Atomic structure and plasma diagnostic

Roger Hutton, Lunds University, Sweden (Physics) and Beijing Normal University, China (Astronomy)

We begin with a discussion of the atomic structure of Hydrogen and how this lead (amongst other things) first to quantum mechanics and then to our most successful theory to date, quantum electro-dynamics, QED. QED is where the photon field is coupled to the structure of atoms and ions and leads, amongst other things, to the so-called Lamb shift. A simple argument based on involving the photon field shows that the Coulomb field is a $1/r^2$ attraction.

We then more to the much more complex problem of Helium. Helium has 2 electrons orbiting outside of the nucleus and is therefor a three-body problem, and as such, does not have an exact solution (unlike Hydrogen). We will introduce the way we couple the orbital angular momentum and spin of the electrons to give us the different atomic energy levels and start looking at why some energy levels give rise to spectral lines that can be used in plasma diagnostics;

We then move to Beryllium and Beryllium like ions and look in more detail at why ratios of spectral lines can tell us, for example, the electron density of the plasma at the position where the lines originate. We will discuss what are forbidden transitions and what are the problems introduced by the resulting spectral lines. Line rations from transitions from Beryllium like Nitrogen allow is the measure the electron density in Nebulas. This density is very low, on the order of $10^4/cm^3$. Line emission from such low-density plasmas can never be studied in the laboratory, instead the laboratory is a Nebula.

Next, we will discuss spectral lines sensitive to the external magnetic field, for example the field of the solar corona. These lines, are called Magnetic Induced transitions, MITs, and are a relatively new area of spectroscopic research. An MIT in the spectrum of Fe9+ has been used to measure the magnetic field of the solar corona for the first time.

We will finish, if there is time, with a discussion of forbidden transitions within the ground configuration of highly charged ions and possible uses of such lines.

I will look for relevant references and publications