1160: Does the force that holds electrons around the nucleus have nothing to do with gravitation?

(Many people think they understand this correctly, but we will verify with numerical values that gravitation has no effect in the world of atoms and molecules.)

Key words: gravitational constant, Coulomb force, gravitation is negligible in atoms and molecules

In conclusion, gravitational force (gravity) has no effect at all on individual systems of atoms and molecules. The forces of both Coulomb force and gravitational force are inversely proportional to the square of the distance. However, since the gravitational constant (G, $6.6726\times10^{-11}m^3kg^{-1}$) is small and the mass of both the electron and the nucleus are very small, the force of gravitation is very small. Let's use a hydrogen atom as a model to calculate the gravitational force and Coulomb force acting on the nucleus and electron. Let's assume that the distance between the nucleus and the electron is 0.5Å (0.5×10^{-10}m).

Coulomb (electrostatic) force:

$$f^{electrostatic} = -\frac{1}{4\pi\varepsilon_0}\times\frac{Q\times Q}{r^2} = -\frac{\left(1.6\times10^{-19}C\right)^2}{4\times3.14\times8.85\times0.5^2\times10^{-12}C^2\cdot N^{-1}\cdot m^{-2}\times\left(10^{-10}m\right)^2}$$
$$\approx -9.2\times10^{-8}\ N$$

Gravitaion:

$$f^{gravitation} = -G\frac{m_1\times m_2}{r^2} = 6.67\times10^{-11}N\cdot m^2\cdot kg^{-2}\times\frac{\left(1.67\times10^{-27}kg\right)\left(9.11\times10^{-31}\right)}{\left(0.5\times10^{-10}m\right)^2}$$
$$\approx -4.0\times10^{-47}\ N$$

If we take the ratio of the two, the gravitational force is 10^{-39} of the Coulomb force, which is a completely negligible amount. Therefore, we can say that the cause of holding electrons in place is the Coulomb force, not the gravitational force.