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The Wave Function Must Represent a Physical Wave

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Abstract

The Einstein relationship, the de Broglie relationship, and the Born rule are considered fundamental in quantum mechanics, yet in mathematical logic, as usually written, they are not self-consistent [1]. On the other hand, each has had great success individually at predicting the outcome of experiments. It is shown here that the lack of self-consistency can be remedied if it is assumed the wave is physical, and the equation for the wave, and not the particle, is actually the Schrödinger equation.

It would generally be considered that non-relativistic quantum mechanics is fully described through the Schrödinger equation, in which the expectation energy of the particle is related to a wave function ψ. Interestingly, the Schrödinger equation as originally written is fully deterministic and without uncertainty. The Uncertainty Principle for the particle is considered to arise from the wave nature defined by the Schrödinger equation, yet it is generally held that ψ is a mathematical abstractions and not physical. It shall be argued here that that is wrong.

It may come as a surprise to some that the physics that led to three Nobel prizes are not mathematically self-consistent. The first is the Einstein relationship $E = h\nu$, which, recalling that the frequency is the reciprocal of the periodic time τ can be rewritten [2].

$$E\tau = h \tag{1}$$

The second is the de Broglie relationship [3].

$$p\lambda = h \tag{2}$$

The third is the Born rule in which the value of $\psi.\psi^*$ at a point gives the probability of locating the particle at that point [1].

The phase velocity u for a wave is given by the distance travelled for the wave to repeat divided by the time used. The wavelength defines a distance travelled in a period, hence

$$u = \lambda/\tau = (h/p)(E/h) = E/p \tag{3}$$

(3) is not original, but the significance seems to be ignored. Consider a particle moving from A to B under Newton's first law, i.e. no accelerating forces. The only legitimate energy term is the kinetic energy, and we have, when we substitute for energy and momentum and cancel the mass and h

$$u = v/2 \tag{4}$$

Therefore the Born rule cannot give the probability of locating the particle because the particle and the wave are never in the same place. The three relationships are not self-consistent.

We can avoid this *only if* we make the energy term in (3) twice the kinetic energy. The question is, how do we do this? The simple answer is to revisit the Schrödinger equation as originally written. That equation relates the energy to a wave function. It is generally held that the energy is that of the particle, but the problem goes away if the energy in the Schrödinger equation is actually of that of the wave, which happens to equal that of the particle, and is defined by the energy of the particle. That requires the wave to be physical, as in the pilot wave, and to have a specific energy, as in the guidance wave variant [4].

Accordingly, it is concluded that the Schrödinger equation defines a physical wave, and only defines the expectation energy of the particle because the particle is guided or piloted by the wave.

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