THE ATOM AND THE BRIGHTON ROCK

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A NEW PERSPECTIVE BY K. STRANG

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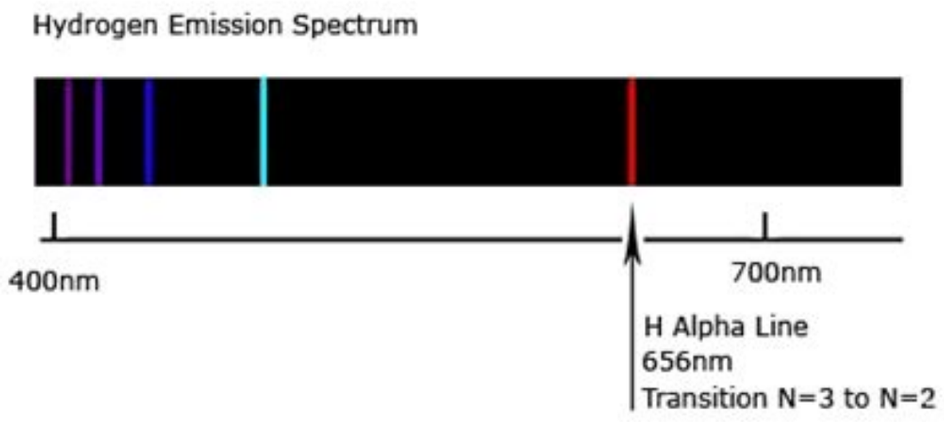
The Hydrogen Emission Spectrum

One of the so called mysteries of quantum mechanics is the identical emission spectrum of each atom of each element when heated. See Figure 1 below for the emission spectrum of hydrogen. Once again physicists have fallen into the trap noted by Alfred North Whitehead of mistaking the map for the territory. Of course if one believes at the outset that one is describing two separate atoms of hydrogen then it is astonishing that they are absolutely identical. If on the other hand, one believes that one is looking at a fraction or a part of a continuous and consistent whole then each part will have the same qualities as any other part. Take the analogy of the Brighton rock from the Graham Greene novel which is the same no matter where you bite through it.

It has to be kept in mind that Bohr's model of the hydrogen atom with only two sub-atomic particles could not be adapted to suit Helium or any other atom with multiple electrons. Broadly, he encountered the same problem as in cosmology, namely the three body problem.



What's wrong with the particle theory of matter

The greek philosophers Leucippus and Democritus around 420 BC are usually credited with the first atomic theory of matter.

'Their point of view was remarkably like that of modern science . . . they believed that everything is composed of atoms, which are physically but not geometrically indivisible; that between the atoms there is empty space; that atoms are indestructible; that they always have been, and always will be, in motion; that there are an infinite number of atoms and even of kinds of atoms, the differences being as regards shape and size.' [The History of Western Philosophy, Bertrand Russell, Unwin Paperbacks 1979, p83]

Centuries later Newton (1642–1727) held that the defining characteristic of the world was extension, supported in absolute space and held a corpuscular theory of matter which was part of his overall mechanistic view of the world. This was criticised by Leibniz (1646–1716) on a number of grounds, but principally:

(i) based on the Identity of Indiscernibles, any two things which are differentiated only by time and space are identical. So applying this to modern atomic theory, as all atoms of the same element are identical (leaving aside isotopes) then they cannot have separate existence. The mechanistic analogy of two identical billiard balls colliding and then moving away from each other, is a reversible process i.e., if a film was taken of the collision it could be played forwards and backwards and would look the same. This characteristic is taken to be evidence refuting the second law of thermodynamics, that entropy and the arrow of time only goes in one direction.

' . . . there are no purely extrinsic denominations, because of the interconnexion of things, and that it is not possible for two things to differ from one another in respect of place and time alone, but that it is always necessary that there shall be some other internal difference.' [Leibniz, Philosophical Writings, *On the Principles of Indiscernibles,* p133edited by G.H.R. Parkinson, J.M. Dent & Sons Ltd 1973 p 121]

and

(ii) that as matter is infinitely divisible and inert, it cannot form the basis of reality.

'Thus physical points are indivisible in appearance only: mathematical points are exact, but they are nothing but modalities. It is only metaphysical points, or points of substance (constituted by forms or essence), which are both exact and real; and without them there would be nothing real, since without true essences there would be no plurality.'
[Leibniz, Philosophical Writings, *New System and Explanation of the New System*, ibid]

Fast forward to J.J. Thomson (1856-1940) who is credited with the discovery of the electron in 1897. Broadly, the experiment involved passing an electric current into a tube which had a negative cathode at one end and a positive anode at the other; the current positively ionises residual gas molecules which accelerate towards the cathode and knock negatively charged cathode rays from the surface, which then travel in parallel lines to the positively charged anode creating an electric circuit. When these rays contact the glass of the tube they create fluorescence (green light). When a magnetic field was applied the cathode rays were deflected.
Why construe this clearly wave-like phenomenon as a 'stream of corpuscles'?

'In identifying cathode rays as corpuscles, Thomson adhered to the particle view of cathode rays, ostensibly because this was definite and its consequences could be predicted, whereas we were ignorant of the laws governing the ether (Thomson 1897b, p293)1. His attitude was symptomatic of the Mechanical Philosophy through which many British physicists sought a unified theory of nature. The Mechanical Philosophy was the belief that all phenomena could be described ultimately in terms of matter in motion. Thus, in investigating an unknown phenomenon such as cathode rays, Thomson's first interest was in their velocity and mass.

Earlier, during the 1880s, Thomson had pursued the Mechanical Philosophy to its mathematical conclusion. His results led him to believe that '*a theory of matter is a policy rather than a creed. Its object is to connect or coordinate apparently diverse phenomena, and above all to suggest, stimulate and direct experiment*' (Thomson 1907, p1). Thomson manipulated his theories in just this way. He seldom allowed them to be tied closely to experimental 'facts' which might limit their scope for imaginative extension to other phenomena or further experiment.' [Isobel Falconer (1999), J J Thomson and the discovery of the electron Physics Education, vol 32, pp226-231, http://iopscience.iop.org/ 0031-9120/32/4/015]

This amounts to a utilitarian approach which is perfectly valid way of proceeding, but it falls short philosophically, and led others to believe and champion an unfounded ontology.

20th Century Particle Theory

Leibniz's criticism is just as pertinent now as it was three centuries ago. If particle dynamics are replaced by Schrödinger's wave mechanics these criticisms do not apply: the interconnectedness of waves avoids the problem of differentiating two identical objects, and then speculating about what connects them. Collisions between waves are not identical when reversed and the second law is preserved.

Schrödinger summed up the philosophical position:

'Let us now return to our ultimate particles and to small organisations of particles as atoms or small molecules. The old idea about them was that their individuality was based on the identity of matter in them. This seems to be a gratuitous and almost mystical addition that is in sharp contrast to what we have found to constitute the individuality of macroscopic bodies, which is quite independent of such a crude materialistic hypothesis and does not need its support. The new idea is that what is permanent in these ultimate particles or small aggregates is their shape and organisation. The habit of everyday language deceives us and seems to require, whenever we hear the word 'shape' or 'form' pronounced, that is must be the shape or form of something, that a material substratum is required to take on a shape. Scientifically this habit goes back to Aristotle, his *causa materialis* and *causa formalis*. But when you come to the

ultimate particles constituting matter, there seems to be no point in thinking of them again as consisting of some material. They are as it were, *pure shape*, nothing but shape; what turns up again and agin in successive observations is this shape, not an individual speck of material.' [*Science and Humanism*, 1951 CUP and reprinted CUP 1996]

Schrödinger goes on to explain that he does not mean geometric shape but *gestalt* which has a wider meaning and relates more to configuration. I would hazard a guess that the atom is more akin to a non-euclidian geometric fractal than a point or a billiard ball.