THE PARTICLE MENACE PART 1

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THE SOLAR SYSTEM MODEL OF THE ATOM

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The solar system model of the atom consists of a nucleus composed of positively charged protons bound to a varying number of neutral neutrons (i.e. the varying number of neutrons for the same element produce isotopes) surrounded in shells of increasing energy levels by an equal number (to the number of protons) of negatively charged electrons. So the finished atom has no charge. Dealing with each in turn:

<u>The Electron</u>

The electron is characterised by four quantum numbers noted in Table 1 below. Bohr arrived at the first number after an analysis of the Zeeman effect: the next two were added by Arnold Sommerfeld; and the more controversial 'spin' introduced to satisfy Pauli's exclusion principle. The principal quantum number, n, describes the possible energy levels of an electron and Figure 1 illustrates the quantities of energy at each level. The electron moves between levels by either absorbing or emitting a photon of the corresponding frequency difference between levels divided by the Planck constant. Figure 2 shows the colour fingerprint (emission and absorption) of the H atom. The remaining three numbers (angular, magnetic and spin) describe the movement, orientation and an unknown variable 'spin' of the electrons at each energy level. All these description are 'quantised' in that they have definite values with nothing in between, meaning that the description for each quality is discontinuous. This is opposite to continuous wave phenomena.

According to Pauli's exclusion principle no two electrons can share an identical set of quantum numbers. This was initially a problem prior to the notion of 'spin' because the two electrons in the first energy level of the Helium atom would have identical sets of 3 quantum numbers. 'Spin' was introduced to avoid this but was controversial from the outset. See the essay *Atomic Circus: Jumps and Spins* for some background on this concept. To this day its definition is far from clear.

What is clear is that the model had to involve fresh ideas because classical mechanics could not explain amongst other things, why the electron when emitting radiation and losing energy, would not fall into the positively charge nucleus.

There are (at least) two specious pieces of reasoning related to this model that are worth noting: (i) the argument from spectral lines (the Zeeman effect and the anomalous Zeeman effect) and (ii) the argument for introducing spin – the Stern-Gerlach experiment.

Table 1

QUANTUM NUMBERS	VALUES	DESCRIPTION
n	The principle quantum number may be any positive whole number and describes the energy level	The size of the orbital or energy
ℓ	The orbital or angular quantum number can take a whole number value from 0 to n - 1	the shape of the orbital
m_ℓ	The magnetic quantum number with $(2\ell+1)$ different values between $-\ell$ to $+\ell$	the orientation of the orbital
m_s	for each combination of the above three numbers there are two possible values of the spin quantum number +1/2 -1/2	spin

Table 1The four atomic numbers

<u>(i) Spectroscopy and the Zeeman Effects</u>

The construction of this model relied on the results of spectroscopy and the unexpected irregular separation of the visible spectral lines. It was argued that classical electrodynamics would have predicted a continuous emission of radiation and the reason for the results is that the electron is 'jumping' between energy levels rather than progressing along a classical path of increasing or decreasing energy levels. This is extremely odd as it is clear that radiation is being emitted continuously in emission and absorption but some of it is in the non visible spectrum, represented by the colour black in Figure 2 above. See Figure 3 below of the tiny range the visible spectrum has within the extremes of frequencies available.

The fact that the visible lines split up further when a magnetic field was applied (the anomalous Zeeman effect) suggested further qualities of the electron, namely angular momentum and magnetic orientation and these two qualities were combined in the Stern-Gerlach experiment to 'prove' the fourth atomic number, 'spin'. A more elegant approach was championed by Schrödinger where the electron is conceived as a standing wave with an integer number of waves and as it absorbs a photon the number of waves increases, or its frequency increases: the transition is continuous and may involve frequencies outwith the visible section of the electromagnetic spectrum. The reverse would happen when the electron emits a photon. It may be in the emission spectrum that the standing wave has a transitory or still moment before it settles on a lower frequency; similarly in the absorption spectrum the standing wave undergoes a frisson of high energy before settling on a higher frequency.

Figure 1 The energy levels of the Hydrogen atom

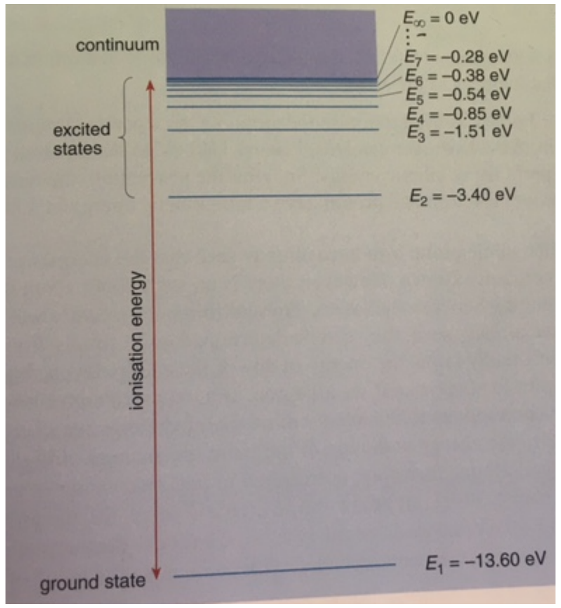
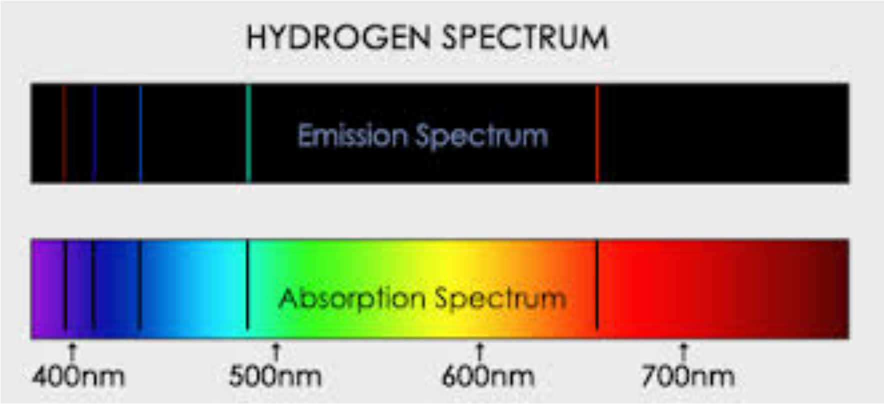


Figure 2 The emission and absorption spectrums of the Hydrogen atom



<u>(ii) Spin and the Stern-Gerlach experiment.</u>

A full explanation of the contradictions in this experiment and its failure to support the notion of 'spin' can be found in the Additional Material section. The two main points to note are (i) that this experiment conducted in 1822 pre-dated the introduction of the concept of 'spin' in 1825 by about three years and was actually designed to disprove the quantised orientation of the electron; and (ii) the experiment involved an ensemble of silver atoms and the results applied to a single electron which is 3000 times smaller than an atom. So harnessing the results is really an ex post facto attempt to lend some credibility to the otherwise dubious variable.

The Proton

The proton, though huge in comparison to the electron has the same amount of charge but opposite to the electron. As in gravity, where mass makes no difference to the acceleration, mass has no role to play in the magnitude of the charge. So too when the electron moves to a higher energy level there is no effect on charge. The occult 'strong nuclear force' holds the positively charged protons together and there is no good particle explanation (other than 'spin') as to why negatively charged electrons don't collapse into the nucleus.

Neutron

The neutron has no charge and has broadly the same mass as the proton. These particles are held together by the 'strong nuclear force' which is attractive at certain small distances limited to boundaries of the nucleus and repulsive at even shorter distances, and together form the nucleus of an atom. The combined mass is less than the sum of the mass of individual particles and this deficit is referred to as 'binding energy'. When there is insufficient 'binding energy' the nucleus becomes unstable or radioactive (most isotopes are unstable) and 'decays' by emitting energy in the form of alpha, beta and gamma rays or particles. The alpha particle is the same as a Helium nucleus (i.e. two protons and two neutrons). The beta particle is an electron created by the transition of one of the neutrons in the unstable element into a proton and electron. The gamma decay is the emission of a gamma-ray photon. There are a couple of other types of decay involving positrons, neutrinos and antineutrinos.

For the purposes of the present argument, only these three functional sub-atomic particles will be considered. The meaning of 'functional' in this context means that they have serious and intrinsic roles to play in chemistry and biology. The scientists at CERN have broken these three sub-atomic particles down into quarks, bosons, leptons, fermions with further sub-divisions, (see Figure 4 below). I do not believe these are functional in any interesting way. As an analogy, think of a car's constituent parts eg wheels, windscreen engine, battery and so on. A competent mechanic could assemble these named functional components to make a car. If however each functional component were smashed into tiny pieces and names given to each of them, what purpose would this serve? Possibly some chemists and biologists have flirted with some of the claims of the particle physicists but I do not believe that it has resulted in anything fruitful in these disciplines.

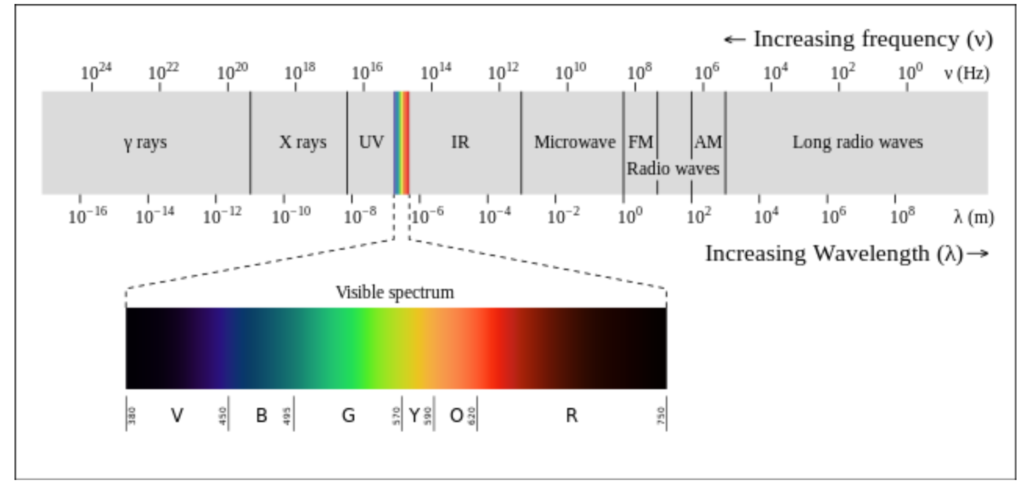


Figure 3 The electromagnetic spectrum

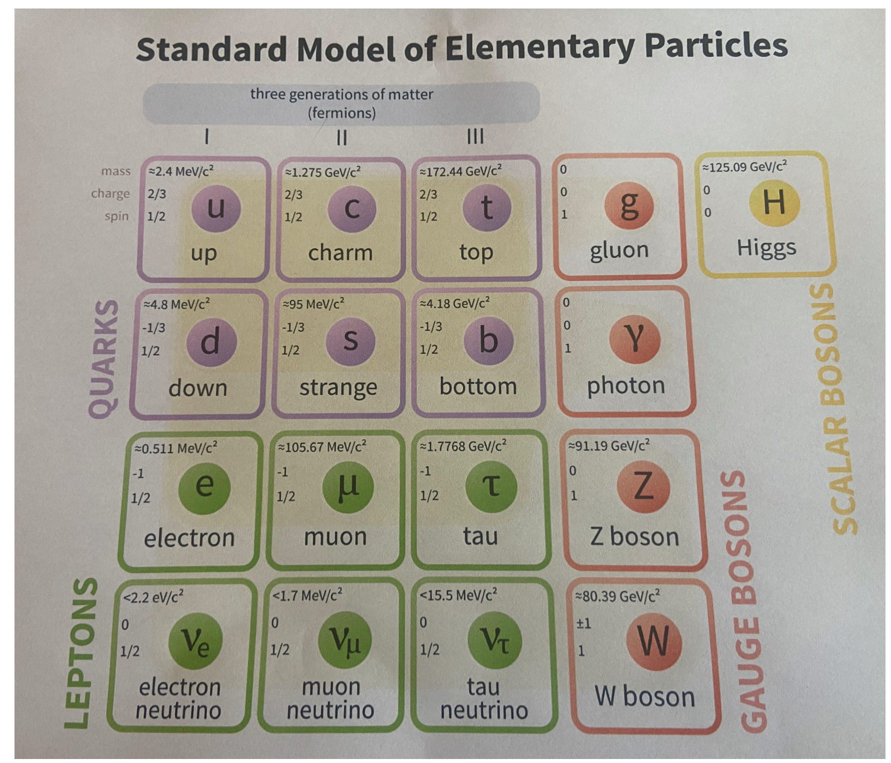


Figure 4 The standard model of elementary particles

If an atom is a bundle of concentrated energy, that energy might be more usefully described as a superposition of standing waves with 'charge' being redefined as synchronised or unsynchronised pulses or frequencies which either resonate with similar pulses in some form of harmonics or cancel them out. Schrödinger described in his six essays on wave mechanics a detailed formulation of this idea. But first, the transitional idea or bridge between classical and quantum physics was proposed by Bohr by his 'Correspondence Principle'.

Bohr's Correspondence Principle

The model of the atom with electrons orbiting the nucleus and analysed as a progression of periodic motion along classical lines would result in a spectrum of evenly spaced lines. The Zeeman effect showed that this was not the case and so the idea of discrete energy levels and quantum jumps by the electrons became the go-to explanation. Bohr nevertheless, persevered by maintaining that each permitted quantum transition between stationary states corresponds to one harmonic component of the classical motion. See Figure 5 below.

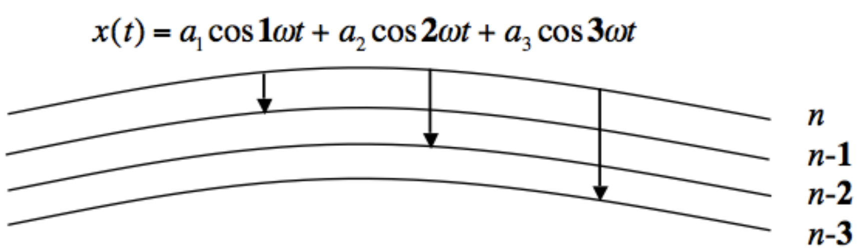


Figure 5 Bohr's musical analogue

In his 1928 Como lecture, Bohr writes:

'The aim of regarding the quantum theory as a rational generalisation of the classical theories led to the formulation of the so-called correspondence principle. The utilisation of this principle for the interpretation of spectroscopic results was based on a symbolical application of classical electrodynamics, in which the individual transition processes were each associated with a harmonic in the motion of the atomic particles to be expected according to ordinary mechanics.' (Bohr 1928, p. 584; BCW 6, p. 152)

And David Bohm provides a succinct overview of the principle:
'The correspondence principle, which was first given by Bohr . . . states that the laws of quantum physics must be so chosen that in the classical limit, where many quanta are involved, the quantum laws lead to the classical equations as an average.' [Bohm, D., 1951, *Quantum Theory*, New York: Prentice Hall. Reprinted by Dover Publications, Inc. 1951, p. 31].

Bohr's principle attracted much criticism from Sommerfeld and Sommerfeld's two doctoral students Wolfgang Pauli and Werner Heisenberg. Their stance was that there could be no use of models and analogies in dealing with atoms and that QM stood on its own mathematical formalism which represented a complete departure from classical physics.

There is a great deal of literature on this but for the purposes of this essay all that needs to be pointed out is the unifying or bridge-building approach adopted by Bohr was jettisoned for a schism. Unfortunately, the Heisenberg camp prevailed and attempts at a unified field theory amounted to the empty formalism of Dirac's equation and a logically flawed QFT. Before that happened, Schrödinger attempted to reformulate a model of the atom involving waves rather than particles.[1]

Note 1: See the paper by Leibniz c 1886 on *Primary Truths*. The takeaway point is that the corpuscular or atomic theory of matter was discredited centuries ago. The particle model should be viewed as a shorthand for solving practical problems but not the last word on ontology. It is a case of not mistaking the map for the territory as A. N. Whitehead cautioned.

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