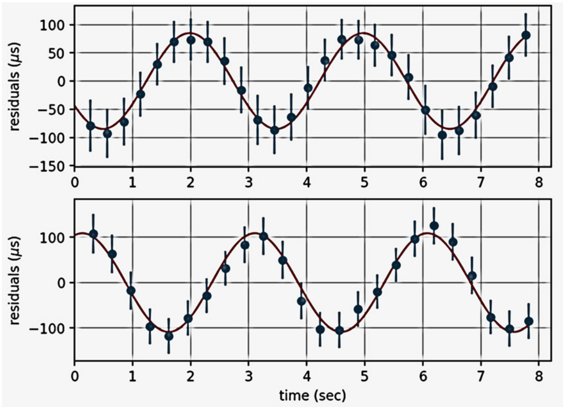
$$\text{corr coeff} \equiv \frac{\langle xy \rangle}{\sqrt{\langle x^2 \rangle \langle y^2 \rangle}}\,, \quad \text{where} \quad \langle xy \rangle \equiv \frac{1}{T}\int_0^T dt\, x(t)y(t)$$ [2]

Theoretically, the value of the correlation coefficient should be equal to cos (x), where x depicts the separation angle between the line-of-sights to the two sound sources.

Results

The results of the research showed some rather interesting results. Overall, approximately 8,000 experiments were conducted, varying the sound, distance, and angles of the sound sources.

Figure 4: Experiment with Two Sounds Sources



For approximately 86% of the experiments, a (close to a) standing wave pattern was observed between the waves of the two sources. In these cases, the mean correlation coefficient was measured at approximately -0.83, with a peak average of approximately -0.91. As the resources and equipment for this research have to be considered as rather limited, the results presented here only apply to the basic setup discussed in this paper. Nevertheless, the high number of experiments that point to a (close to) standing wave behaviour are significant and hence require further explanation. Taking the rather basic equipment available for the experiments, the results are very encouraging as it is assumed that an even stronger standing wave pattern could be observed with more sophisticated gear.

Discussion

Sound is often referred to as a wave, but we have to be careful with the generally used term *sound wave* as it can lead to a misconception about the nature of sound as a physical phenomenon. On one hand, there is the physical wave of energy passed through a medium as sound travels from its source to a destination. Here we assume for simplicity that the sound is travelling through air, although it can travel through other media. Related to this is the graphical view of sound, a plot of air pressure amplitude at a particular position in space as it changes over time. For single-frequency sounds, this graph takes the shape of a wave, more precisely, a single-frequency sound entity can be conveyed as a sine function and so can be graphed as a sine wave.

But a sound wave depicts a simple sine wave only if the sound contains one frequency component, also known as "just one pitch". Most sound entities are composed of multiple frequency components, multiple pitches. A sound with multiple frequency components can also be represented as a graph that plots amplitude over time, basically just depicting a more complex graph than just a simple sine wave. For simplicity, we sometimes use the term *sound wave* rather than *graph of a sound wave*, assuming that the audience understands the difference between the physical phenomenon and the graph representing it.

The regular pattern of compression and rarefaction is an example of harmonic motion, also called harmonic oscillation. Another example of harmonic motion is a spring dangling vertically. If you pull on the bottom of the spring, it will bounce up and down in a regular pattern. Its position (its displacement from its natural resting position) can be graphed over time in the same way that a sound wave's air pressure amplitude can be graphed over time. The spring's position increases as the spring stretches downward, and it goes to negative values as it bounces upwards. The speed of the spring's motion slows down as it reaches its maximum extension, and then it speeds up again as it bounces upwards. This slowing down and speeding up scenario as the spring bounces up and down can be modelled by the curve of a sine wave. In the ideal model, with no friction, the bouncing would go on forever. In reality however, friction causes a damping effect such that the spring eventually comes to rest.

Now consider how sound travels from one location to another. The first molecules bump into the molecules beside them, and they bump into the next ones, and so forth as time goes on. It is something like a chain reaction where cars are bumping into one another in a pile-up wreck. They do not all hit each other simultaneously. The first car hits the second car, the second hits the third car and so on. In the case of sound waves, this passing along of the change in air pressure is called sound wave propagation. The movement of the air molecules is different from the chain reaction of the car pileup in that the molecules vibrate back and forth. When the molecules vibrate in the direction opposite to their original route, the drop in air pressure amplitude is propagated through space in the same way that the increase was propagated.

We have to be careful not to confuse the speed at which a sound wave propagates with the rate at which the air pressure amplitude changes from highest to lowest. The speed at which the sound is transmitted from the source of the sound to the destination is the speed of sound. The rate at which the air pressure changes at a given point in space (vibrates back and forth) is the frequency of the sound wave. The following analogy may help; Imagine that we are watching someone turn a flashlight on and off, perpetually, at a certain fixed rate in order to communicate a sequence of numbers to us in binary code. The image of this person is transmitted to our eyes at the speed of light, analogous to the speed of sound. The rate at which the person is turning the flashlight on and off is the frequency of the communication, analogous to the frequency of a sound wave.

This description of a sound wave implies that there must be a medium through which the changing pressure propagates. We have described sound travelling through air, but sound can also travel through liquids and solids. The speed at which the change in pressure propagates is the speed of sound. The speed of sound is different depending upon the medium in which sound is transmitted. It also varies by temperature and density. The speed of sound in air is approximately 1130 ft/s (or 344 m/s). In a nutshell, that all changes the *shape of the sound wave* that we analyze. In other words, we are not just dealing with simple sine or cosine waves here. All our conducted experiments are affected by what has been discussed here so far!

Standing sound waves in pipes/tubes have been discussed in basically all college level physics classes. Elementary introductions to the concept of mechanical standing waves discuss vibrating perfectly elastic strings with rigid boundary conditions or acoustic waves reflecting inside a pipe with open or closed ends. Under the idealized conditions given in such scenarios, no sound waves can ever be produced! The standing wave just goes on forever and ever, confined to the string medium or the air inside the pipe.

What happens in practice for a string in an acoustic instrument is that the unsteady force on the mounting of the string (the bridge) causes the top of the instrument to vibrate, which in turn generates a sound wave. The point is that the boundary condition cannot be perfectly set for sound to be produced.

In other words, a standing wave is not the initial source of a sound but rather the result of a sound entity whose wavelength corresponds to the dimension of an object such as a room. As sound depicts vibrating air, the rate of vibration (or frequency) is expressed in Hertz. Each frequency has a corresponding wavelength. The lower the frequency, the longer its wavelength. As an example, a standing wave forms when a wavelength matches the distance between two walls of a room. A certain frequency will fit nicely between those two surfaces. The reflections off the walls can reinforce the initial wave if they remain in phase with each other. In this case the reflections are considered constructive, and the room will favour that frequency.

Conclusions

This research postulates that some quantum waves may result in standing waves that have their own energy attributes. For a quantum standing wave, the probability density is independent of time while the distribution of matter is time independent or stationary. This is why it can be labelled as a stationary state, states of definite energy. Because their charge distribution is static, atoms in stationary states do not radiate. The main question the reader may have at this point though is how we can postulate on this by comparing sound waves to quantum-level wave behaviours? In other words, while the conducted experiments with sound travelling through air do point towards a potential standing wave behaviour, where is the link to quantum waves?

Well, let us get cranking on that. Let us try to quantize the sound field. As we all learned in basic physics, sound waves traveling through a solid (such as a crystal) are nothing but microscopic oscillations of the crystal's atoms around their position of equilibrium. These oscillations are being spread through the crystal at some finite speed *c* (that speed is not the speed of light!). What else do we know? We know that the propagation of the sound waves could be described via by a typical wave equation:

$$\frac{\partial^2\varphi}{\partial t^2} - \frac{\partial^2\varphi}{\partial x^2} = 0$$ [3]

For the sake of simplicity, we can right now ignore any potential non-linear terms and we assume that we can initialize the speed of the sound wave to 1. Contrarily to the waves of a guitar string or waves at sea, the sound waves (propagating through a crystal) are not macroscopical motions of masses. Here, the wave is just a collective manifestation of the microscopic motion of many microscopic objects and given that each one of these microscopic motions has to be described by the laws of quantum physics, the same should also hold true for the collective motion of them.

So, we can conclude at this point that equation 3 can be thought of as a quantum wave equation and from this equation we can physically interpret the quantum nature of sound. When we observe equation 3, a light bulb may go off, especially if we rewrite it while adding an additional term.

$$\frac{\partial^2\varphi}{\partial t^2} - \frac{\partial^2\varphi}{\partial x^2} = m^2\varphi$$ [4]

Equation 4 depicts the well-known 1D Klein Gordon equation. The only difference is that the mass term is absent (mass = 0 with units c = $\hbar$ = 1) and therefore the usual quantization procedure can now occur. By modifying the energy-momentum relationship (as mass = 0), we get:

$$\begin{gathered} \omega^2 = k^2 + m^2 \Rightarrow \\ \Rightarrow \omega = \sqrt{k^2 + m^2} \Rightarrow \\ \Rightarrow \omega = \sqrt{k^2} \Rightarrow \\ \boxed{\omega = k} \end{gathered}$$ [5]

This implies that the sound waves inside a crystal behave exactly like photons do, the same energy momentum relationship exists here. The reference to photons is important here as quantum waves do travel at the speed of light. The fact that *phonons* (sound particles) behave like particles makes a lot of sense as the crystal's electrons are exposed to multiple elastic collisions with the phonons propagating through the crystal, causing them to lose (in every smash) a small fraction of their momentum.

However**,** phonons do not behave precisely like photons. What is indicated by this is that phonons show this behaviour only when inside a crystal and their existence can therefore be thought of as a collective manifestation of the crystal and its atoms' oscillations. This implies that there is no point in theorizing about phonons in a vacuum and that is why phonons are categorized as quasi-particles (particles that exhibit all the characteristics of particles but cannot exist outside the crystal). We can therefore solve equation 3 and expand to plane waves to conclude:

$$\varphi(x,t) = \sum_k \alpha_k \frac{\exp(i(kx - \omega_k t))}{\sqrt{L}\sqrt{\omega_k}} + a_k^\dagger \frac{\exp(-i(kx - \omega_k t))}{\sqrt{L}\sqrt{\omega_k}}$$ [6]

where L (in equation 6) depicts a normalization factor arising from:

$$k_n = \frac{2\pi n}{L}$$ [7]

The energy of the state equals to $E_k = N_{k\omega k}$ where N_k depicts the particle number operator which is equal to:

$$a_k^\dagger a_k$$ [8]

Essentially, the eigenvalues n_k of the operator N_k are counting the number of phonons present in the particular quantum state where the phonons contain energy ωk and momentum k. In essence, the states of the quantized sound field are basically similar to the Klein-Gordon field:

$$|k\rangle = a_k^\dagger|0\rangle$$
$$|k_1, k_2\rangle = a_{k_1}^\dagger a_{k_2}^\dagger|0\rangle$$ [9]

The first term in [9] corresponds to the state of a phonon of momentum k being created in a vacuum state while the second term in [9] references the state where two phonons of momenta k1 and k2 are created. Ergo, this all now corresponds to a simplified quantum Fourier transform of phonons, also known as showing the quanta of the sound field. In other words, this research does have a link into the quantum world and hence the potential standing wave behaviour of quantum ripples should be further evaluated as it could lead to new insights into the energy distribution of the cosmos. It is strongly believed that while simple sine and cosine waves basically depict infinity, standing waves do provide a form of order that is trusted to theoretically be at the source of better understanding how the chaos in the cosmos can actually function when it comes to dispersing energy.

By implication, the findings appear to support Quantum Ripple Theory (QRT) and hypotheses 1-4, namely:

- Hypothesis 1: Decoherence provides the link (possibly theory) between Classical Physics and Quantum Mechanics.
- Hypothesis 2: Decoherence is the result of interference.
- Hypothesis 3: Detection is a form of interference leading to decoherence, and detection equates to observation.
- Hypothesis 4: Entanglement correlation is due to quantum ripple interference, with measured objects (particles) being measurements of the same quantum ripple, therefore they correlate independent of distance and require no information passing of any sort.

Thus, if QRT and hypotheses 1-4 can be verified by conducting further simulations with more advanced and scalable hardware, a new look (from a different angle) at the Standard Model may be appropriate, assessing the possibility that QRT could be considered as a stage or precursor to the Standard Model and hence could be viewed as a prerequisite, or a potential addition to it.

Lastly, the application of the Fourier Transform to the simulation data (sound waves), and the energy momentum relationship between phonons (sound particles) and photons (light particles), may be further evaluated to assess the potential link that some form of light could be considered as an original energy source.

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