1190: Why electrons don't get stuck in atomic nuclei: Flaws in the Earth-Sun model

(This is a typical reason why Newtonian mechanics cannot be applied to microscopic material systems)

Key words: Energy discontinuity; electromagnetic waves; Planck's constant; uncertainty principle

One idea behind why electrons don't get stuck in atomic nuclei is that the centrifugal force caused by rotation balances the gravitational force, as in the Earth-Sun model. This is no good. Two reasons why it's no good should be enough. Let's take the hydrogen atom as an example.

[Discontinuity of electron energy]

The electron of a hydrogen atom is located at about 0.53 Å, and its energy is -1311 kJ/mol. There is no lower energy state. There are multiple states higher than this minimum energy, and the energy values are discrete, starting from -328, -145, -82 kJ/mol, etc. The Earth-Sun model cannot explain these facts.

[Moving electrons emit energy]

When a substance with a charge moves, it generates electromagnetic waves. Electromagnetic waves are energy. If an electron orbits around an atomic nucleus, it constantly emits energy. This energy is compensated for by shortening the distance between the electron and the atomic nucleus, so the distance becomes smaller, and the electron eventually sinks into the atomic nucleus.

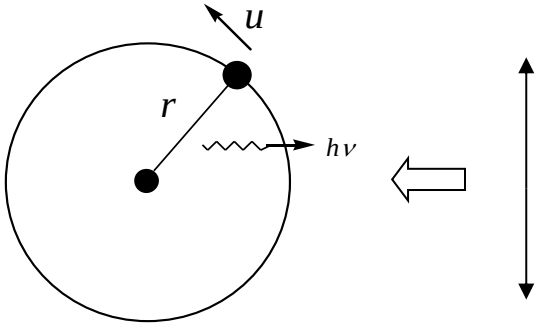

Figure 1. Model of electron motion around an atomic nucleus. When the circular motion of the electron is viewed from the direction of the arrow, it appears to be vibrating. If the frequency of vibration is ν, then energy of $h\nu$ is emitted as electromagnetic waves. h is a number known as Planck's constant.

[Uncertainty principle]

When electrons condense near the nucleus, V decreases, but due to the uncertainty principle, the kinetic energy (T) of the electrons increases. Normally, electrons exist mainly at r where the electron energy E ($=T+V$) is at its lowest value.