Re: IS this for real?!

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"Mok−Kong Shen" <mok−kong.shen@t−online.de> wrote in message
news:cfshkrdj03$1@news.t−online.com...
>
>
> *Douglas A. Gwyn wrote:*
>
> *[snip]*
> > *the Heisenberg uncertainty principle, which is a*
> > *direct consequence of a standard fact about Fourier*
> > *transforms.*
>
> *Could you kindly elaborate this a little bit in a way*
> *that a layman can understand? Thanks.*
>
> *M. K. Shen*
>

Suppose you have a sine wave (e.g. sound) that varies in freqency over time, and you ask what the frequency, f, is at some instant in time, t. If you take a broad time window around t, you can measure the frequency fairly accurately by counting the number of cycles, but there is an uncertainty about t (call this dt). If you decrease dt, then you increase the uncertainty, df, in the frequency. The uncertainty principle says that the best you can do is df*dt >= 1.

In quantum mechanics, there is another (less intuitive) Heisenberg uncertainty principle which says that you cannot know the position and velocity of a particle with accuracy greater than Planck's constant, h, about 10^−34 Joule−seconds. The same rule applies to any other combination of measurements with the same units, such as angular momentum. In fact, if you measure the spin of a proton, neutron, or electron, you will always get exactly h/2 or −h/2 along whatever axis you decide to use in your measurement. These correspond to the spin axis aligned with your chosen orientation and spinning in one direction or the other.

According to quantum mechanics, the angle between the actual spin axis and your detector determines the probability of the two possible outcomes. If the spin axis is at 90 degrees to your detector, then the outcome is random. (I believe the probability is (1 + sin a)/2). You can generate such particles and confirm this experimentally for any angle and get results in agreement with quantum mechanics.

Now if a particle with 0 spin (say a neutral pion) decays into two particles with spin 1/2 (say a positron and electron), then the classical law of conservation of angular momentum says that the spins must have exactly opposite orientations. The orientation of one particle is random, and the second is exactly opposite. You can confirm this experimentally. Now if you place two detectors with their measurement axes parallel, you will always observe opposite spins, no matter how you orient the pair of detectors.

Quantum mechanics doesn't offer a satisfying explanation for this. If both particles are at, say, 45 deg. to the detector, and the detectors are independent, then there should be some nonzero probability that both measurements would show spins in the same direction. But this never happens. If you know what happens at one detector, then the other outcome is completely determined, as if the particles are always emitted with spins parallel to the detectors. It can't be the case that the detectors affect each other somehow, because that would require transmitting information faster than the speed of light. A variation of this experiment is known as Bell's inequality.

More generally, quantum mechanics defines a wave equation whose density determines the probability of detecting a particle. For example, you can compute the electromagnetic wave around an antenna, and quantum mechanics will tell you the average rate of photon observations. However, the theory only works if you know nothing else. The theory is incomplete because if you know something about other particles, then you can use classical mechanics to constrain what you might observe. We say that these particles are entangled, but if quantum mechanics is truly a probability function, then there doesn't seem to be a satisfactory explanation for how entanglement works.

I hope my understanding is correct.

−− Matt Mahoney