The impact of screened fifth forces on the local distance ladder

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Outline

- Fifth forces & screening
- Unscreening the distance ladder
- Screening properties of Cepheids in SH0ES
- Consistency tests within the distance ladder
- Effect on H0 $\Rightarrow$ Possible to reduce tension to 1.5σ

Fifth Forces

- Generic extensions of the standard model couple new dynamical fields to matter
- → New (*fifth*) forces, described by strength and range

$$\Phi_{\rm tot} = -\frac{G_N M}{r}\left(1+\frac{\Delta G}{G_N}e^{-mr}\right) = \Phi_N - \frac{\Delta G M}{r}e^{-mr}$$

- Strongly constrained by local tests
  - Lab: Eot-Wash
  - Solar system: LLR, planetary orbits, Cassini

Screening

Fifth force goes away in dense environments

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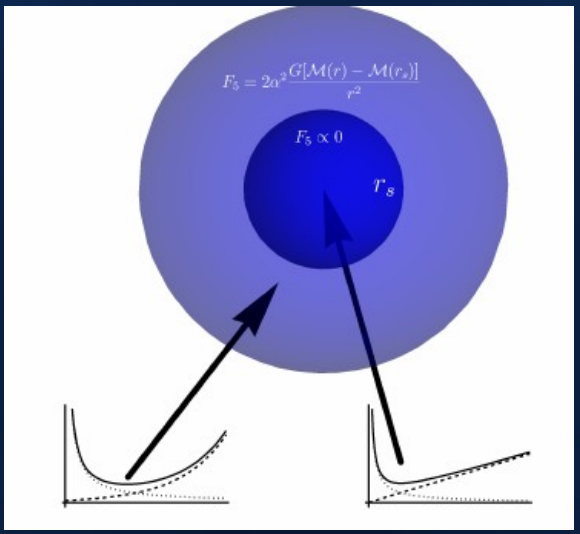
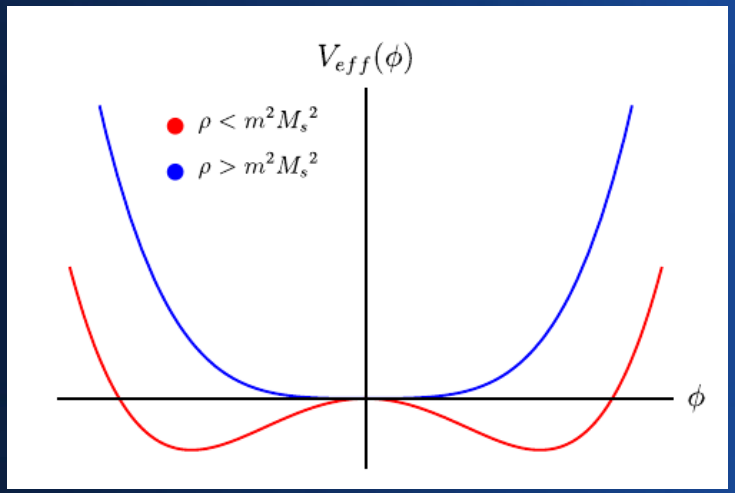
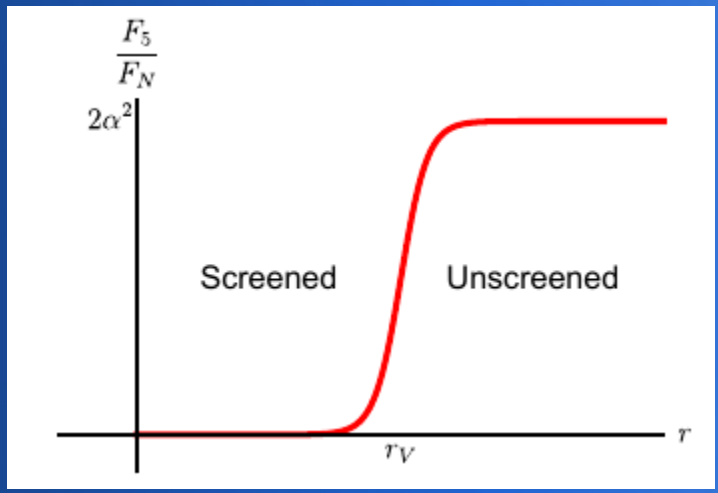
- *Chameleon*: $m_{eff} \rightarrow \infty$ (e.g. f(R))
- *Kinetic*: $\partial\varphi \rightarrow \infty$ (e.g. K-mouflage)
- *Symmetron* & *Vainshtein*: $\Delta G \rightarrow 0$ (e.g. Galileons, DGP)



Chameleon



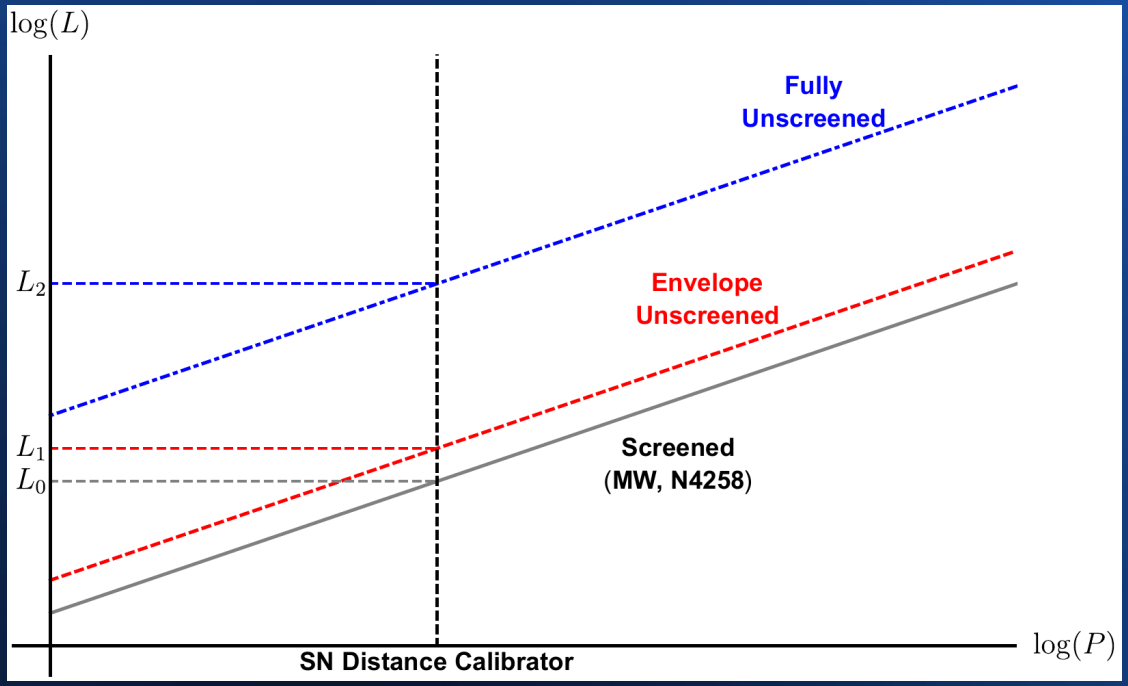
Symmetron



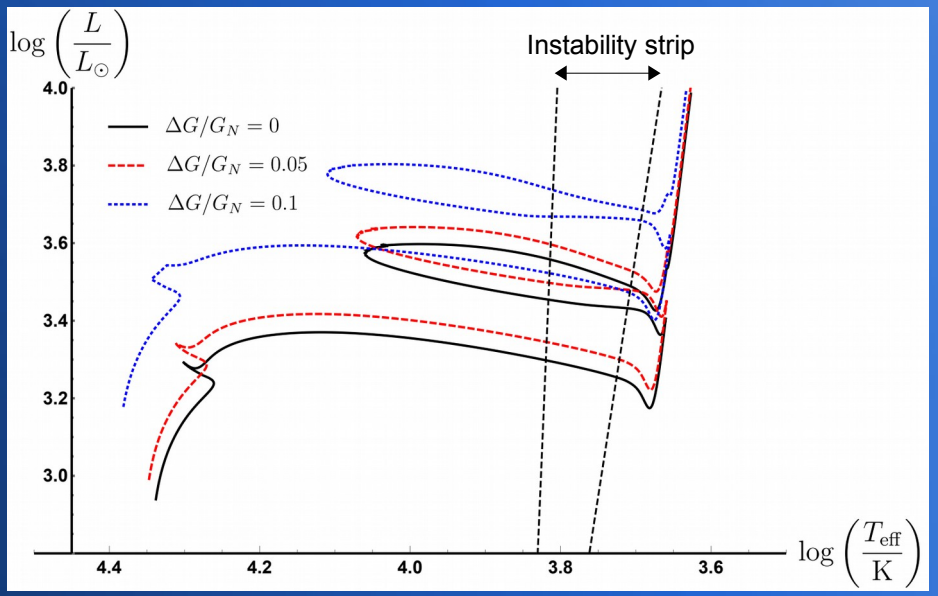
Vainshtein

Unscreening the distance ladder

Cepheid Period–Luminosity Relation



Hertzsprung–Russell Diagram

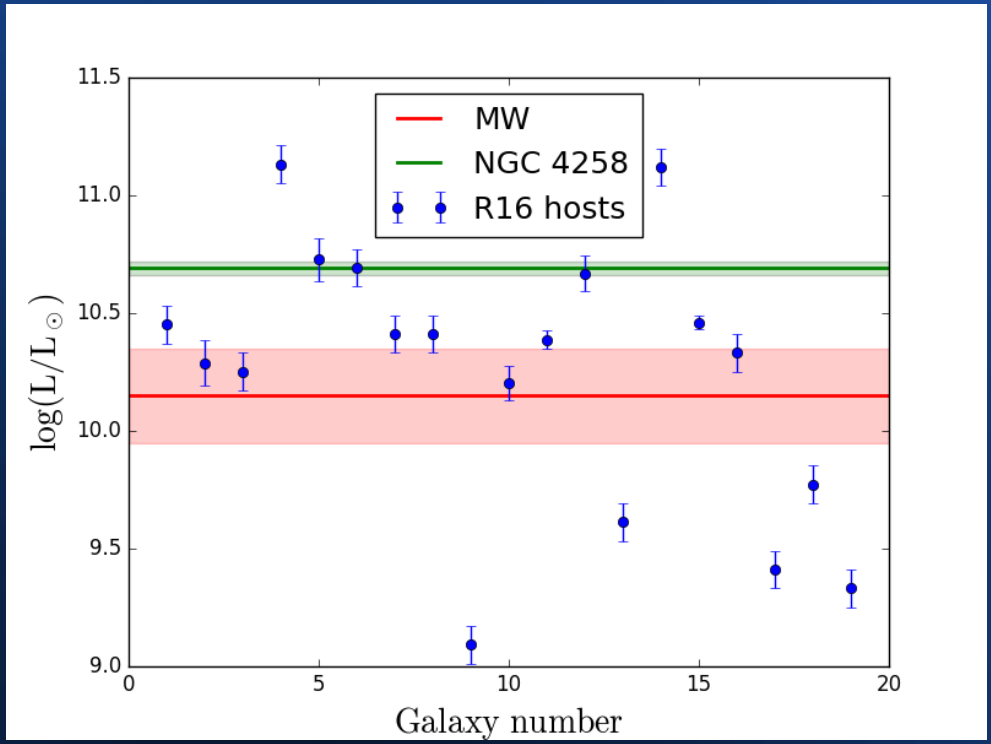


- Under F5: P↓ (envelope), L↑ (core) ⇒ D↑ ⇒ H0↓
- Need PLR-calibrators screened, SN-calibrators unscreened

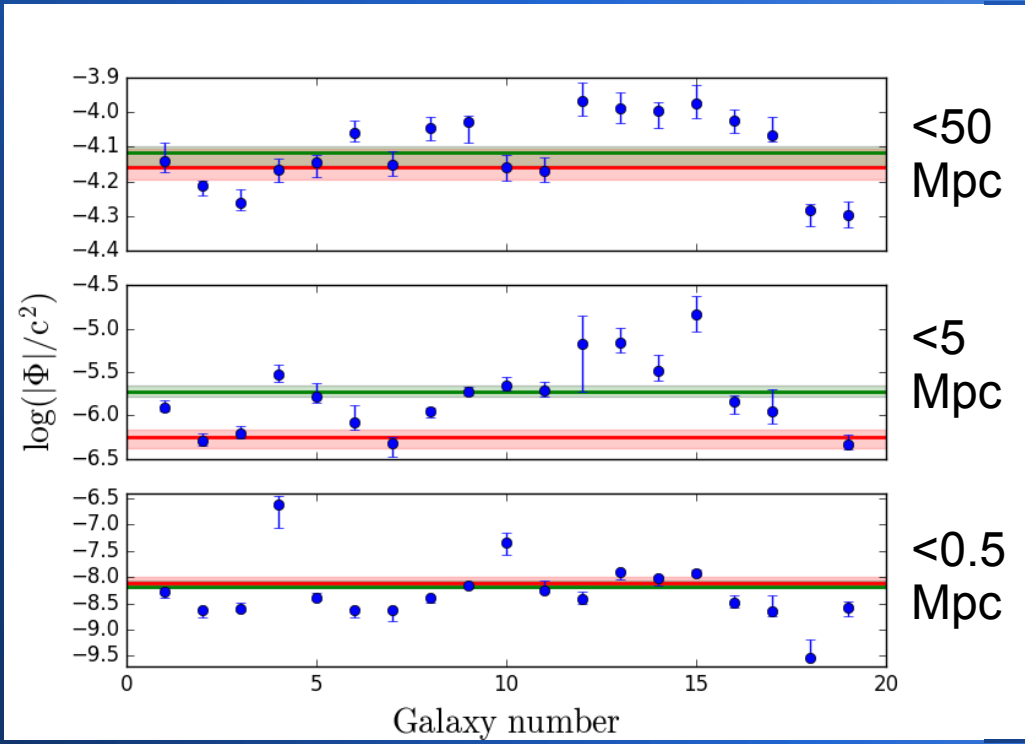
Screening properties of Cepheids

- Screening proxies:
  - Galaxy luminosity
  - Galaxy dynamical mass
  - Halo virial mass
  - Externally sourced Newtonian potential, acceleration and curvature [Desmond+2017]
  - Local dark matter density [Sakstein+2019, arXiv:1907.03775]
- Determined from NED/EDD data, N-body sims, structure formation models & models of galaxy–halo connection

Screening properties of Cepheids



Galaxy luminosity



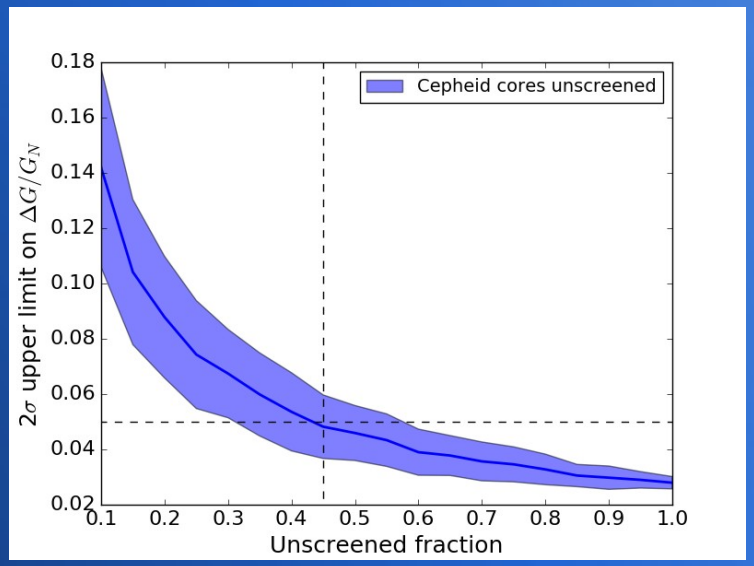
Environmental potential

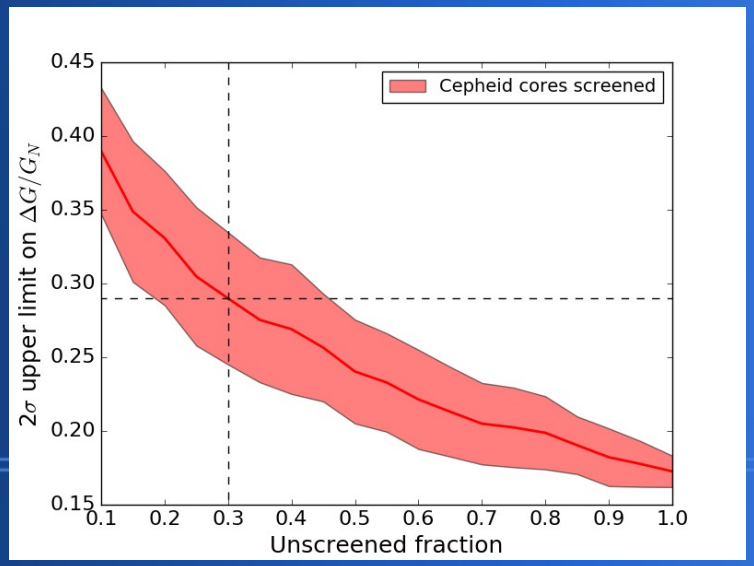
Maximum fifth-force strength: Consistency tests within the ladder

1. Scatter in Cepheid period–flux relation should be minimised for correct F5

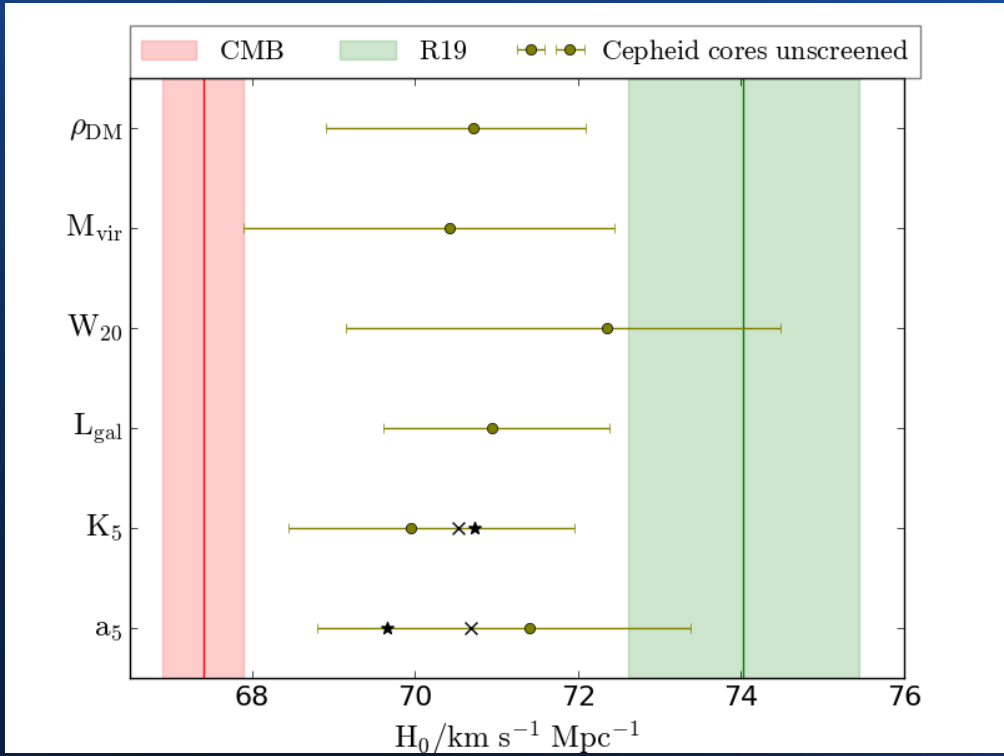
2. As should difference in inferred SN absolute magnitude between screened and unscreened subsamples

3. Cepheid & TRGB distances should be consistent

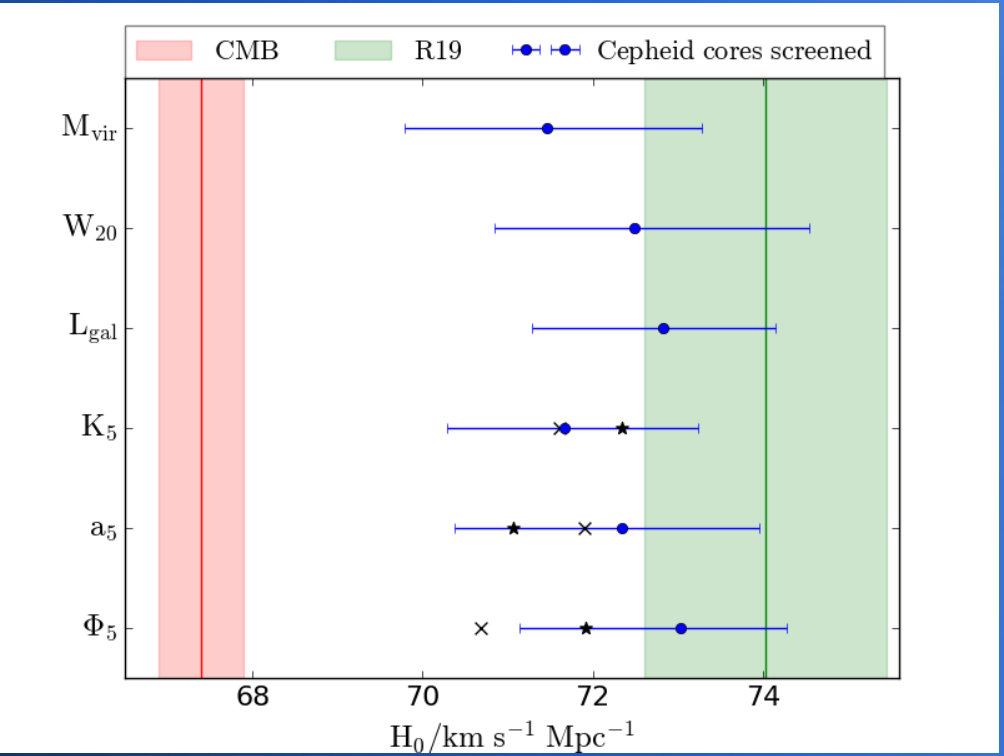




Effect on H0

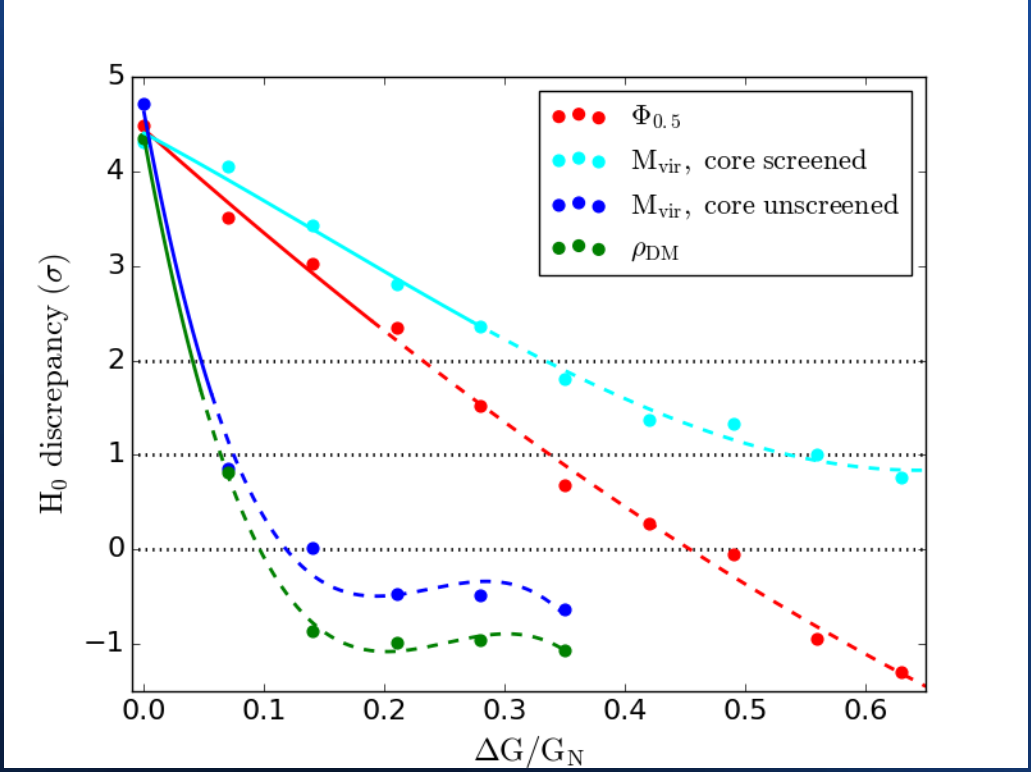


Cores unscreened



Cores screened

Effect on H0



- Possible reduction of H0 tension to 1.5σ
- Requires ΔG/G≈0.05 for Cepheid cores unscreened, ΔG/G≈0.4 otherwise

Conclusions

- Novel *local* resolutions of Hubble tension possible
- Screened fifth forces very well motivated theoretically, and empirically useful too
- Cepheid PLR is offset between screened and unscreened galaxies, biasing distances if assumed to be universal
- Best models reduce tension to ~1.5σ, without (at least obviously) messing up other parts of the distance ladder
- Most concretely-realised screening mechanisms not suitable, but baryon–DM interaction model could be