
Possible explanations and dark matter candidates

31/10/2018

- **Program**

- Explanations:
 - * Modification of gravitational laws
 - * MACHOS and microlensing measurements
 - * Primordial black holes
- Particle candidates:
 - * Particle properties to be the dark matter
 - * Why not standard model particles?
 - * WIMP and its production mechanisms
 - * SUSY candidates
 - * KK particles & superheavy WIMPs
 - * Sterile neutrinos and axions

- **Literature:**

- M. Milgrom, *A modification of the newtonian dynamics as a possible alternative to the hidden mass hypothesis*, *Astrop. J.* **270** (1983) 365
- *Modified gravity as an alternative to dark matter*, Chapter 6 in 'Particle dark matter', Ed. by G. Bertone, Cambridge University Press (2010)
- Sanders & Verheijen, *Rotation curves of Ursa Major in the context of modified Newtonian dynamics*, *ApJ* **503** (1998) 97
- C. Alcock *et al.* [MACHO Collaboration], *The MACHO project: microlensing results from 5.7 years of Large Magellanic Cloud observations*, *ApJ* **542** (2000) 281
- A. Green, *Primordial Black Holes: sirens of the early Universe*, *Fundam. Theor. Phys.* **178** (2015) 129
- B. Carr *et al.*, *Primordial black holes as dark matter*, *Phys. Rev. D* **94**, 083504 (2016)
- White, Frenk & Davis, *Clustering in a neutrino-dominated Universe*, *ApJ* **274** (1983) L1
- S. Tremaine and J. E. Gunn, *Dynamical role of light neutral leptons in cosmology*, *Phys. Rev. Lett.* **42** (1979) 407
- G. Jungman, M. Kamionkowski and K. Griest, *Supersymmetric dark matter*, *Phys. Rep.* **267** (1996) 195
- L. Roszkowski, *Particle dark matter: A Theorist's perspective*, *Pramana* **62** (2004) 389, hep-ph/0404052
- E. W. Kolb *et al.*, *WIMPZILLAS!*, arXiv:hep-ph/9810361
- H.V. Klapdor-Kleingrothaus and K. Zuber, *Particle Astrophysics*, IoP (2000) Chap.11

- **Material for lecture:**

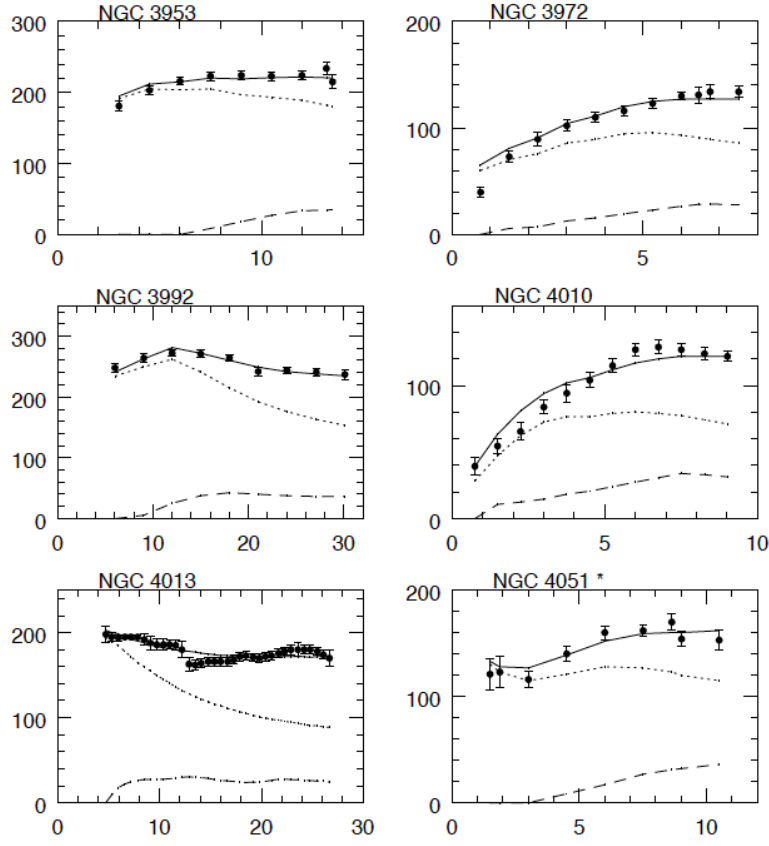


Figure 1: Fits of the MOND model (continuous line) to rotation curves data in Ursa Major galaxies. The dashed line represents the luminous disk and the dotted line the gaseous disk. Figure from Sanders & Verheijen, ApJ 503 (1998) 97.

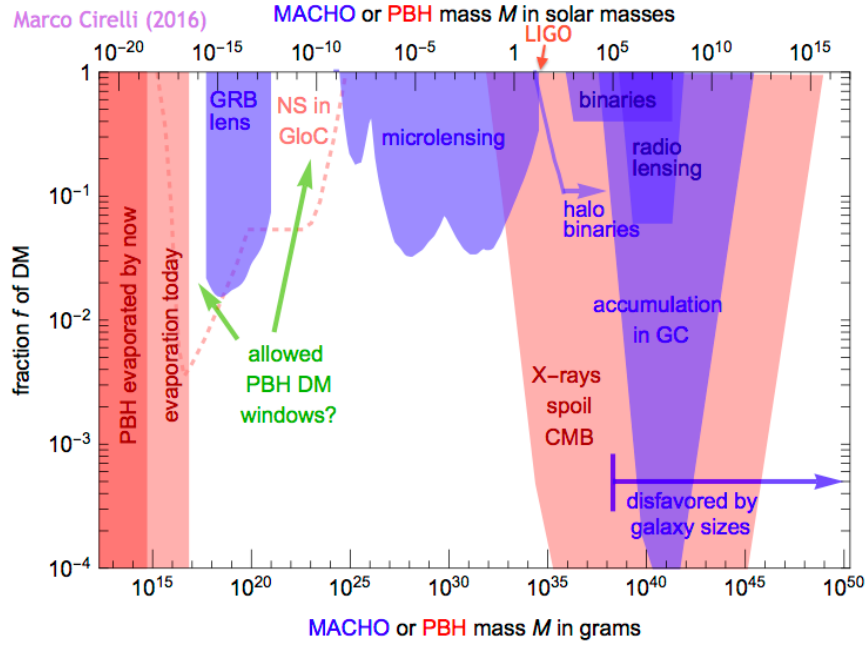


Figure 2: Constrains to the fraction of black holes that contribute to dark matter as a function of the black hole mass. Figure from M. Cirelli (2016).

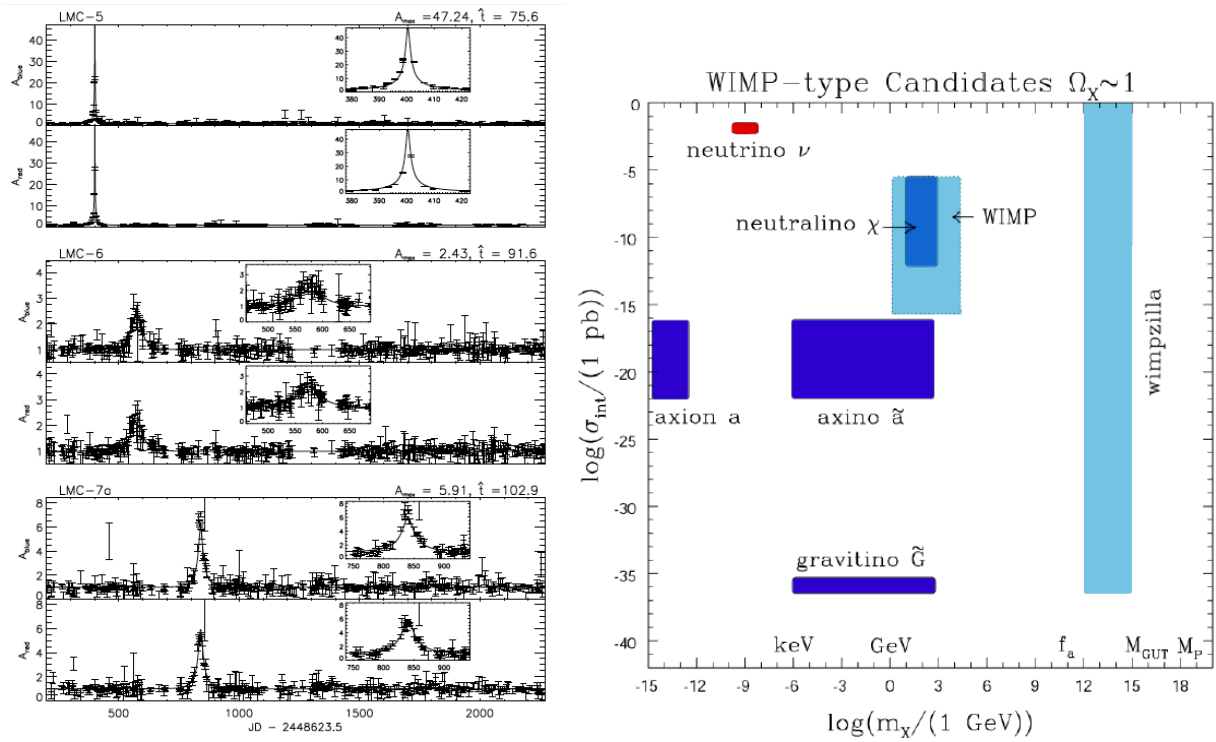


Figure 3: (Left) Examples of microlensing observations in the Large Magellanic Cloud. From C. Alcock *et al.* [MACHO Collaboration] *Astroph. Journal* 542 (2000) 281. (Right) Dark matter particle candidates. Figure from L. Roszkowski arXiv:hep-ph/0404052.

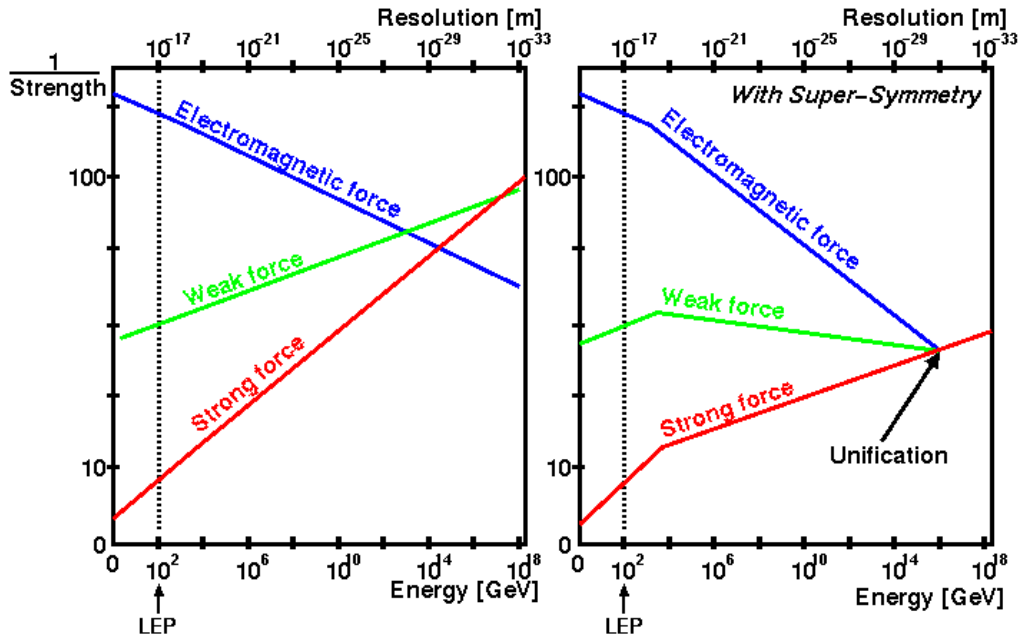


Figure 4: Unification of forces in Supersymmetry. Figure from CERN (European Organization for Nuclear Research).