Answer on Question #69539 – Physics – Atomic and Nuclear Physics

What is the ratio of the speed of the electrons in the ground state of hydrogen to the speed of light in vacuum?

Solution.

Let us use the Bohr model of the atom.

The electron is held in a circular orbit by electrostatic attraction, than we have from the second Newton`s law:

$$v_n = \sqrt{\frac{1}{4\pi\varepsilon_0}\frac{e^2}{m_e r_n}}.$$

From the Bohr model of the atom we have:

$$r_n = 4\pi\varepsilon_0\frac{n^2\hbar^2}{e^2 m_e},$$

so than we can find that

$$v_n = \frac{e^2}{4\pi\varepsilon_0\hbar n} \text{ or } \frac{v_{ground}}{c} \equiv \frac{v_1}{c} = \frac{e^2}{4\pi\varepsilon_0\hbar c} = \alpha,$$

Where α – the fine-structure constant:

$$\frac{1}{\alpha} = 137.035999139.$$

Answer: the ratio is equal to the fine-structure constant $\alpha \approx 1/137$.