Constraints from the solar system

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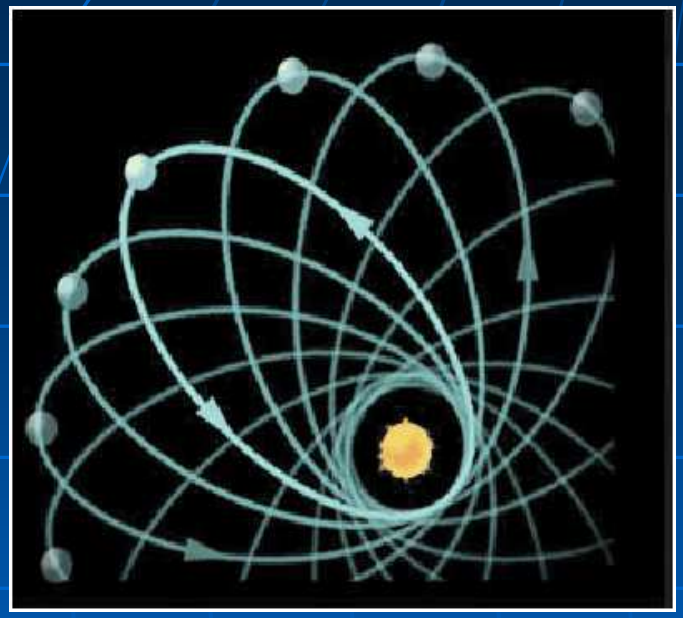
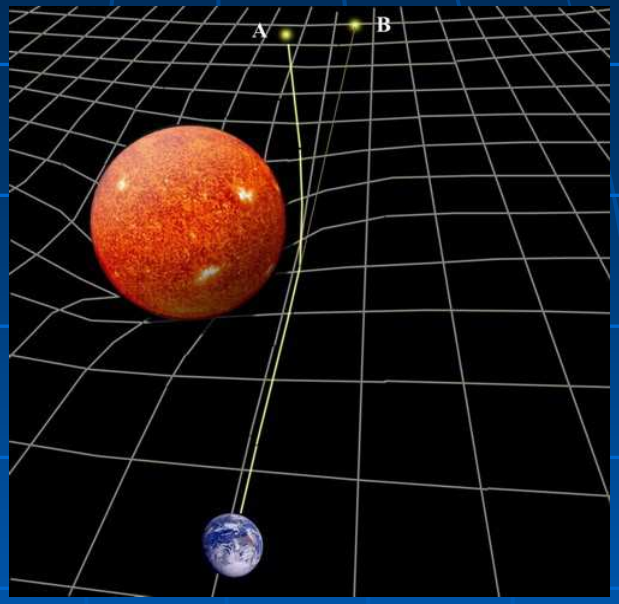
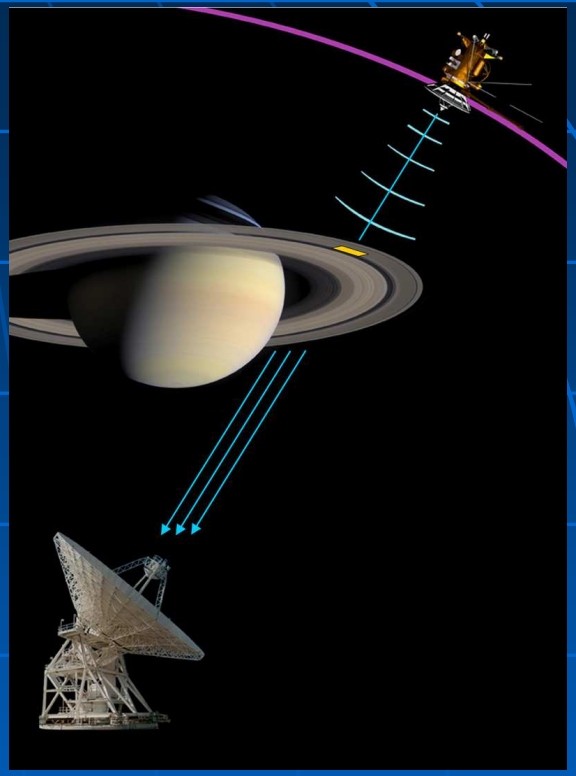
Bohmer, GDR, Harko, Lobo, CQG 27 (2010), arXiv: 0910.3800
GDR, Harko, Lobo, JCAP 1207 (2012), arXiv: 1206.2747

Classical tests of General Relativity







Perihelion precession

Deflection of light

Radar echo delay

"Direct" tests of the validity of General Relativity

Could be used to test discrepancies from the "expected behaviour"

The method

We can evaluate the relevant quantities starting from a general spherically symmetric solution.

$$ds^2 = A(r)c^2dt^2 - B(r)dr^2 - r^2d\Omega^2$$

Uncertainties on the results of the classical test may be used to constraint the form of the solution

$$\sigma = \frac{1}{2}\left(\frac{dF}{du}\right)_{u=u_0}$$

Perihelion advance

Functionals of the metric functions

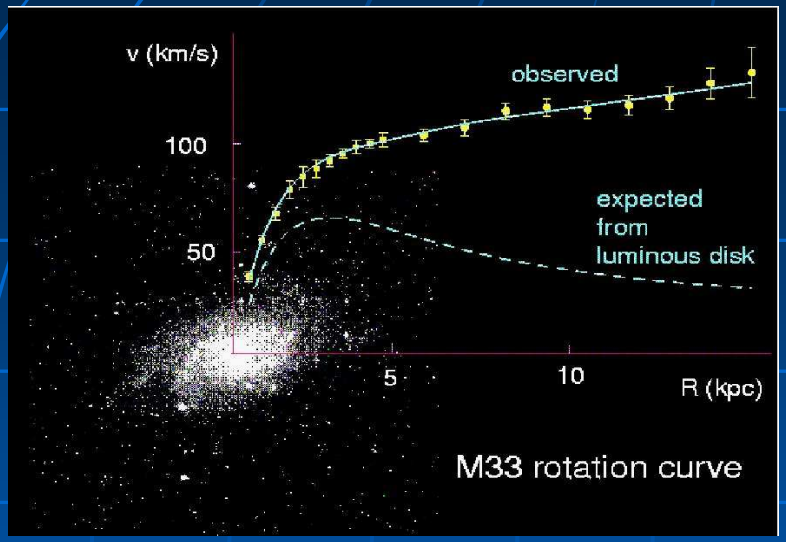
$$\frac{d^2u}{d\phi^2} + u = Q\left(\frac{\cos\phi}{r}\right)$$

Geodesic equation for the light ray

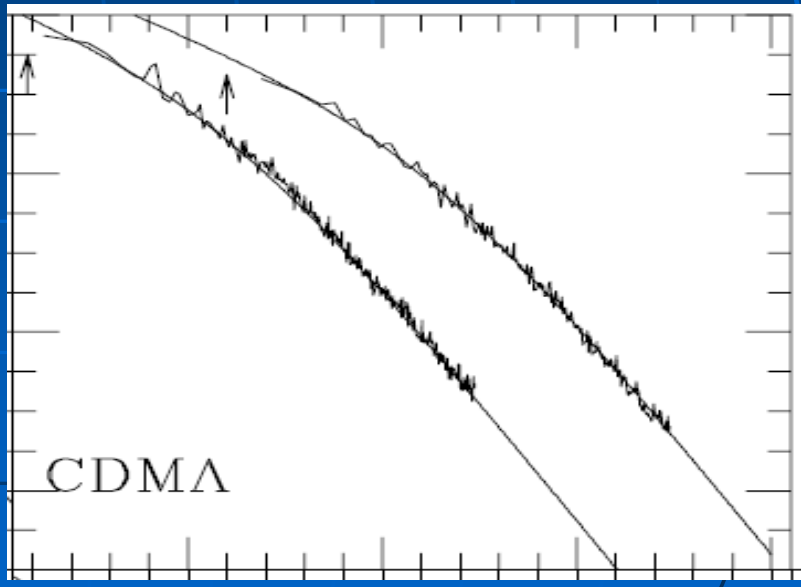
Corrections to the classical results can not be greater than the errors

Upper limits on the metric parameters

Application: Local dark matter distribution



Dark matter existence is inferred from galaxy rotation curves, which suggest a flat distribution with no features



On the contrary, simulations suggests a strongly peaked hierarchical distribution (NFW curve)

Dark matter distribution "follows" luminous matter

What about dark matter "around the sun"?
Does it have a steep or flat density profile?

Constraints on local dark matter halo

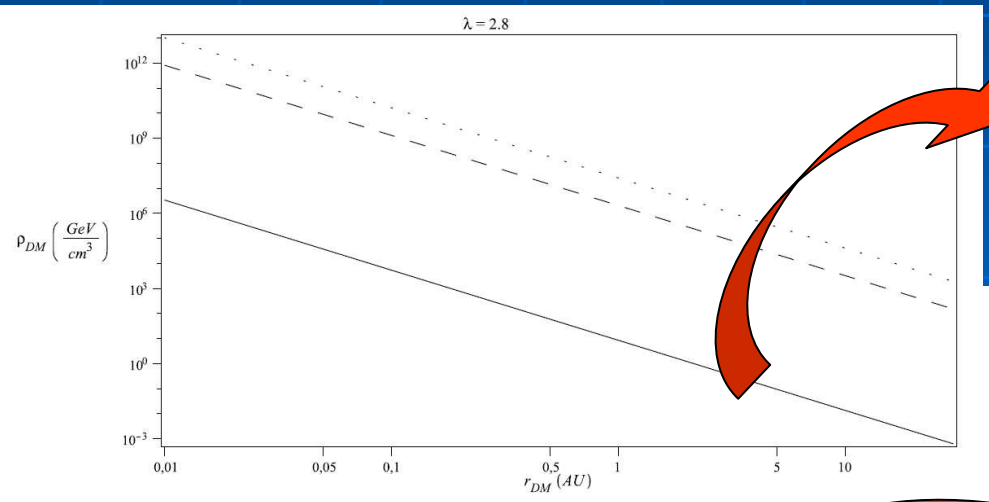
We set an anstatz on the DM distribution…

$$\rho_1(r) \equiv \rho_{\rm DM} \left(\frac{r}{r_{\rm DM}}\right)^{-\lambda}$$

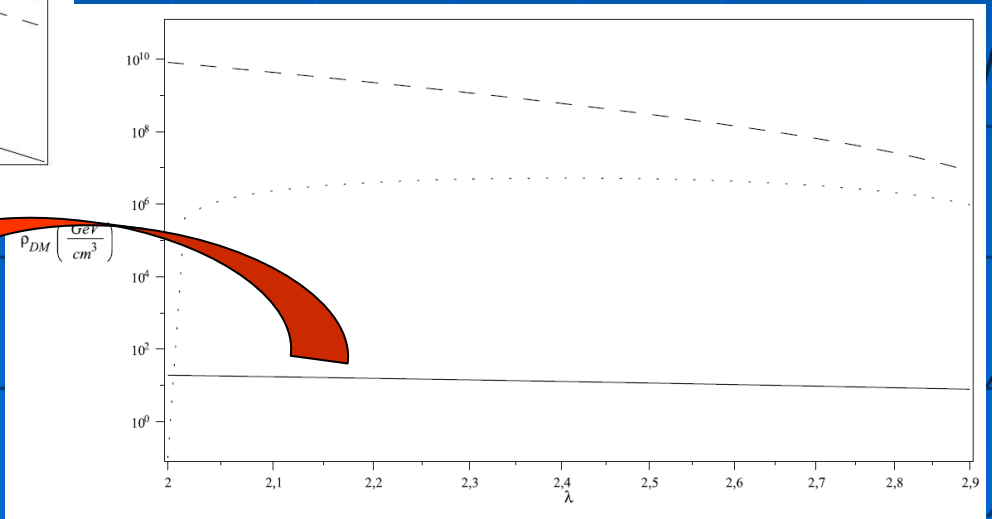
…and evaluate the metric functions

$$A_1(r) = \frac{4\pi}{3-\lambda}\frac{r_{\rm S}}{r_{\rm DM}}\frac{r_{\rm DM}^3\rho_{\rm DM}}{M}\left(1-\frac{r_{\rm S}}{r}\right)\int \frac{1}{r_{\rm DM}}\frac{(r/r_{\rm DM})^{1-\lambda}}{(1-r_{\rm S}/r)^2}dr$$

$$B_1(r) = \frac{4\pi}{3-\lambda}\frac{1}{(1-\frac{r_{\rm S}}{r})^2}\frac{r_{\rm S}}{r_{\rm DM}}\frac{r_{\rm DM}^3\rho_{\rm DM}}{M}\left(\frac{r}{r_{\rm DM}}\right)^{2-\lambda}$$



The energy density falls below the galactic mean



The slope dependence is mild

Conclusion…

The presence of a dark matter overdensity around the sun is less in tension with observational data if the distribution is packed around the sun.

…and outlook

- Use of a more realistic ansatz for the DM distribution
- Apply the same method to all the SS planets (having a set of measures would make it possible to fit data and obtain an estimate of the slope?)
- The method is quite general: Use it to test different extension of GR, such as bimetric gravity and massive gravity (GDR, Parisi, work in progress)

THANK YOU!