Where my DAEMON hides

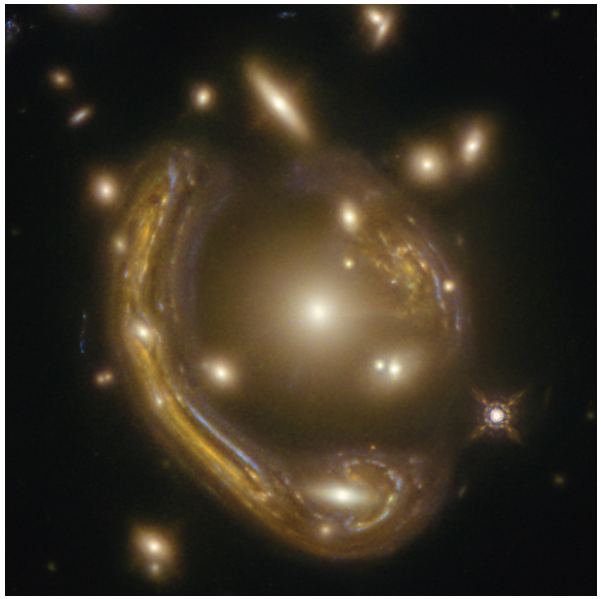
One explanation to rule all lens models

Jenny Wagner

Universität Heidelberg,
Zentrum für Astronomie

Youtube: https://tinyurl.com/yy7kyedc

Almost universal gravitational lenses



power-law mass densities from galaxy to galaxy-cluster scale

$$\rho_{\rm Moore}(r) = \frac{\rho_{\rm s}}{(r/r_{\rm s})^{3/2}(1+(r/r_{\rm s})^{3/2})}$$

$$\rho_{\rm PIEMD}(r) = \frac{\rho_0}{(1+r^2/r_{\rm core}^2)(1+r^2/r_{\rm cut}^2)}$$

$$\rho_{\rm SIS}(r) = \frac{\sigma^2}{2\pi G r^2}$$

$$\rho_{\rm NFW}(r) = \frac{\rho_{\rm s}}{(r/r_{\rm s})(1+r/r_{\rm s})^2}$$

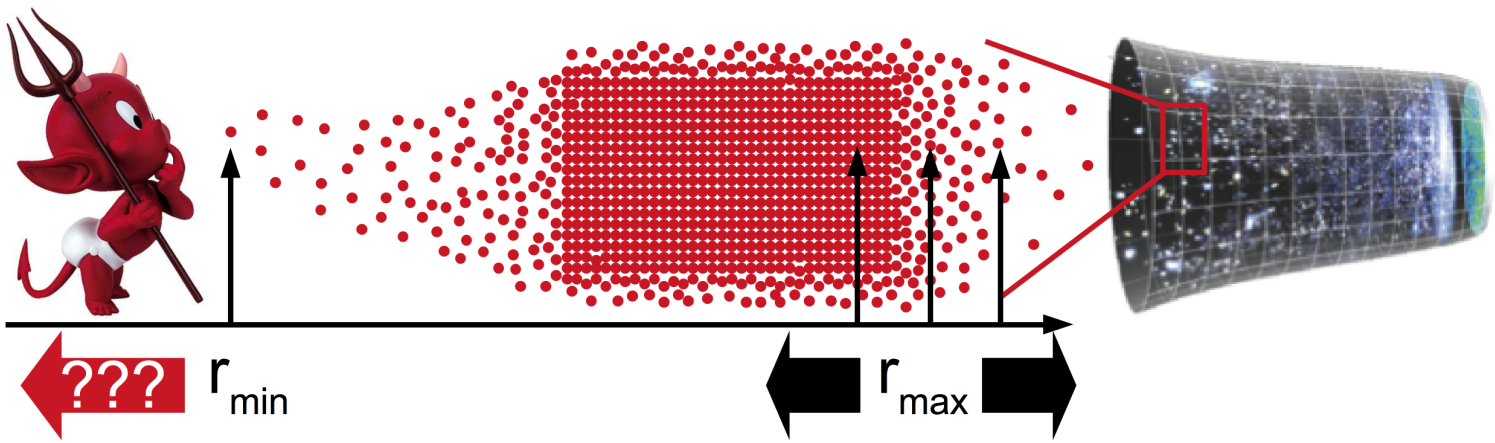
$$\rho_{\rm Jaffe}(r) = \frac{\rho_{\rm s}}{(r/r_{\rm s})^2(1+r/r_{\rm s})^2}$$

Image credits: ESA/Hubble, NASA, S. Suyu et al.; ESA/Hubble & NASA, S. Jha, L. Shatz

A fundamental reason for power-law mass densities

scale-free Newtonian gravity causes self-similar structures

$$\phi(r) \propto r^{-(\gamma-2)} \quad \rightarrow \quad \Delta\phi(r) \propto \rho(r) \quad \rightarrow \quad \rho(r) \propto r^{-\gamma}\,, \quad \gamma > 0$$



mass density from sample of collisionless self-gravitating particles

$$\rho(r) = m_{\rm p}\, n(r) = m_{\rm p}\, n_{\rm p}\, p(r) = m_{\rm p}\, n_{\rm p}\, N(\gamma, r_\sigma, r_{\rm max}, r_{\rm min}) \left(\frac{r}{r_\sigma}\right)^{-\gamma}$$

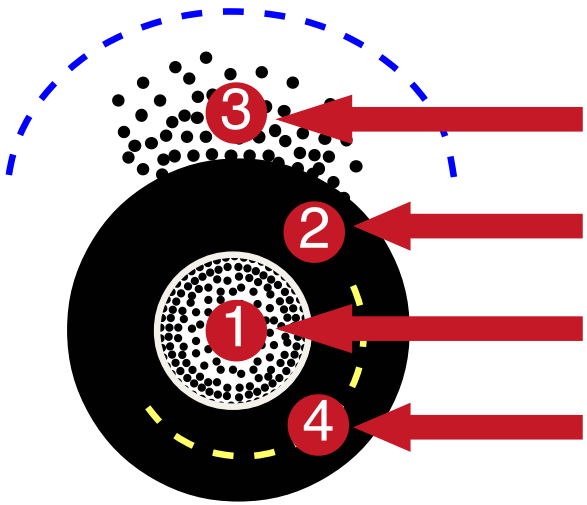
Image credits: Harvey Comics; NASA/WMAP Science Team

DAEMON = DArk Emergent Matter halO explanatioN

joint PDF → **log-likelihood** → **extremum config.**

$$p_{\mathrm{E}} = \prod_{j=1}^{n_{\mathrm{p}}} p(r_j) \quad \rightarrow \quad \mathcal{L}(p_{\mathrm{E}}) = \log\left(p_{\mathrm{E}}\right) \quad \rightarrow \quad \partial_\gamma \mathcal{L}(p_{\mathrm{E}}) \stackrel{!}{=} 0$$

$$\boldsymbol{\gamma = 2 + \frac{n_{\mathrm{p}}}{\sum_{j=1}^{n_{\mathrm{p}}} \ln\left(\frac{r_j}{r_{\mathrm{max}}}\right)}}$$



thinning outskirts: $\rho(r) \propto r^{-3}$ $(r_{\mathrm{max}} \rightarrow \infty)$

isothermal fluid case: $\rho(r) \propto r^{-2}$ $(n_{\mathrm{p}} \rightarrow \infty)$

core case: $\rho(r) \propto r^{-1}$ possible (uniform distr.)

overflowing outskirts: $\rho(r) \propto r^{-4}$ $(\langle \delta r \rangle \rightarrow r_{\mathrm{max}})$

Thank you for your attention

I gratefully acknowledge

- inspirations from many colleagues, friends, and collaborators, especially G. Ellis, A. Macciò, X. Er, R. Grand, J. Hjorth, S. Kapfer, A. Lahee, C. Pichon, C. Rovelli, J. Schwinn, V. Springel, R. Vaas, G. Wagner, L. Williams
- funding by the DFG (WA3547/1-1, 1-3)
- this opportunity to present my results!

Further reading:

- Essay (hon. mention of the GRF) → **arXiv:2005.08975**
- Full paper (published in GREG) → **arXiv:2002.00960**

Further information:
www.zah.uni-heidelberg.de/staff/jwagner **j.wagner@uni-heidelberg.de**