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Dark Energy in the two body problem

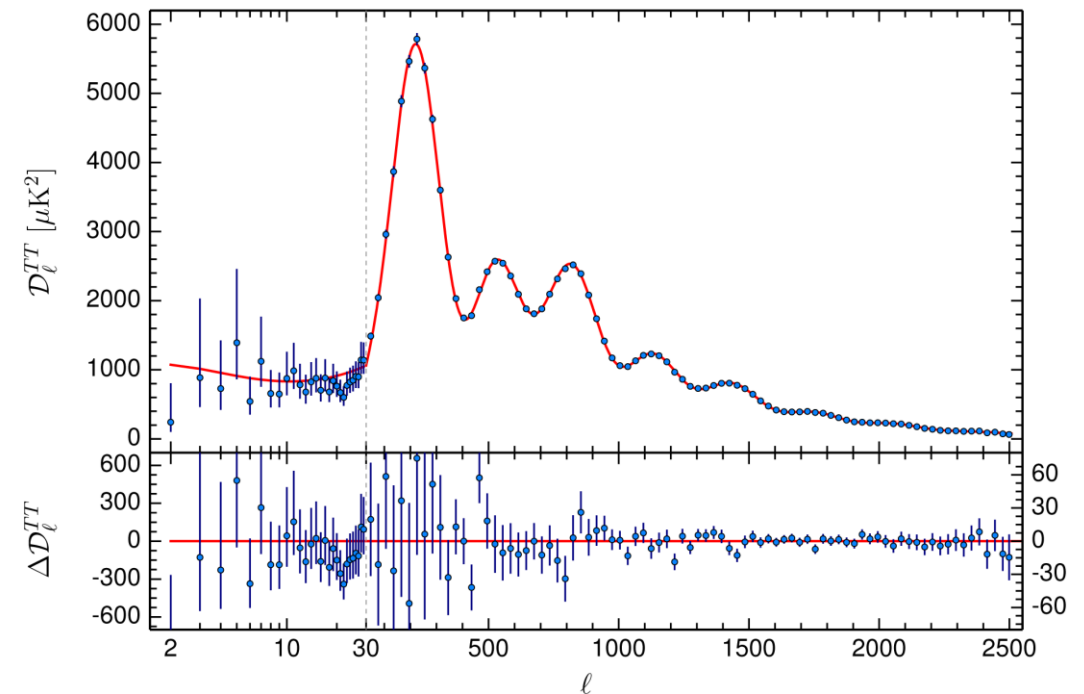
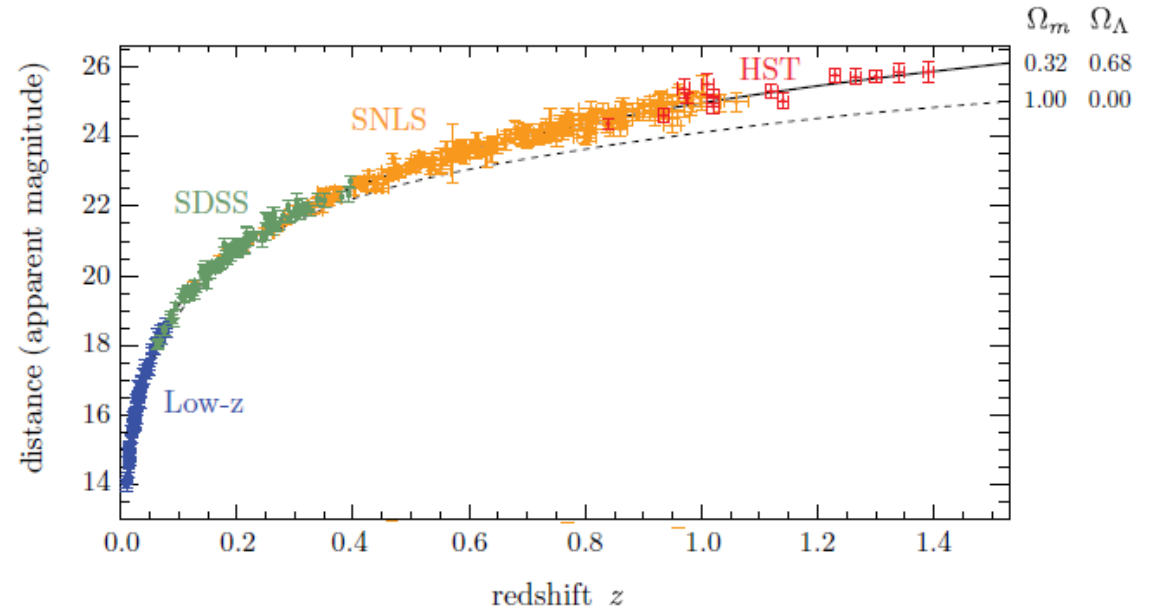
David Benisty

Second EuCAPT Annual Symposium

Phys.Rev.D 105 (2022) 2, 024052
Astrophys.J.Lett. 928 (2022) 1, L5

Signs for Dark Energy

- “Pantheon” - Type Ia Super Nova
Astrophys. J. 859, 101 (2018)
- Cosmic Chronometers
Jimenez & Loeb (2002)
- Baryon Acoustic Oscillations
Phys. Rev. D 92, 123516 (2015)
- Cosmic Microwave Background
(Planck 2018)
- Others...



$$\Lambda \sim 10^{-52} \text{ km}^{-2}$$

GR + Λ in the low energy limit

- The Einstein Hilbert action:

$$\tilde{\mathcal{L}} = \frac{1}{16 \pi G} \sqrt{-g} (\mathcal{R} - 2\Lambda)$$

- In the weak field limit, yields the spherically symmetric solution the potential:

$$\phi = -\frac{GM}{r} + \frac{\Lambda c^2}{3} r^2$$

- Dark Energy in the solar system? From $\dot{\omega} = \frac{\Lambda c^2 P}{4 \pi} \sqrt{1 - e^2}$ in the solar system

$$\Lambda < 10^{-37} \text{ m}^{-2}.$$

Physics Letters B 634 (2006) 465–470

Local Group and Λ

van der Marel R. et al., 2012, ApJ, 753, 8

- The measured physical values of M31:

$$r = 0.77 \pm 0.04 \text{ Mpc}$$

$$v_{rad} = -109.4 \pm 4.4 \frac{\text{km}}{\text{s}}$$

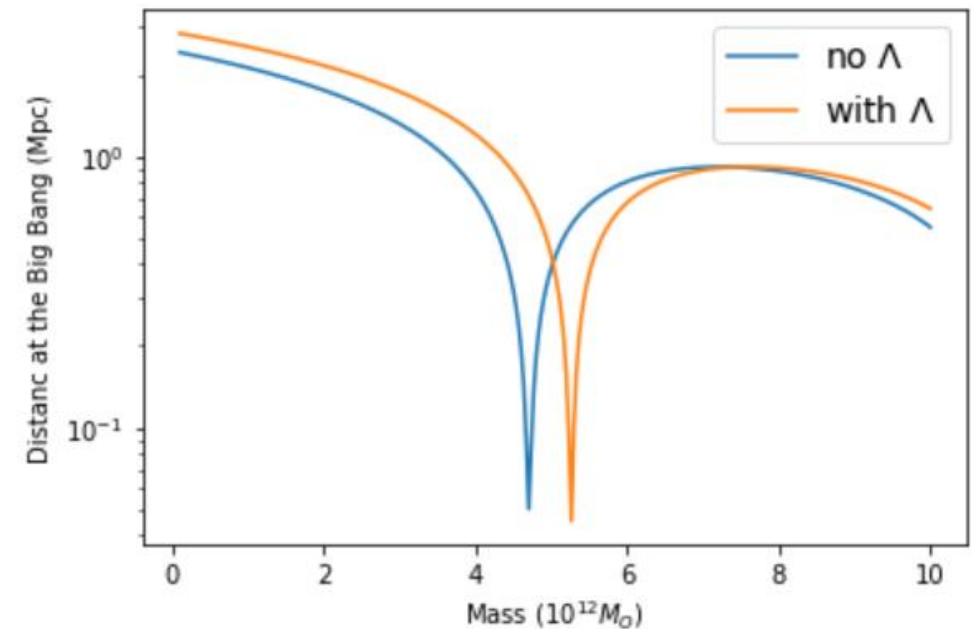
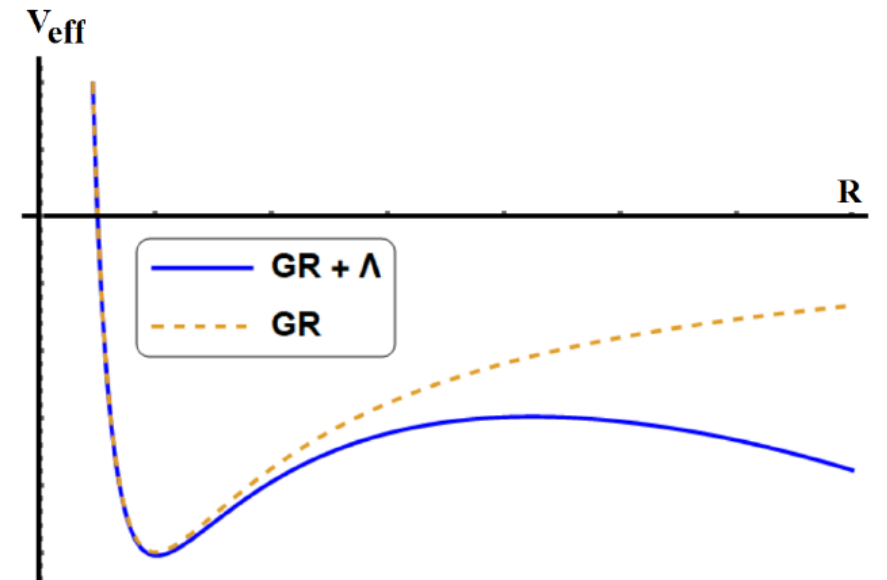
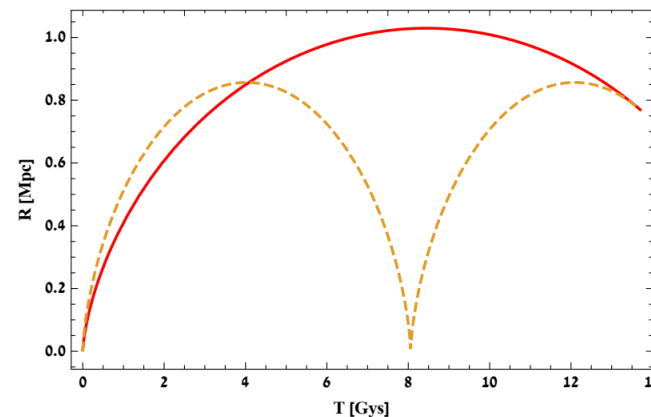
$$v_{tan} = 82.5 \text{ km/s (Salomon et al. 2021)}$$

where $t_u = 13.7$ G. years

$$\ddot{r} = -\frac{GM}{r^2} + \frac{\Lambda c^2}{3} r + \frac{l^2}{r^3}$$

- Timing Argument - Galaxies start their orbits in the early universe close to $r(t=0) = 0$.

(Kahn & Woltjer 1959)

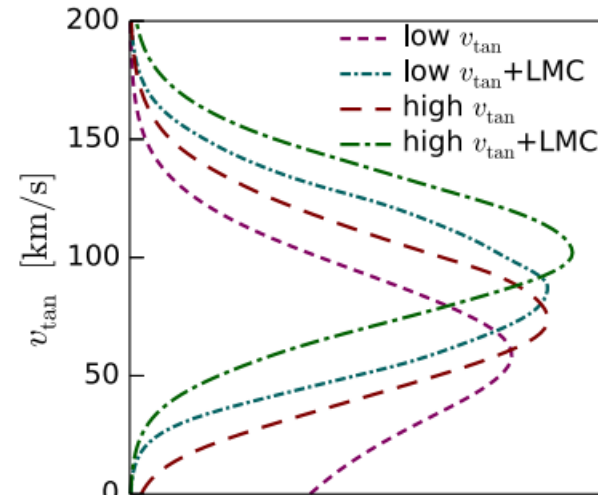
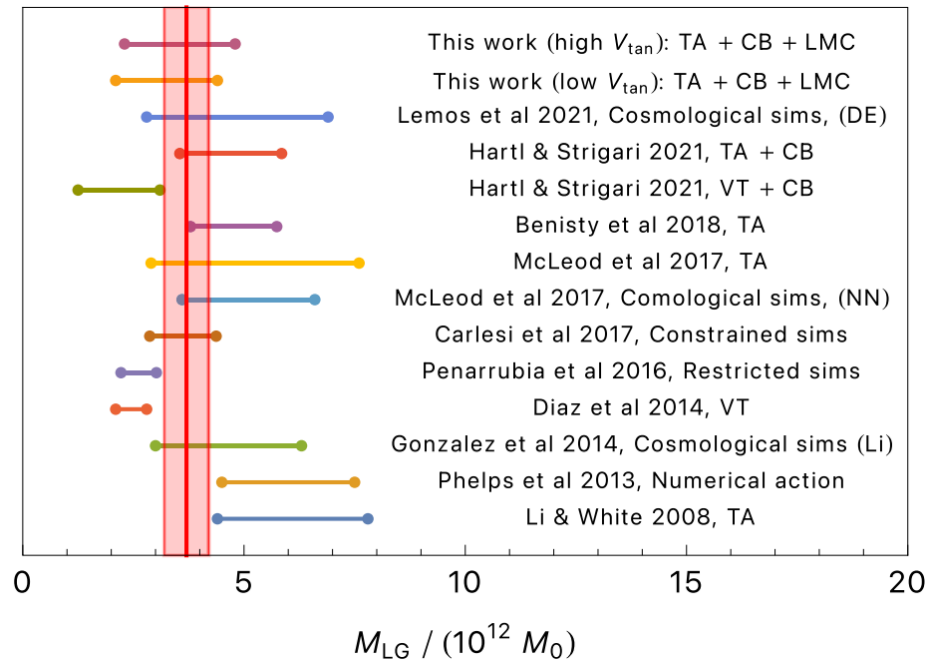


The Local Group Mass in the Light of Gaia

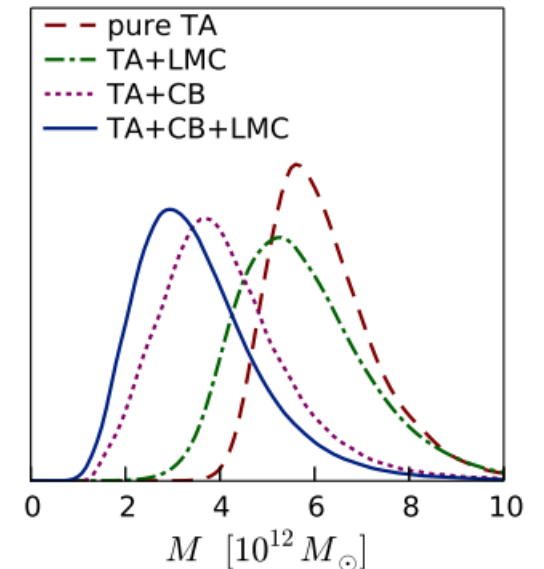
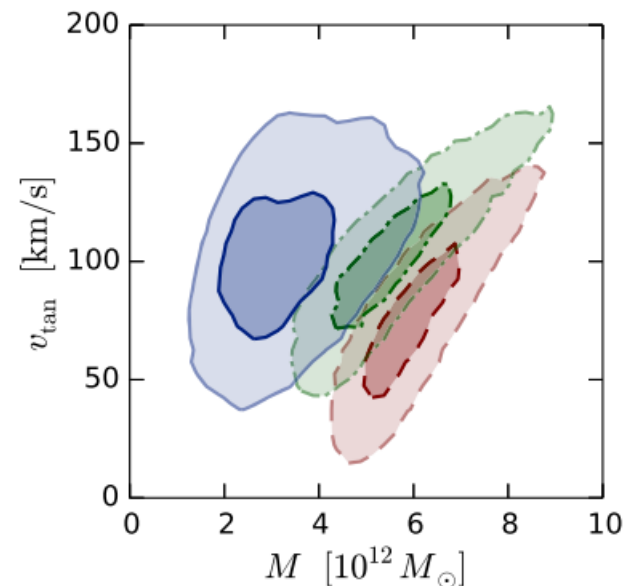
- Hartl & Strigari 2021

Local Group analogs in cosmological simulations based on stellar mass and kinematic criteria.

- The ratio is the **Cosmic Bias**



Model	$M(10^{12}M_{\odot})$
pure TA	$6.0^{+1.3}_{-0.9}$
TA+LMC	$5.6^{+1.6}_{-1.2}$
TA+CB	$3.9^{+1.5}_{-1.1}$
TA+CB+LMC	$3.4^{+1.4}_{-1.1}$
same, low v_{tan}	$3.1^{+1.3}_{-1.0}$



Summary and future research

- Two body problem with DE interactions: Post Keplerian Parameters
- Modified Gravity in the LG
- Combined constraint of different systems