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Revival of the particle concept of Sound

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Abstract

There are two schools of thought for the concept of sound as revealed from history. According to one concept, sound is caused by release of tiny subatomic particles from matter; propagation of particles through a medium and interaction with other existences at a distance such as the ear of living beings. The second accepted sound is caused by vibration of a source communicated by waves in a medium and capable of affecting any existence at a distance. The above hypotheses stand on different footings which cannot be harmonized to develop a single theory for sound. The reality being one, only one concept of sound is real. The wave concept of sound is well accepted leaving behind the particle concept. At times, reality is suppressed if it is not promoted properly. It is something like an honest client sometimes loses the case due to the weak argument of his pleader. Now phonons (particles) are conceptualized as the quantized units of vibrational energy in solids. The phonons are formally integrated into solid-state physics, describing sound as a quantum mechanical phenomenon in materials. Thus, both particle concept and the wave concept are accepted allowing the dual concept for sound. This author has shown that mechanical waves of sound frequency produced in air by oscillation of a plunger/piston does not produce sound which straight away disagrees with the wave concept of sound. Hence, the particle concept of sound needs to be augmented by realizing additional qualities in sound particles in the light of reality so that the particle theory alone can justify 1) why sound is not heard from outside the ringing bell in vacuum jar and 2) how different phenomena of sound including diffraction and interference can be explained from the particle concept of sound. Quantum Acoustics and the interpretation of solid-state physics on sound conceptualizes hypothetical sound particles as phonons. Thus, the particle concept is inevitable in advance analysis of sound in solid state. If sound particles have natural existence in the structure of solid then it is rational to conceptualize the same instead of formalizing the hypothetical phonon. It is further necessary to identify new qualities of sound particles for understanding interference and diffraction thereby dispensing the duality. The new concept of sound particles as envisaged here carries fractional charge. This paper shows how the sound-wave concept is far from reality and explains why the sound particles produced in vacuum cannot cross the wall of the vacuum chamber. The new particle theory of sound has scope of explaining the diffraction & interference phenomenon of sound and is in harmony with solid state physics.

Key Words: *Particle concept of sound, Wave concept of sound, Phonons, Vibrational energy, diffraction, interference, Solid state physics, Quantum Acoustics.*

Historical development on concept of sound

- Pythagoras in **6th century BCE** associated sound with the movement of objects but did not formalize a particle-based model.
- Democritus in **5th century BCE** speculated that all matter, including sound, could consist of tiny particles, hinting at a particulate understanding of various phenomena.
- Aristotle in **4th century BCE** correctly suggested that a sound wave propagates in air through motion of the air.
- Lucretius in the 1st **century BCE** described sound as being made up of small, fast-moving particles that interact with air and the ear.
- Vitruvius, in **1st century BCE** determined the mechanism of transmission of sound waves.
- Boethius in **6th century AD** suggested that the human perception of pitch is related to the physical property of frequency.
- Marin Mersenne in **1637** studied the vibration of stretched strings; the results of these studies were summarized in the three Mersenne's laws.
- Galileo Galilei in **1638** identified the role of frequency in determining pitch.
- Pierre Gassendi in the 17th **century** theorized that sound was transmitted through air via particle impacts, akin to billiard balls colliding.
- René Descartes in **1644** proposed that sound involved the motion of tiny particles in the air.
- Athanasius Kircher in **1650** made the first bell-in-vacuum experiment and showed sound is not through motion of particles.
- Robert Boyle in **1660** demonstrated that sound requires a medium (air) to travel, confirmed that it is not transmitted in a vacuum.
- Marin Mersenne in **1665** calculated the speed of sound in air, marking the first quantitative analysis of sound waves.
- Christiaan Huygens in **1678** proposed the wave theory of light, indirectly influencing later scientists to consider sound as a wave phenomenon.
- Robert Hooke in **1681** first produced a sound wave of known frequency, using a rotating cog wheel as a measuring device.
- Isaac Newton in **1687** suggested that sound travels as a series of compressions and rarefactions in air but also modeled sound propagation mathematically similar to particle motion.
- Isaac Newton in the 1700s attempted to calculate the speed of sound in air using his laws of mechanics, he supported the idea of sound as a pressure wave.
- Daniel Bernoulli in **1738** explored the idea that sound could result from the motion of air particles in a fluid-like model.
- Jean-Baptiste le Rond d'Alembert in **1747** derived the wave equation, providing a mathematical description of sound waves.
- George Stokes in **1827** refined the understanding of wave propagation in fluids and gases, improving the accuracy of sound speed calculation.

- Hermann von Helmholtz in the 1850s explored the physics of sound and its perception, introducing resonance and analyzed the harmonics of vibrating systems.

Rejection of the Particle Theory and Acceptance of wave theory

The particle theory of sound was rejected due to several reasons:

1. Interference and Diffraction phenomenon of sound is incompatible with particle motion.
2. Sound reflects and refracts predictably, better explained by wave propagation rather than discrete particles.
3. Particle theory could not explain why sound requires a medium (air, water, solids) for propagation.
4. Euler and Bernoulli developed mathematical models treating sound as pressure variations in air, matching experimental data more accurately.
5. The development of the wave equation provided a comprehensive framework for predicting sound behaviour.
6. Experiments of Thomas Young and Augustin-Jean Fresnel demonstrated wave interference patterns, solidifying the wave model.
7. Robert Boyle showed, sound could not travel without air, reinforcing the need for a medium, which is well explained by wave theory.

Today, sound is understood as a mechanical wave involving oscillations of particles in a medium without the transport of particles themselves.

Further Development on Sound

While sound is fundamentally accepted as a mechanical wave propagating through a medium. In quantum context, it is described through phonons, demonstrating particle-like behaviour. The wave-particle duality of sound is accepted in fields such as ultrasonic, nanotechnology, and quantum acoustics.

Why again the particle model of sound at this stage?

The observed pictures of an object viewed from different angles using visible light, ultraviolet ray and x-ray are different though the object remains the same for different observations. Thus, one cannot draw a complete conclusion on the reality of the object from any single view even though each view of the object is a reality. We need to integrate all views of the object for the comprehensive understanding of the object. This philosophy is applicable in exploring the reality of any object or event.

Looking into the history of sound we notice, there are two schools of thought for the science of sound: one assumes sound as made up of small, fast-moving particles that interact with air & the ear and the other presumes sound as a mechanical wave involving oscillations of particles of air medium. These two concepts of sound are of diverse nature; hence it is not possible to unify the concepts for understanding the reality. We cannot accept both the concepts since duality is not the reality of nature. When we fail to perceive the reality of sound in an unseen domain from one single concept, we introduce additional concepts to somehow understand different aspects (phenomena) of sound. This led us to believe, **duality of sound is also a reality of nature**. Now the wave-particle dual concept has proliferated in physics of sound, light and electrons in atomic structure and became established beyond doubt. On the other hand, the reality of nature is perceived as unchanging truth (without duality) in macro domain science, Vedic science, Vedanta, puranas and Bhagavat Geeta. Hence, to help achieve success in unification of sciences, the dual concept is required to be reduced to a single feasible concept. Thus, it is either the particle theory of sound or the wave theory sound corresponds to reality leaving the other as purely hypothetical. To ascertain the reality, both particle and wave concepts need to be examined properly. It is absolutely necessary to examine the circumstances in which sound particles are not propagated through vacuum before rejecting the particle theory of sound. Similarly, it is necessary to justify why sound is not produced by reciprocation of a piston in an open-ended cylinder or oscillation of an electromagnetic plunger that produces waves of sound-frequency in air before accepting the wave theory of sound. The author has provided justification as to how the sound particles generated inside vacuum cannot enter the wall of vacuum chamber. On the other hand, it is difficult to explain why sound is not produced by simulating forced waves of sound-frequency in air. Since waves in air do not produce sound, the wave theory of sound is not a reality and it should not be pursued for theoretical analysis of sound. It is no less a mystery as to how the erroneous wave theory of sound is capable of explaining diffraction and interference of sound. This is possible only when the frequency parameter of a hypothetical sound wave goes to proxy some intrinsic property of sound particles. This author has identified the new significance of electric charge where charge appears in matter (particles) in non-equilibrium state of mass-space association relative to that of its surrounding. The new concept of charge [1] allows existence of fractional charges in particles of matter. The frequency of sound waves in reality goes to describe the charge potential state of real sound particles.

Discussion on particle concept of sound

Sound particles present in the micro structure of solid (interstices of atoms & molecules and in grain boundary) are relatively loosely bonded with the microstructure. The strength of bonding of sound particles varies depending on the nature of

microstructure of solid and the position of sound particles in the microstructure which is a material specific property. If a sound responding solid is hammered then the microstructure as well as the surface of solid would vibrate liberating some sound particles from the structure. The released sound particles would enter the air medium and move through the medium making collisions with atoms and molecules of the air medium thereby developing a distribution pattern of number density of sound particles in the vicinity of the sound source. Depending on the position of a sound receiver in the said vicinity, it receives different extent of sound particles thereby records different loudness of sound. The surface-vibration of solid generates longitudinal waves in the adjacent air medium which die down within a short distance from the source due to the damping property of the air medium. In any case, the distance of propagation of longitudinal sound waves is much less than the range of sound propagation. The diaphragm of a sound receiver vibrates by the impact of sound particles which in turn form waves in air-medium. The waves at source and at the receiving end make an illusion, as if the waves are travelling right from the source up to the reception point without break.

In vacuum medium the mean free path is longer for the sound particles hence sound particles would travel faster due to minimum collision with atoms and molecules of the air medium. Then, why do the sound particles emitted from a ringing bell in vacuum do not come out of the chamber? It implies, some unknown phenomenon prevents the entry of sound particles through the walls of the vacuum chamber. In the absence of the knowledge of this unknown phenomenon, the fact could not be justified. This was the primary reason why scientists developed faith in the wave theory of sound. The unknown phenomenon is discussed below.

Every matter particle/body has an extra-nuclear space structure surrounding the particle/body due to mass-space attraction [2]. This phenomenon is well revealed in the celestial body system and atomic system [3]. The same phenomenon also holds good for sound particles. The size of the extranuclear space structure of sound particles is a function of both mass of the nucleus and background space density (pressure), similar to the size of a balloon that depends on internal pressure and external pressure. The sound particles released from the electric bell in vacuum have enlarged extranuclear structure much larger than that in atmospheric air. The solid wall of the vacuum chamber has micro-porosity due to interatomic gaps. The extranuclear space structure of sub-micro sound particles in atmospheric air are of small size which is less than the dimension of micro porosity of the solid wall of the vacuum chamber. Hence the sound particles easily pass through the wall of the vacuum chamber when air is not evacuated from the chamber. But when the air of the chamber is evacuated, the size of the extranuclear space structure of sound particles becomes very large, exceeding the dimension of porosity in the solid wall. The sound particles with increased extranuclear

space structure cannot pass through the wall of the vacuum chamber. Hence, no sound of a bell is heard from outside the vacuum chamber. Therefore, the sound produced by an electric bell inside the vacuum chamber propagates up to the wall but fails to penetrate the wall. Hence, no sound is heard from outside the chamber. This gives the misconception that sound does not travel through vacuum.

Sound is not propagated through wave

All forms of solid have microstructure composed of micro atomic particles. The micro domain particles also have micro-microstructure composed of micro-micro domain particles (light particles) [4] Many subatomic particles below the range of known microparticles and above the range of micro-micro particles (light particles) have placement in interatomic space in the complex structure of solid. Some of these particles fall in the range of sound particles. Depending on the nature of the microstructure and locational sites of sound particles in the micro structure of solid, the bond-strength and charge state of sound particles have different values.

If we hammer a bell-metal, the microstructure of bell metal vibrates at different frequencies depending on the impact of the hammer. Due to the structural vibration, the surface of the bell-metal also vibrates. The vibration of the surface of the bell-metal interacts with the air medium in contact with the surface forming waves in the medium. Due to impact of hammer on bell-metal the following dynamic phenomena occurs:

1) The sound particles are released from the structure of the bell-metal and move into the medium.
2) Waves are formed in the air medium by interaction of vibrating surfaces of the solid which are short lived.
3) We hear sound while remaining in the air medium at a distance from the source.

One class of thought is that propagation of sound occurs by motion of sound particles through the air medium and interacts with the ear at a distance. The other class of thought is that the wave formed in the medium by the bell metal propagates in the medium and the wave interacts with the ear. The reason why the sound particles produced by the electric bell in the vacuum chamber cannot come out of the chamber has already been discussed. In fact, there is no problem for the motion of sound particles through vacuum medium but faces problems in entering into the wall of the vacuum chamber. To re-establish the reality of sound waves a different experimental setup is designed (Fig.1).

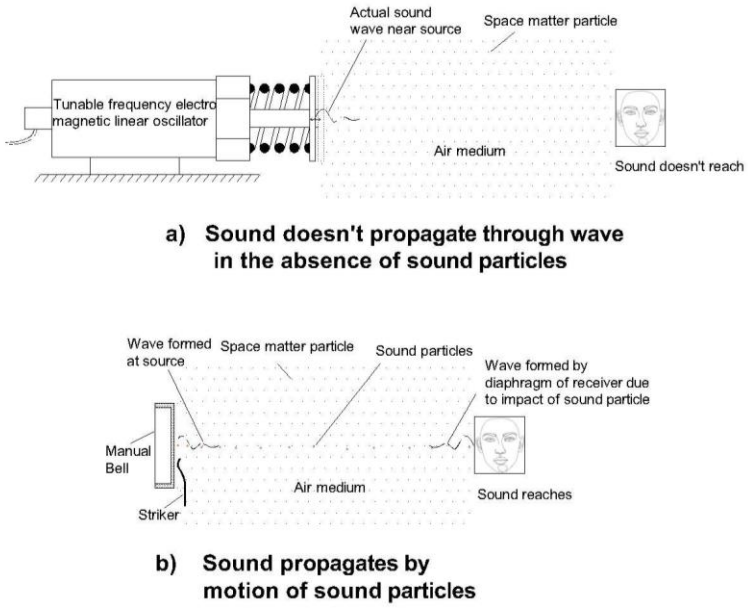


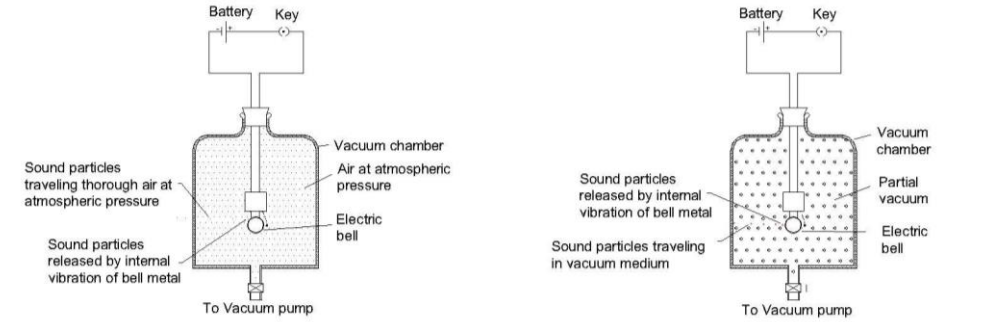
Fig.1 Schematic view of sound propagation by motion of sound particles and not by wave in air medium

Where the matter produces waves without release of sound particles. The experiment shows no sound is propagated even when the longitudinal waves are produced in the medium by oscillation of piston/plunger. Hence, sound is not propagated through wave motion in the medium. The explanation of diffraction and interference phenomenon of sound from wave theory of sound is null and void when sound is not propagated by wave motion. The quantum Acoustic and solid-state physics leads to particle-like description of sound. If sound particles are a reality then one should realize the same directly and not through quantized units of vibrational energy and accepting wave particle duality. If the hypothetical concept of sound waves promotes understanding of diffraction and interference then there is no reason why the real sound particles cannot explain these phenomena. In reality, the so-called frequency of sound waves is the indirect description of some intrinsic property of sound particles. There is no difficulty in conceptualizing the charge and charge potential of sound particles from the new understanding of charge through non-equilibrium association of mass and space in a particle relative to that of the surrounding. A new charge state of sound particles has scope of understanding diffraction and interference.

Reality in sound production and motion

Generation of a forced wave motion in air medium by oscillation of a substrate doesn't produce sound, thus sound is not communicated through wave motion in air medium. Hence, sound particles are released by vibrating the microstructure of matter where the macro body also vibrates. The vibration of microstructure releases sound

particles from the complex microstructure that moves outwardly to reach the receiver at a distance. The vibration of the surface of the body translates the vibration to the air medium in contact with it creating waves in the medium. The amplitude of the wave dies down within a short range of distance due to the damping property of the air medium. But the sound particles continue to move longer distances, reaching the receiving end where the receiver is made to vibrate due to the impact of the sound particles. This in term generates waves in the medium at the receiving end which again dies down after a short distance. An observer experiencing only the partial information of wave motion in air at source and receiving end gets easily biased with the concept that the wave generated at source travels all the way up to receiver end (Fig.2).



a) **Sound particles with reduced extra nuclear space structure in air easily enter and pass through the wall material**

b) **Sound particles with enlarged extra nuclear space structure in vacuum fails to enter the wall material**

Fig.2 Schematic picture of experiment on propagation of sound through air and vacuum

The air-medium is essentially space containing atoms and molecules as space matter particles. Hence, the sound particles released from the source make collisions with space matter particles causing further release of identical sound particles from secondary source (space matter particles) and causing avalanche of absorption and generation of sound particles. Due to the above collision interaction, a dynamic number density distribution of randomly moving sound particles occurs in the vicinity where the density of sound particles decreases outwardly from the source. Thus, the loudness of sound is decreased with the distance from the source. Besides random motion of sound particles there exists directional group motion which develops directional property of sound.

Conclusion

Recent development of Quantum Acoustics and the interpretation of solid-state physics on sound conceptualizes hypothetical sound particles as phonons thus introducing the wave particle duality for sound. This concept has application in different fields such as ultrasonic, nanotechnology, and quantum acoustics. In the present paper it is seen that sound propagates through motion of particles and not waves. Thus, the duality concept of sound is reduced to motion of sound particles carrying fractional charge. The new interpretation of sound particles carrying fractional electric charge has far reaching consequences in removing duality from the theory of light with the new consideration of non-electric charge (photonic charge).

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