Wave-Particle Duality

Some things we are happy to call matter – tables, chairs, squirrels. Some things we are happy to call waves – sound, water ripples, Mexicans. However some things have lead to long arguments about what they are. Light is a significant example.

Back at the end of the 17th century Newton believed that light was made up of little particles (he called them corpuscles) and so was matter. Huygens believed light was waves. At the time Huygens won the debate with a series of experiments demonstrating how light did indeed behave as a wave – it could spread out through a gap (diffract).

The matter (ha ha) seemed settled until we started being able to study the sub-atomic realm.

In 1905 Einstein published a paper on an obscure phenomenon called the 'photoelectric effect'. It had been observed that when light was shone on some charged metals they lost their charge. However it wasn't all metals or all types of light. Zinc, for instance, retains its charge when white light is shone on it but loses it when ultraviolet light (the type used in tanning booths) is shone on it. This couldn't be explained if light were a wave. Einstein realised that this was proof that Newton had been right and light was indeed made of particles. He called them 'quanta of light' or photons. The branch of physics called quantum mechanics was born.

But hang on, Huygens' experiments proved that light was a wave. Those experiments still work today. So what is going on; surely they can't both be right?

Well actually they are. It seems that light is both a wave and a particle. It just behaves differently depending on the circumstances. Sound familiar? Yes, it is just like mass-energy and space-time. In this case the principle is called 'wave-particle duality' and we say that light is made of wavicles (from WAVe-partICLES).

So, if we strongly believed that light was a wave but it turned out to be made of wavicles, what about things we strongly believed were particles?

In 1906 JJ Thompson received a Nobel Prize for proving that electrons were particles. He had done this by showing they had quantised mass and charge – they came in fixed lumps rather than being able to have any amount. In 1937 his son, George Thompson, received a Nobel Prize for proving that electrons were waves. Nowadays we recognise that they too are wavicles and both Thompsons were correct.

1. How did Huygens prove light was a wave?
2. What is the photoelectric effect?
3. What was the conclusion from the photoelectric effect?
4. What is a wavicle?
5. What did the Thompsons show about electrons?