

# The Thomsons – father and son discoverers of the electron

## Topics

Atomic structure, chemists

Joseph James ('JJ') Thomson is well known for his discovery of the electron, a negatively-charged sub-atomic *particle* of mass  $1/1840$  of the mass of a hydrogen atom. This discovery took place in 1897 and JJ was awarded the 1906 Nobel Physics Prize for his achievement.

What is less well known is that JJ's son, George Paget Thomson also won the Nobel Prize (in 1937, shared with Clinton Davisson) for showing that a beam of electrons could be diffracted. Diffraction is the spreading out of a beam as it passes through a small gap and is a property of a *wave*, not a particle.

The two discoveries are not contradictory; they are an example of wave-particle duality, an aspect of quantum mechanics which means that all sub-atomic particles (in fact all particles) show aspects of particle behaviour and wave behaviour *at the same time* and that all waves also can behave like particles. Some scientists have used the word 'wavicle' to describe this. Some examples of wave-particle duality are:

### 1. Light

When a beam of light passes through two narrow slits the two beams spread out from the slits and interfere with one another to produce an interference pattern of dark and light stripes. The dark stripes are where the peaks of one light wave coincide with the troughs of the other and cancel out. The light stripes are where two peaks coincide and add together. Interference can only be explained in wave terms.

When a beam of light shines on certain metals, an electron is ejected - the so-called photo-electric effect. This can only be explained using a particle model of the light in which a beam of light is thought of as being composed of photons.

### 2. Electrons

Diffraction of electrons (above) can only be explained if electrons are thought of as waves.

In the electron gun of a mass spectrometer, a beam of electrons ejects electrons from atoms or molecules of the sample to form positive ions. This can only be explained if the electrons are thought of as particles.

There is no contradiction about wave-particle duality, nor is it a question of particles sometimes behaving as waves and *vice versa*. It is simply that our everyday classification of phenomena into 'wave' and 'particle' breaks down when we are considering things on a sub-atomic scale. Everything has some aspects of both, hence the name wavicle.

Perhaps surprisingly there are two other father-and-son science Nobel Prize-winning pairs and one mother-and-daughter one. William Henry Bragg (father) and William Lawrence Bragg (son) shared the 1915 Physics Prize for their discovery of X-ray diffraction. Niels Bohr took the 1922 Physics Prize for his model of the structure of the *atom* and his son Aage the 1975 prize for work on the structure of the *nucleus*. Marie Curie won two Nobel Prizes (1903 Physics and 1911 Chemistry) and her daughter Irène Joliot –Curie won the 1935 Physics Prize. The Curies were a

remarkable family for scientific honours – Marie shared her first prize with husband Pierre, and Irène shared hers with her husband Frédéric. All the Curies' prizes were for work on radioactivity.