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Astronomical Tests for Extended Gravity: Possible Constraints on f(R) with Vanishing Cosmological Constant

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Dark matter, dark energy

new physics **new geometry**

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Dark matter, dark energy

New physics **New geometry**

scalar-tensor gravity

Dark matter, dark energy

New physics **New geometry**

Scalar-tensor gravity

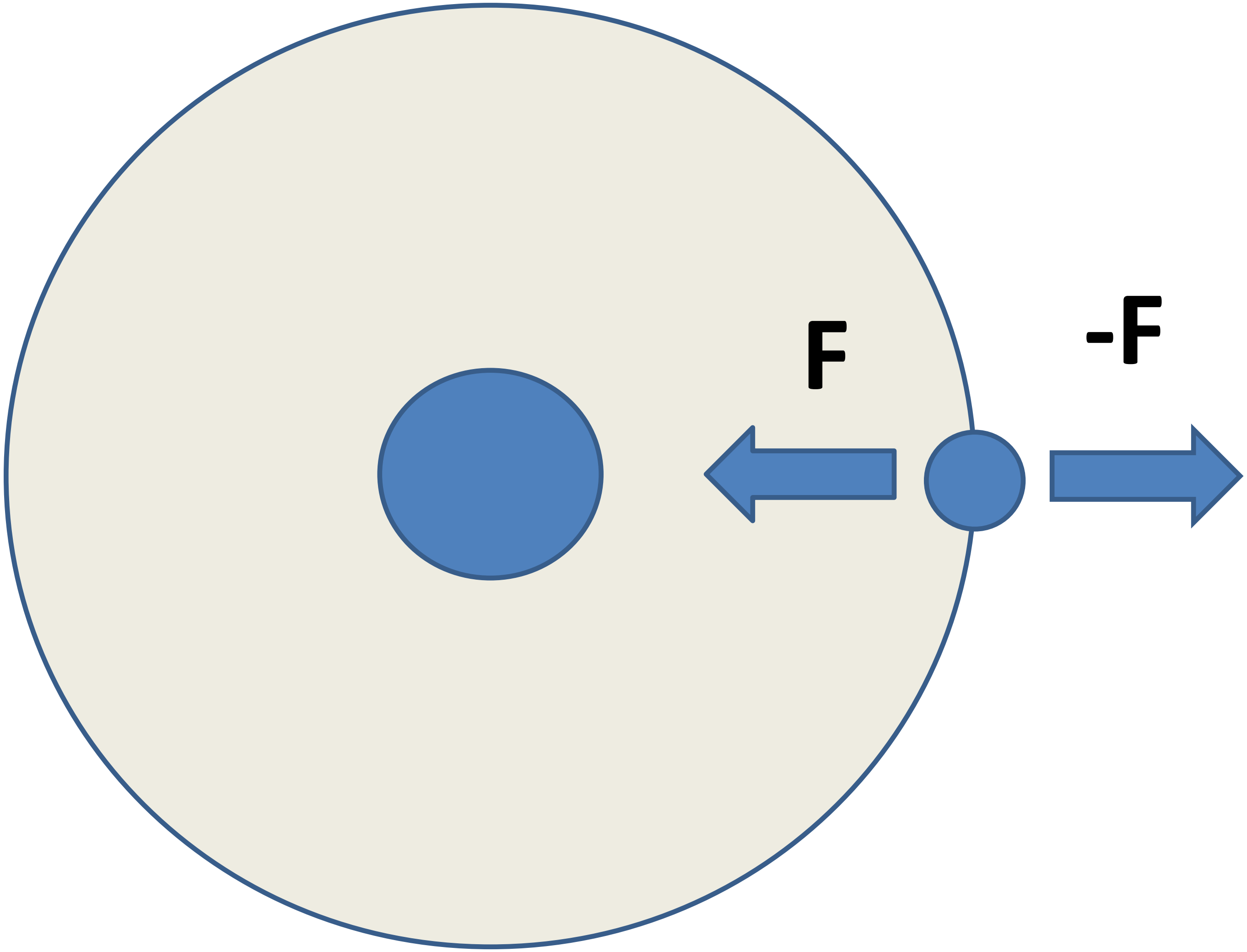
f(R) gravity

Dark energy + f(R) gravity

Starobinsky model

$$f(R) = R + \lambda R_0 \left(\left(1 + \frac{R^2}{R_0^2} \right)^{-n} - 1 \right)$$

Method: cut-off radius calculation



Method: cut-off radius calculation

- **Starobinsky model**
- **ΛCDM**

Mass spectra:

10^{11} M_{Sun} (Milky Way) – 10^{15} M_{Sun} (Galaxy clusters)

- **Metrics**

$$ds^2 = e^{A}c^2dt^2 - e^{-A}dr^2 - r^2d\Omega$$

- **Field equations***

$$f'(R)R_{ii} - f(R)\frac{g_{ii}}{2} - \left(\nabla_i^2 - g_{ii}\Box\right)f'(R) = 0;$$

*Thomas P. Sotiriou and Valerio Faraoni, Rev. Mod. Phys. 82, p.451 (2010)

- **Field equations**

$$\begin{cases} \dfrac{dA}{dr} = a, \\ \dfrac{da}{dr} = e^{-A}\left(R + \dfrac{2}{r^2}\right) - a^2 - \dfrac{4a}{r} - \dfrac{2}{r^2} \\ \dfrac{dR}{dr} = \dfrac{f'(R) \cdot R_{00}/g_{00} - f(R)/2}{(e^A(a + 2/r) + a/2) f''(R)} \end{cases}$$

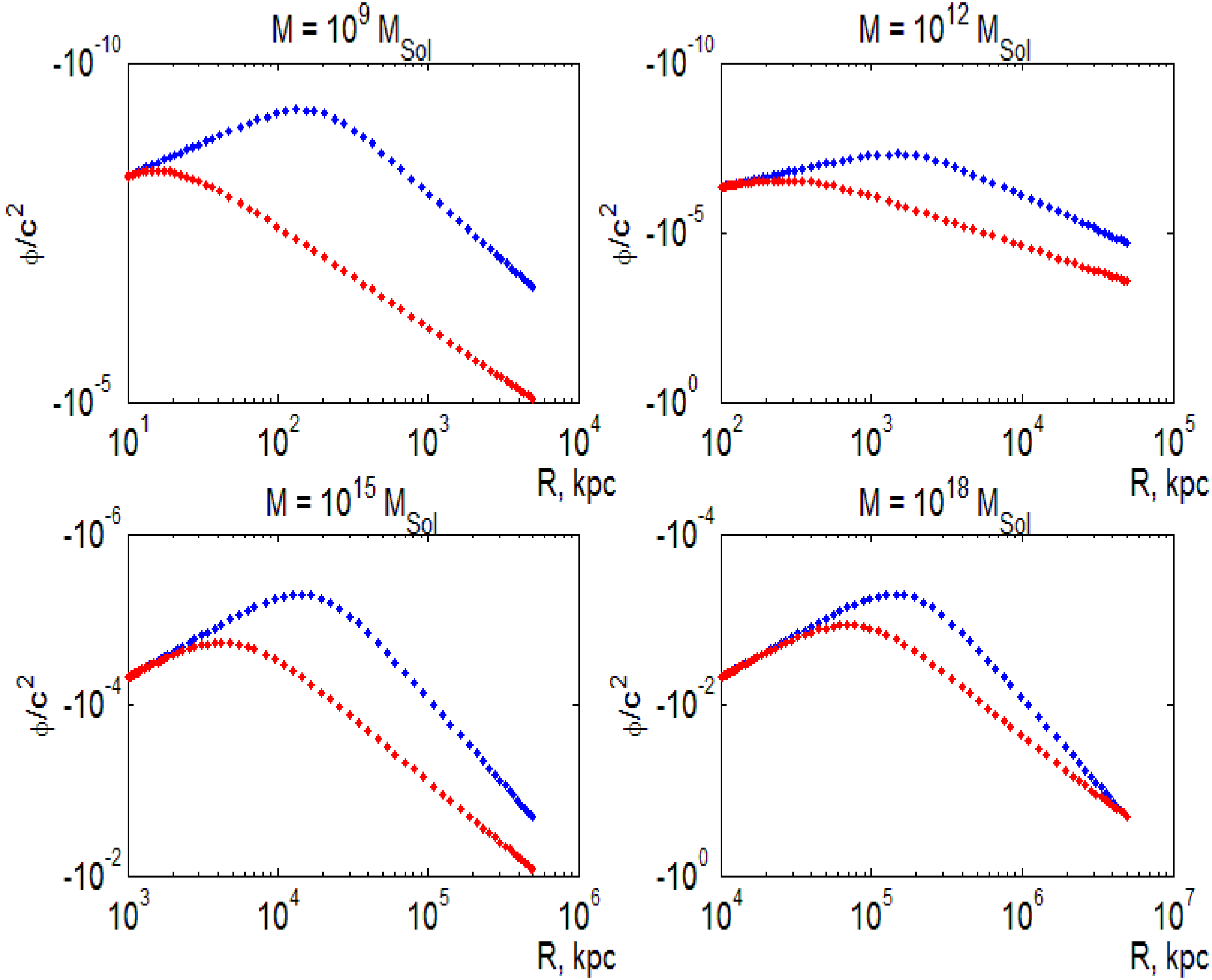
- **Gravitational potential**

$$\phi = \frac{c^2}{2}(g_{00} - 1) = \frac{c^2}{2}(e^A - 1);$$

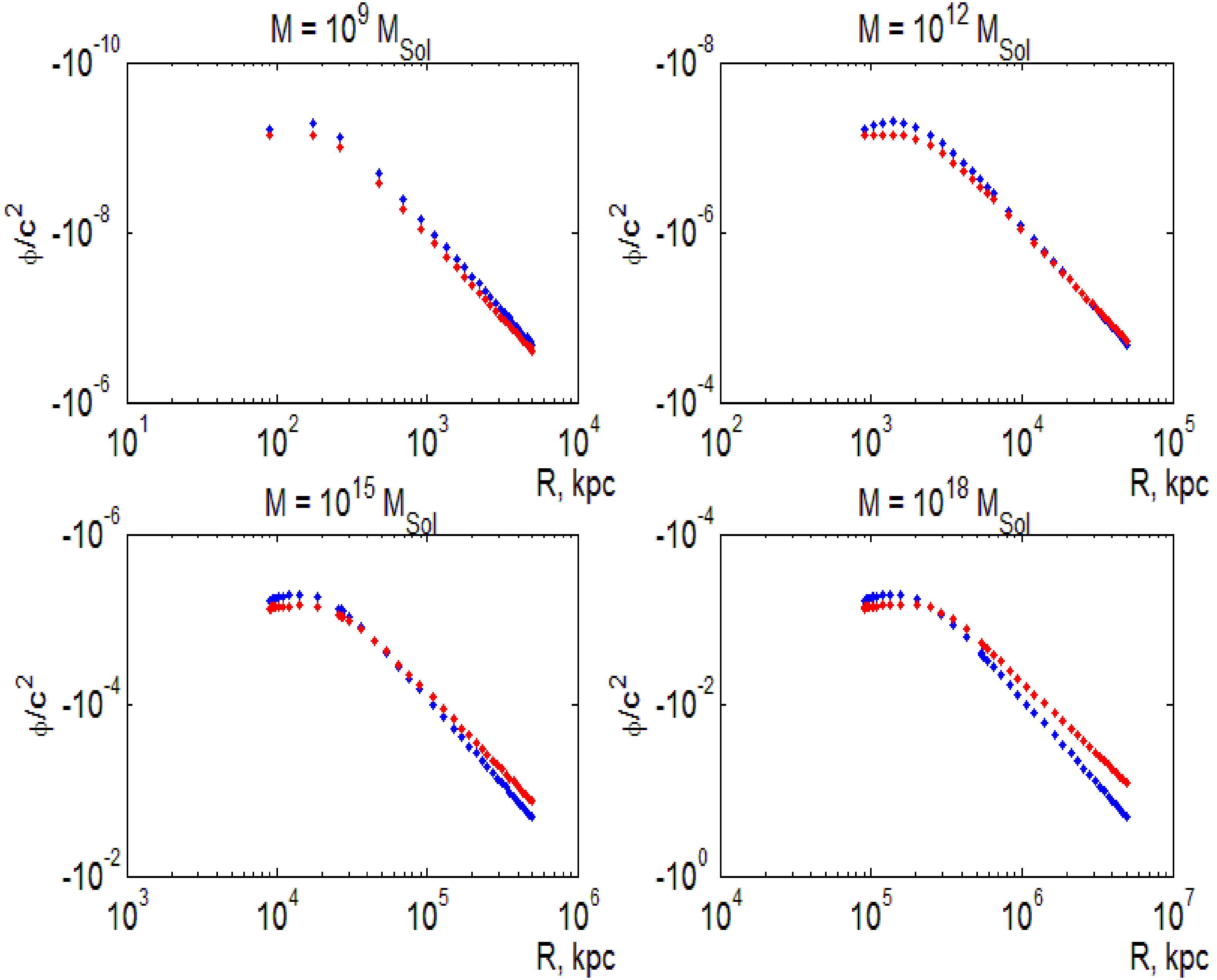
- **Dimensionless gravitational potential**

$$\phi / c^2 = \frac{e^A - 1}{2};$$

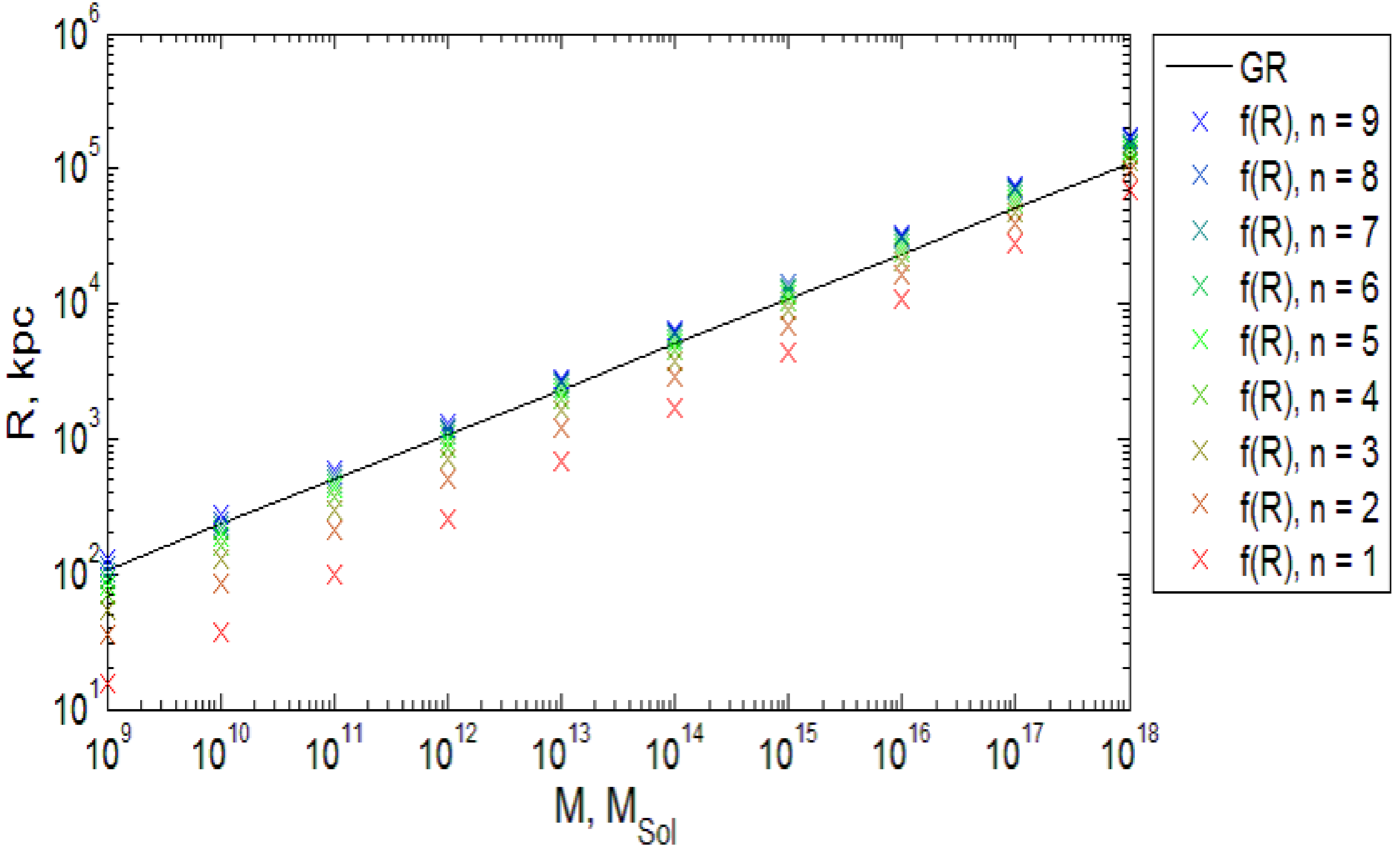
ϕ/c^2 , case n=1



ϕ/c^2 , case n=9



Cut-off radius *versus* mass

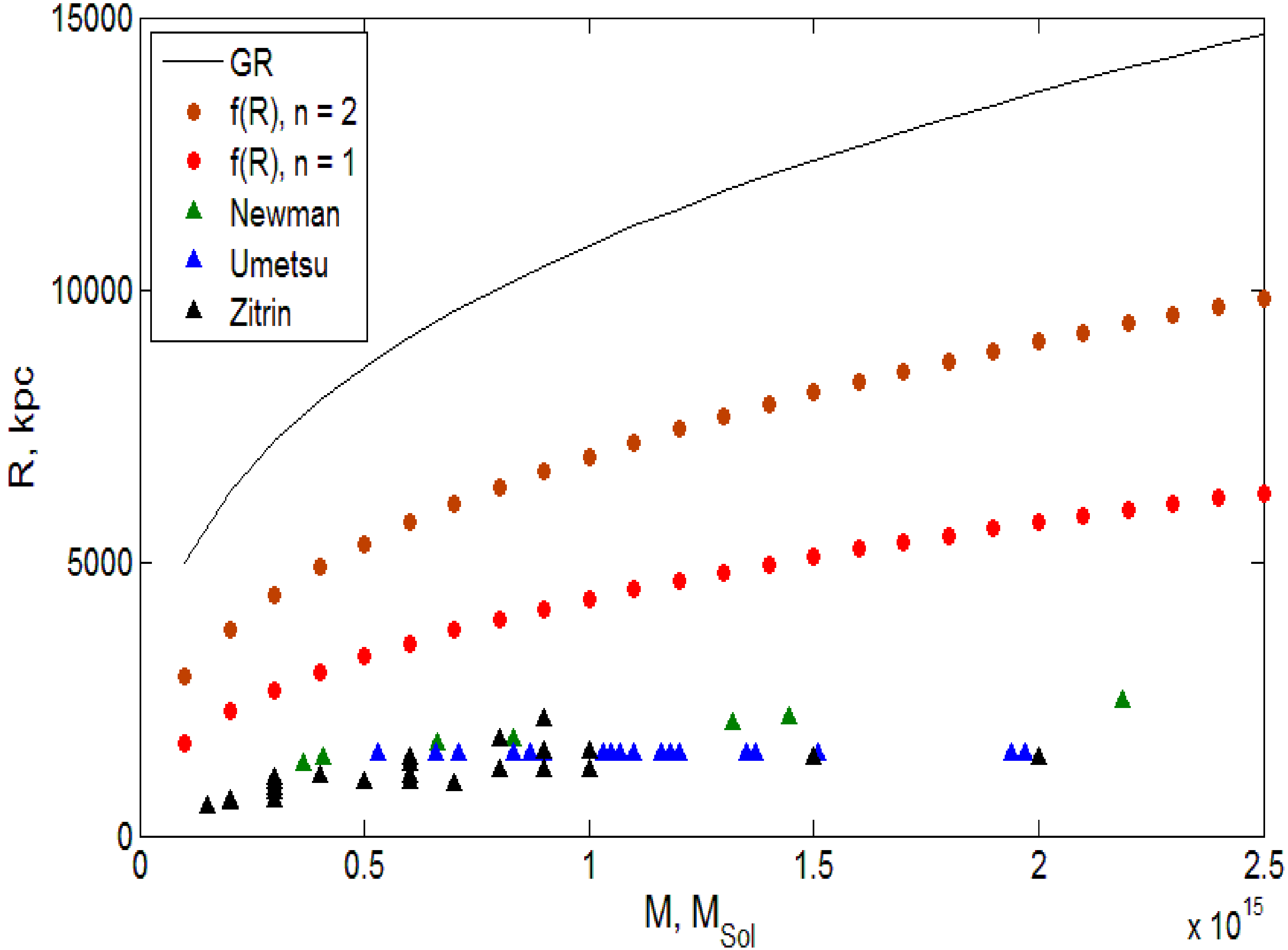


(Numerically obtained) coefficients for n=1..9

$$\log_{10}(R_{cut\text{-}off}) = \alpha \log_{10}(M) + \beta$$

n	α	β
0	0.3333	-0.966
1	0.4084±0.0013	-2.495±0.017
2	0.3807±0.0004	-1.869±0.005
3	0.3683±0.0001	-1.578±0.001
4	0.3617±0.0001	-1.412±0.002
5	0.3577±0.0002	-1.305±0.003
6	0.3552±0.0003	-1.231±0.004
7	0.3528±0.0005	-1.169±0.007
8	0.3486±0.0015	-1.091±0.019
9	0.3428±0.0019	-0.993±0.024

Cut-off radius: theory & observations



Conclusions

The dependence of cut-off radius versus mass for Starobinsky model with vanishing cosmological constant has no visible now difference from GR one in the wide range of masses

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The current accuracy value does not provide additional restrictions and constraints on Starobinsky model

Thank You for Your Attention !