



News and Views

Beware of New Ideas: Views on the Wave-Particle Duality

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The Josephson junction consists of a thin layer of insulating oxide material between two superconducting electrodes and is used mainly in measuring magnetic fields. In 1973, physicist Brian Josephson shared in the Nobel prize for physics “for his theoretical predictions of those phenomena which are generally known as the Josephson effects” [1]. At sufficiently low temperatures, electron-pairs pass through the insulating portion by quantum tunneling [2].

Josephson, then a 22-year-old research student at Cambridge University, had a debate in 1962 with John Bardeen who had shared the 1956 Nobel Prize in Physics with William Shockley and Walter Brattain for the invention of the transistor. Bardeen would share a second Nobel prize in 1972 with Leon Cooper and Robert Schrieffer for their 1957 solution (the BCS theory) of the long-standing riddle of superconductivity [3].

In an e-mail sent in the year 2000, Josephson offered the admonition: “*Beware ye, all those bold of spirit who want to suggest new ideas.*” His words apply to his younger self who, in 1962, was “bold of spirit” and “want(ed) to suggest new ideas”. What did he need to beware? Possibly – older scientists with established ways and conservative views ... perhaps even his older, settled-into-tradition, self.

Throughout history, older scientists have always argued against new ideas – and while many new ideas are indeed wrong, others which may seem to defy the laws of physics always win in the end. A quote attributed to Max Planck, the physicist who was a pioneer of quantum theory, says “*A scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die and a new generation grows up that is familiar with it.*”

Those words may appear harsh but they remind us that elder scientists, even today and in future years, are – besides being vital teachers with much experience – subject to the conservatism which affects every person.

John Bardeen once commented – “*The idea of paired electrons, though not fully accurate, captures the sense of it.*” [4]. Since paired electrons is not fully accurate, the BCS theory of superconductivity needs a further consideration. That factor would be to focus on the wave portion of quantum mechanics’ wave-particle duality instead of on particles. This discussion suggests that both the combination of particles/antiparticles, and the quantum pressure of interacting gravitational and electromagnetic waves, are valid interpretations of:

- a) the Hawking radiation emitted from black holes;
- and
- b) superconductivity;

Referring to the particle-wave duality in (a), "particle/antiparticle pairs" are used in the interaction proposed by Stephen Hawking regarding black holes' Hawking radiation. The "wave" component of duality follows a 1919 paper by Albert Einstein [5] which was updated in 2023 to show that Einstein's paper accounts for the mass and quantum spin of not only the weak and strong nuclear forces' bosons, but also of the Higgs boson [6,7]. Interaction of gravitational and electromagnetic waves creates pressure that can be interpreted as particles/antiparticles.

In relation to superconductivity not using the second half of duality, i.e. paired electron particles, the matter waves and wave mechanics of Louis de Broglie (1892-1987) are used. Electron waves could maintain the superconducting circuit by travelling through the spaces between the atoms in the oxide material. This agrees with a paper in the journal Nature [8], which says quantum tunneling is not instantaneous, but a result of particles' wave function.

References

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