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Does Gravity Exhibit a $1/r$ Force on the Scale of Galaxies?

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Several major features of galaxy dynamics (e.g., flat rotation curves and the stability of cold stellar disks) can be modeled without invoking the presence of dark halos if one assumes that the force law of gravity has the form $F = -GMmr^{-2}(1 + r/d)$, where $d \sim 1$ to 5 kpc. In this form, the gravitational force would fall off as $1/r$ instead of as $1/r^2$ on scales $r \gg d$. The *dynamical* effect of such a deviation from a pure Newtonian force on planetary orbits in our solar system is not measurable, but the *secular* effect is probably detectable. The precession $\Delta\psi$ of the perihelion of a planetary orbit whose semimajor axis in A.U. is "a" and whose orbital eccentricity is e would be

$$\Delta\psi = -0.628\, a^{-1/2}\, d_{\text{kpc}}^{-1}\, [e^2 - 1 + (1 - e^2)^{1/2}]\, e^{-2}$$

arcseconds/century if d_{kpc} is the scale length "d" measured in kiloparsecs. For example, Mercury's orbit should exhibit $|\Delta\psi| \sim 0.5$–0.1 arcsecs/century for the chosen range $d_{\text{kpc}} \sim 1$–5. Precise observations of the motions of planets in our solar system can therefore be used to make a strong, useful statement regarding the long-range nature of the force of gravity on scales that are important to galaxy dynamics.