Rydberg atoms as tests of Coulomb's law over colossal distances

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Abstract

Guided by the problem of flat galaxy rotation curves in Cosmology, it is argued that deviations from Coulomb potential might be observed in the microscopic analogues of galaxies which are Rydberg atoms. It is found that such deviations might occur in Rydberg atoms with principal quantum numbers of more than 780.

In my recent work[1], I have taken MOND seriously[1] and have succeeded to a fair extent in showing that it is due to the expansion of the Universe hence more universal and deeper than it is thought to be.
If I am right in assuming MOND is due to the acceleration of light (caused by the expansion of the Universe) we must expect similar effects to appear in other areas of physics as well, most notably electricity: I argued for the existence of a universal electric field strength

$$E_0 := \frac{a_0}{\sqrt{4\pi\epsilon_0 G}} \simeq 1.39\ V/m \tag{1}$$

at which deviations from Coulomb's law are to be expected[2].

In MOND itself we can find a length scale at which deviations from classical mechanics are expected to appear, by equating

$$a = \frac{GM}{r^2}$$

with a_0, which yields

$$\boxed{r = \sqrt{\frac{GM}{a_0}}} \tag{2}$$

This means that depending on the mass of a galaxy the need for 'Dark matter' might appear at small or large radii, as expected from the data [3].

[1] Evidently much more seriously than its founder!

Similarly, for electricity we can find a critical length by equating

$$E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$$

with E_0. This yields

$$\boxed{r = \sqrt{\frac{q}{4\pi\epsilon_0 E_0}}} \tag{3}$$

which, for a nucleus with charge e is

$$r_e = \sqrt{\frac{e}{4\pi\epsilon_0 E_0}} \approx 32.19\ \mu m. \tag{4}$$

This is gigantic, given the usual distance of electron from the center of atoms is of the order of picometers. We thus see that although the value of E_0 seems ‘mundane’ it leads to an extremely large atomic radius (principal quantum number), hence it cannot have been tested so far in ordinary matter. Luckily there exist *Rydberg atoms* which just touch the gigantic scale of (4).

Equating (4) with

$$r = n^2 r_B,$$

where r_B is the Bohr radius, we have

$$n = \sqrt{\frac{\sqrt{\frac{e}{4\pi\epsilon_0 E_0}}}{r_B}} \simeq 779.94 \approx 780. \tag{5}$$

We must therefore expect deviations from Coulomb’s law in Rydberg atoms with n over 780.

This principal quantum number is probably the last layer for which Coulomb’s law holds. From here on, we will have

$$\sqrt{\frac{eE_0}{4\pi\epsilon_0}}\frac{e}{r} = m\frac{v^2}{r}. \tag{6}$$

Applying the quantum condition

$$mvr = n\hbar, \tag{7}$$

leads to

$$r = n\frac{\hbar}{\sqrt{m_e\sqrt{k_e e^3 E_0}}} =: nr_\infty \tag{8}$$

The radius of the orbit now scales as n.

References

[1] A. Jamali. MOND from FLRW. *viXra:2303.0032*, 2023.

[2] A. Jamali. Possible Modification of Coulomb’s law at Low Field Strengths. *viXra:2208.0130*, 2022.

[3] B. Famaey and S. McGaugh. Modified Newtonian Dynamics (MOND): Observational Phenomenology and Relativistic Extensions. *Living Reviews in Relativity*, 15(10), 2012.