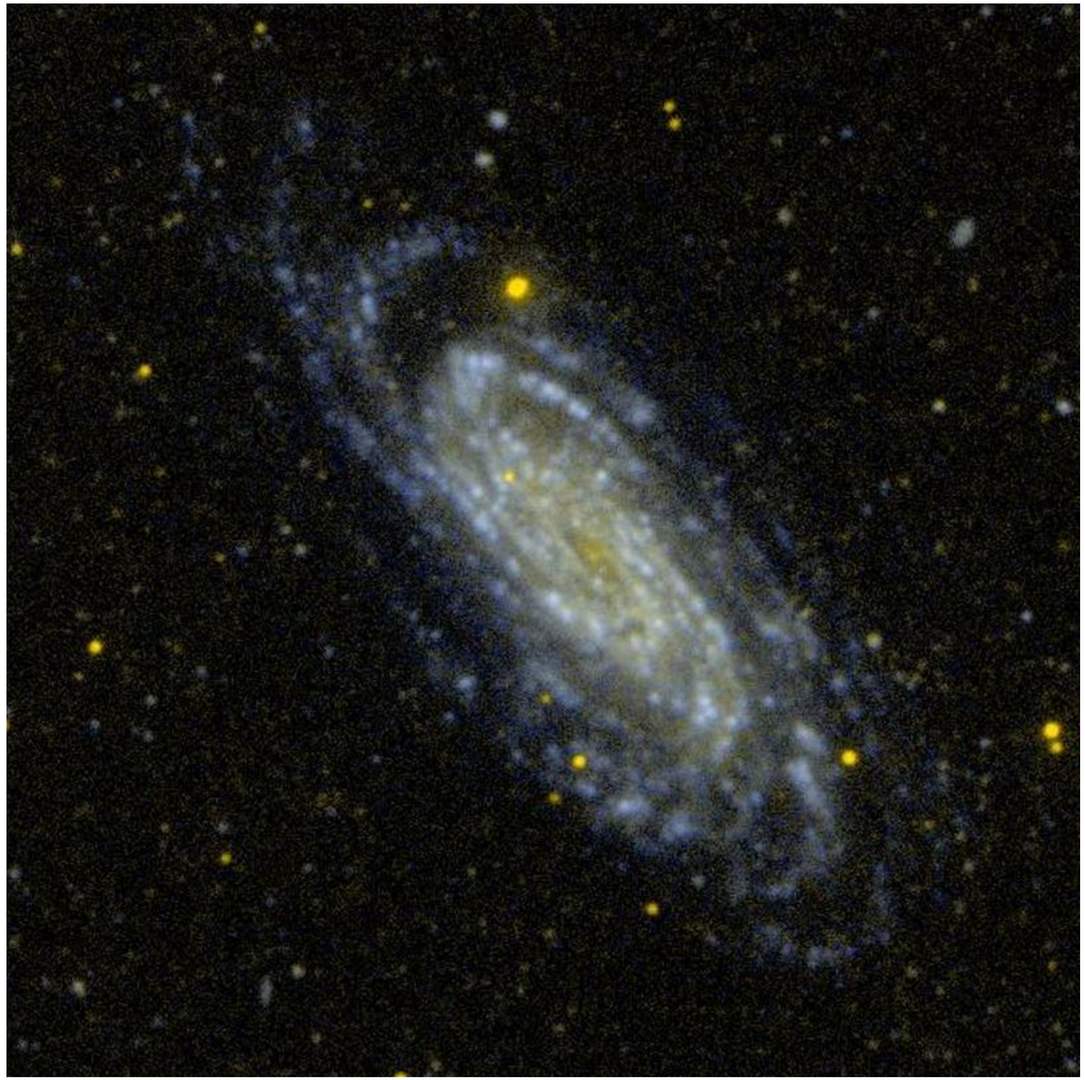
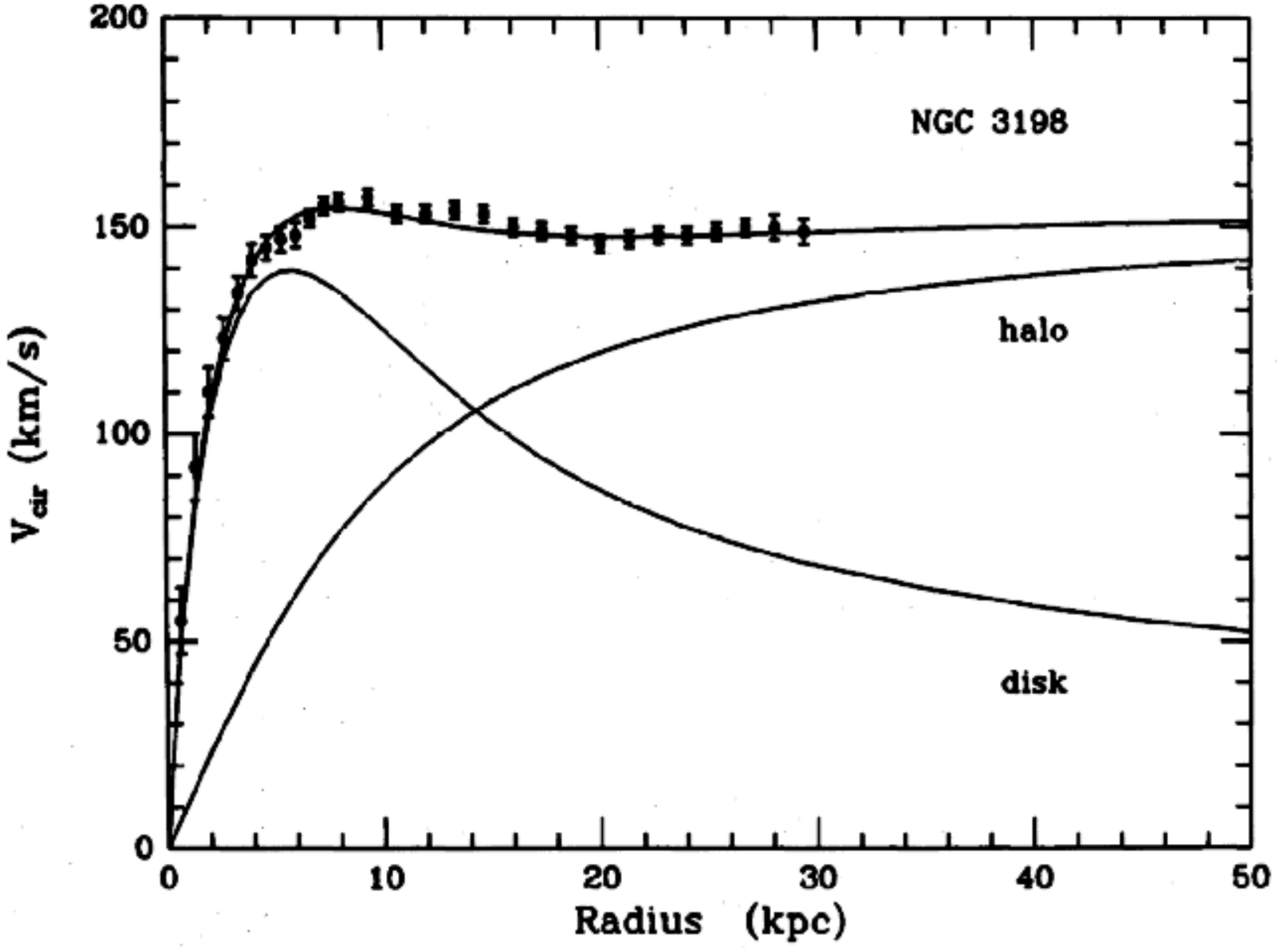


NGC 3198 is a barred spiral galaxy.

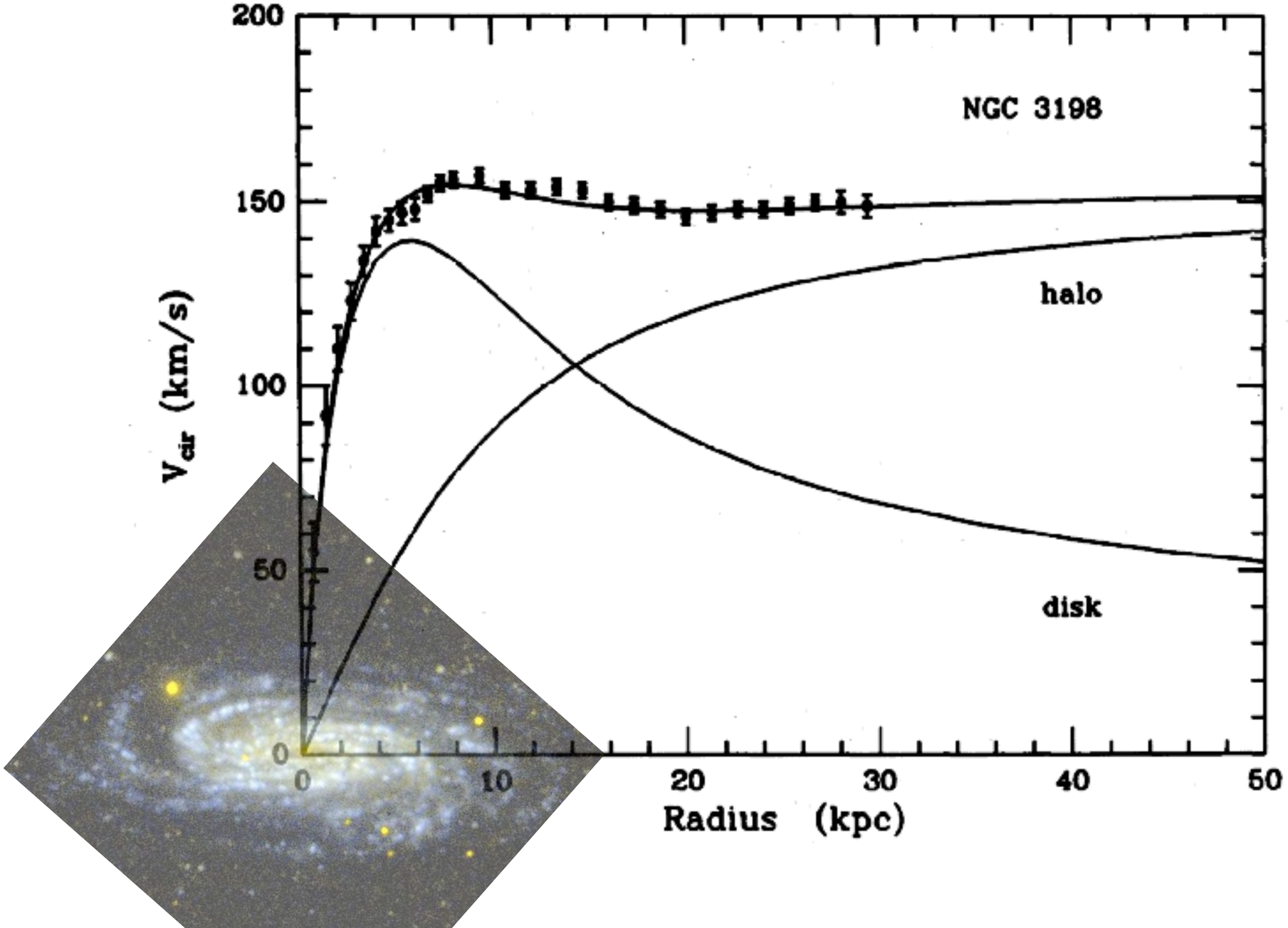
Discovered by William Parsons, 3rd Earl of Rosse (Lord Rosse), sometime before 1850.

NGC 3198 is located in the Virgo Supercluster, and is approximately 47 million light years (14.5 Mpc) away.

DISTRIBUTION OF DARK MATTER IN NGC 3198



DISTRIBUTION OF DARK MATTER IN NGC 3198



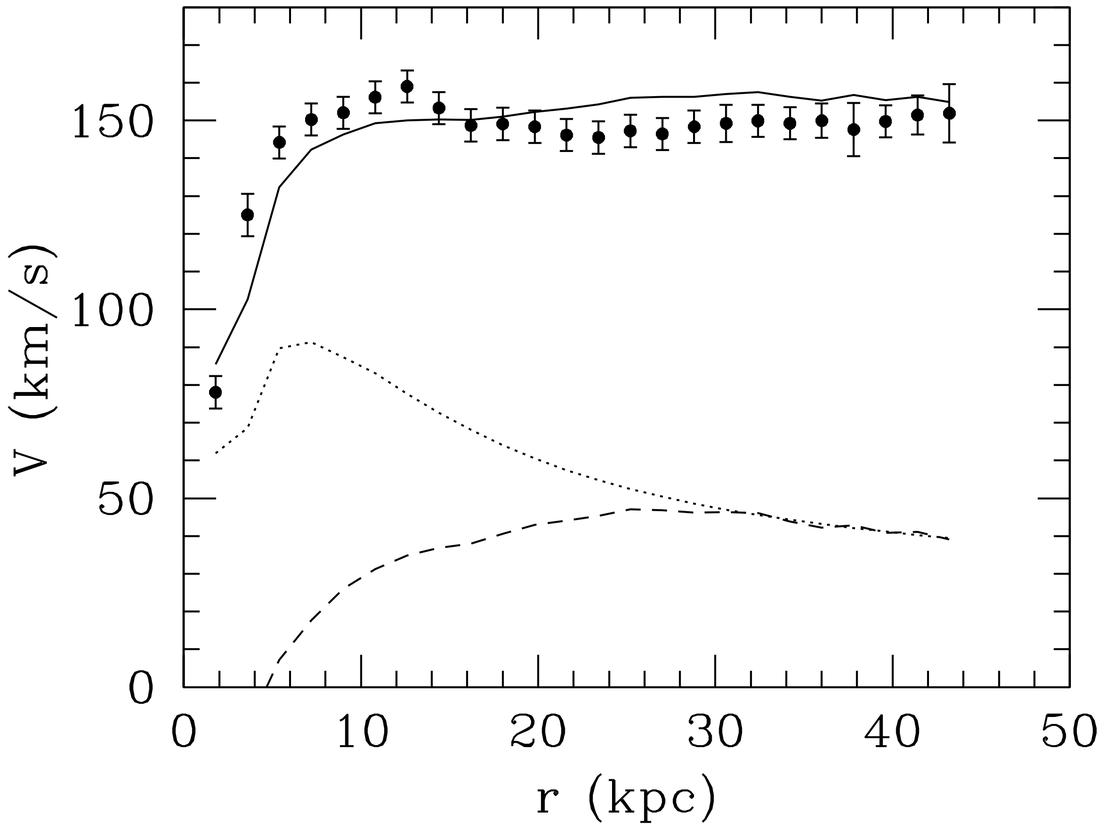
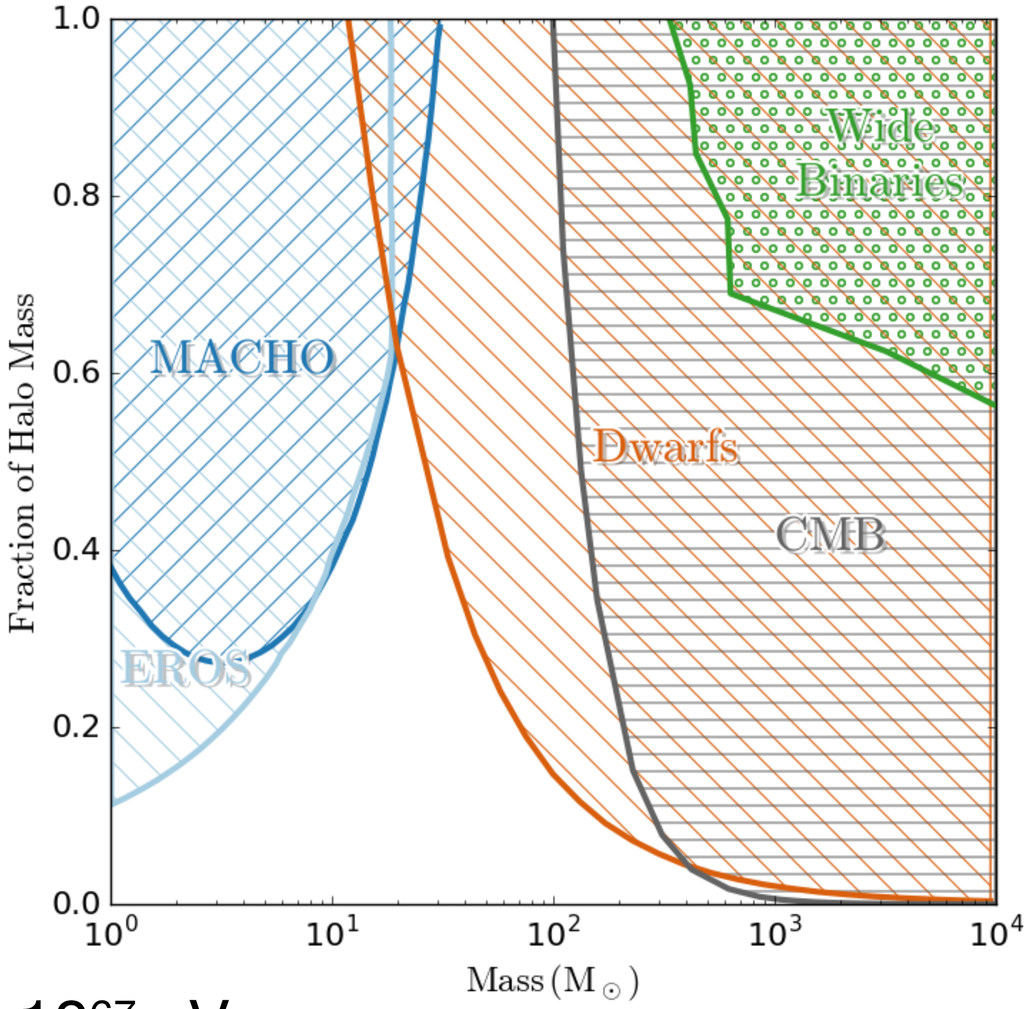


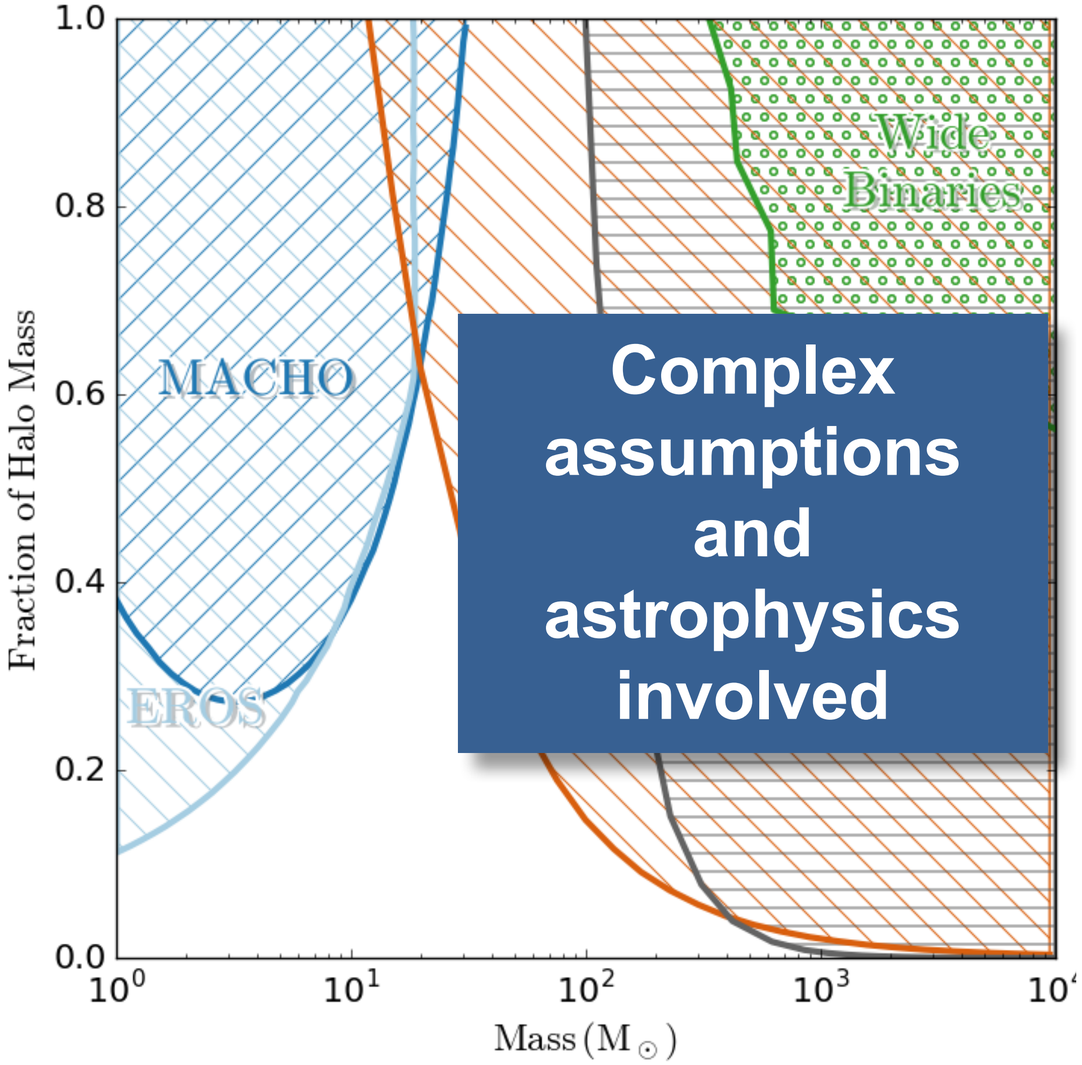
Fig. 13. MOND fit of the rotation curve derived in the present paper, using a distance free within the uncertainties of the Cepheids method (13.8±1.5 Mpc). The dashed line is the Newtonian contribution of the gaseous disks (thin disk and extraplanar gas), the dotted line is the Newtonian contribution of the stellar disk (from de Blok et al. 2008) and the solid line is the best MOND fit.

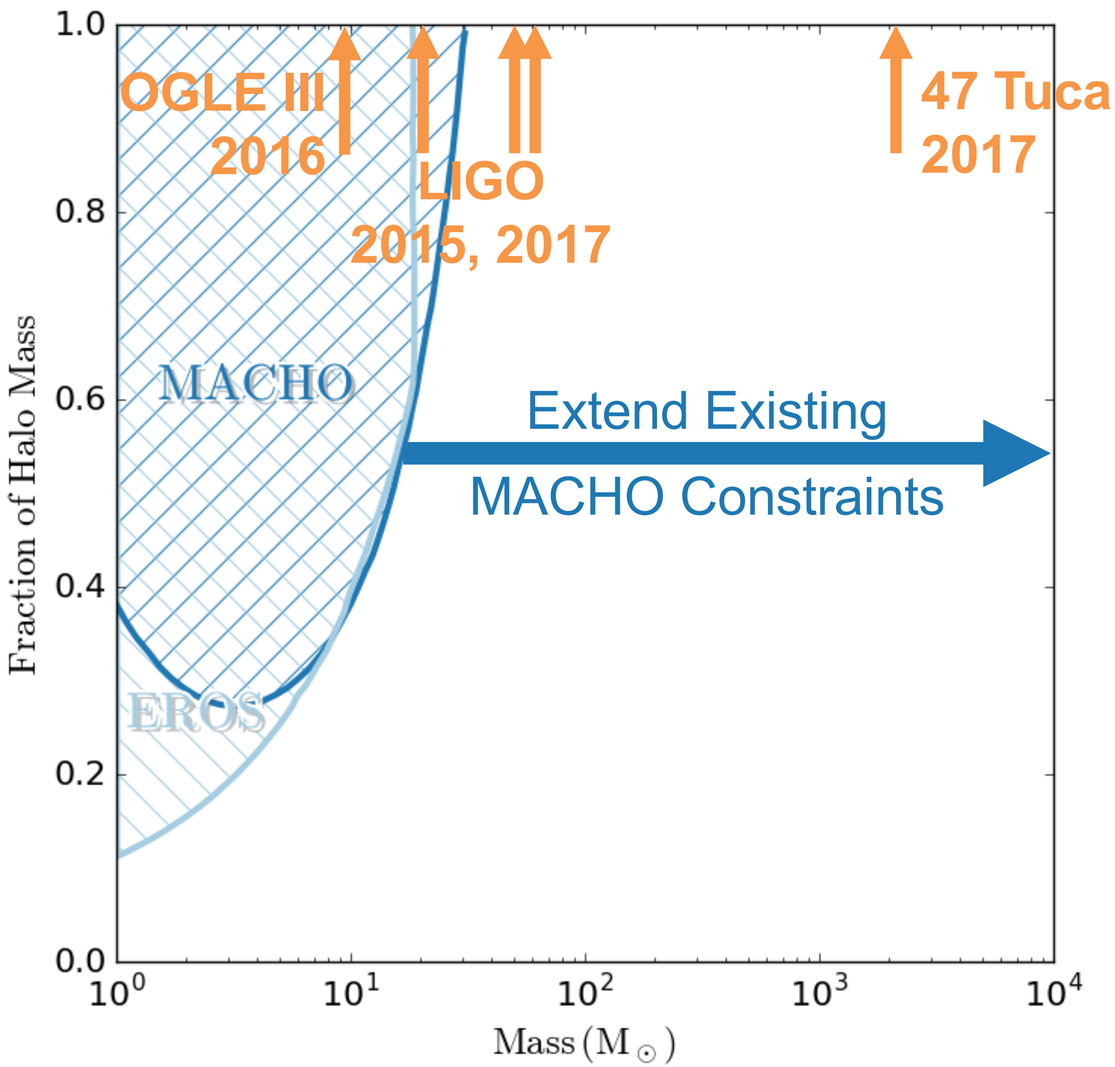
Solar mass DM bounds



10^{67} eV

- Microlensing
  - Alcock et al. 2001
  - Tisserand et al. 2007
- CMB
  - Ali-Haïmoud & Kamionkowski 2016
- Wide Binary
  - Quinn et al. 2009
- Dwarf Galaxies
  - Brandt 2016, & Li et al. 2017


Fraction of Halo Mass
1.0
0.8
0.6
0.4
0.2
0.0
10^0
10^1
10^2
10^3
Mass ($M_\odot$)
MACHO
EROS
Wide Binaries
Complex assumptions and astrophysics involved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1.0
0.8
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10^0
10^1
10^2
10^3
10^4
Mass ($M_\odot$)
MACHO
EROS
OGLE III
2016
LIGO
2015, 2017
47 Tucanae
2017
Extend Existing
MACHO Constraints

TASI Lectures on Indirect Searches For Dark Matter

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1. The Galactic Center Gamma-Ray Excess

In 2009, Lisa Goodenough and I began to analyze the publicly available Fermi data in an effort to place constraints on any contribution from annihilating dark matter. In October of that year, we posted to the arXiv the first paper to identify what would become known as the Galactic Center gamma-ray excess [122]. Over the following years, a number of studies [123–128] improved upon this early work. By 2014 or so [121], a consensus had begun to form that

"Hooperon"

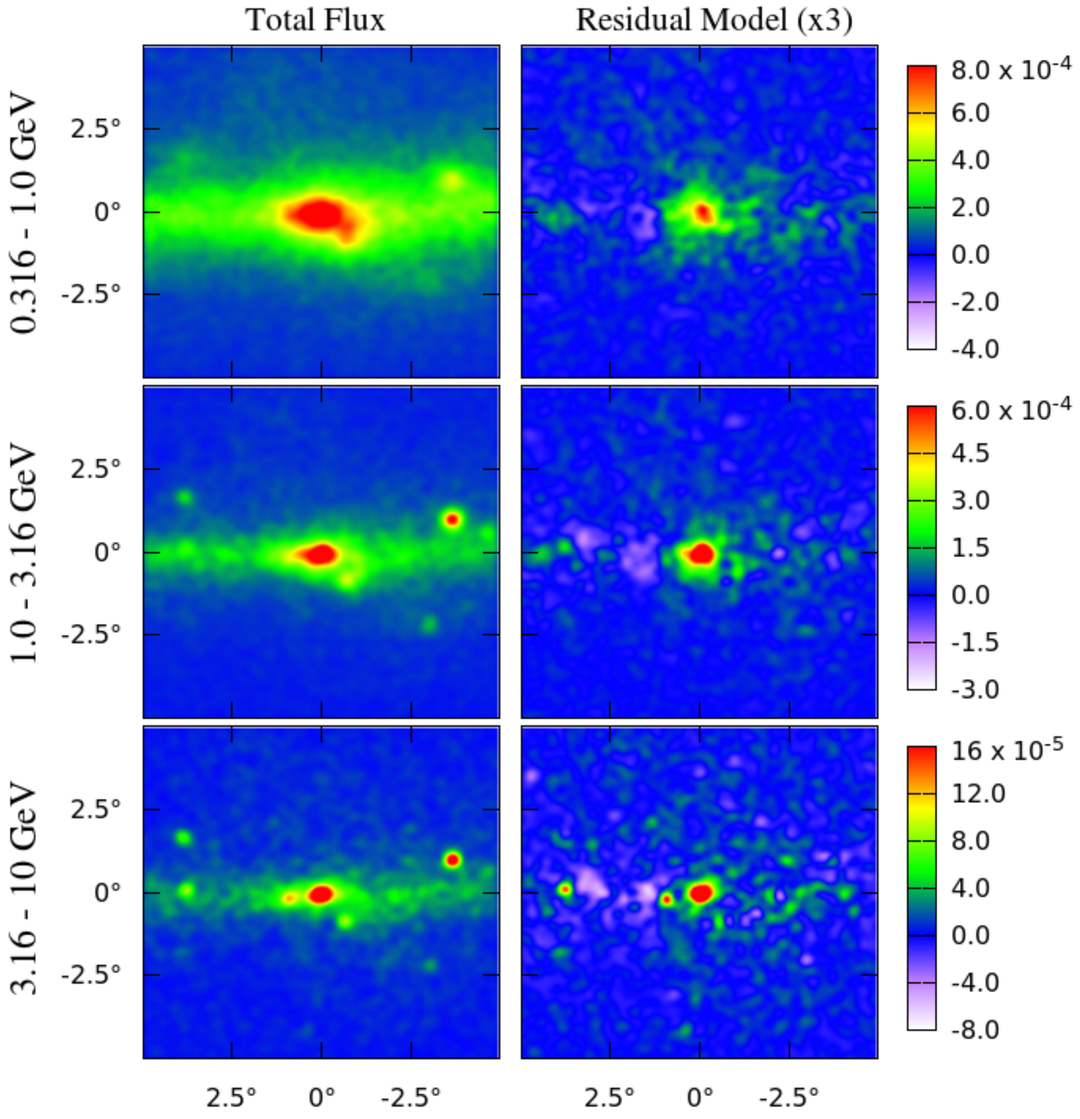

FIG. 5: The raw (left) and residual (right) intensity maps of the gamma-ray emission from the Inner Galaxy, as presented in Ref. [121]. Although the existence of this excess was controversial for several years, by 2014 a consensus had begun to form that this signal is indeed present in the Fermi data. The origin of this emission remains hotly debated today.

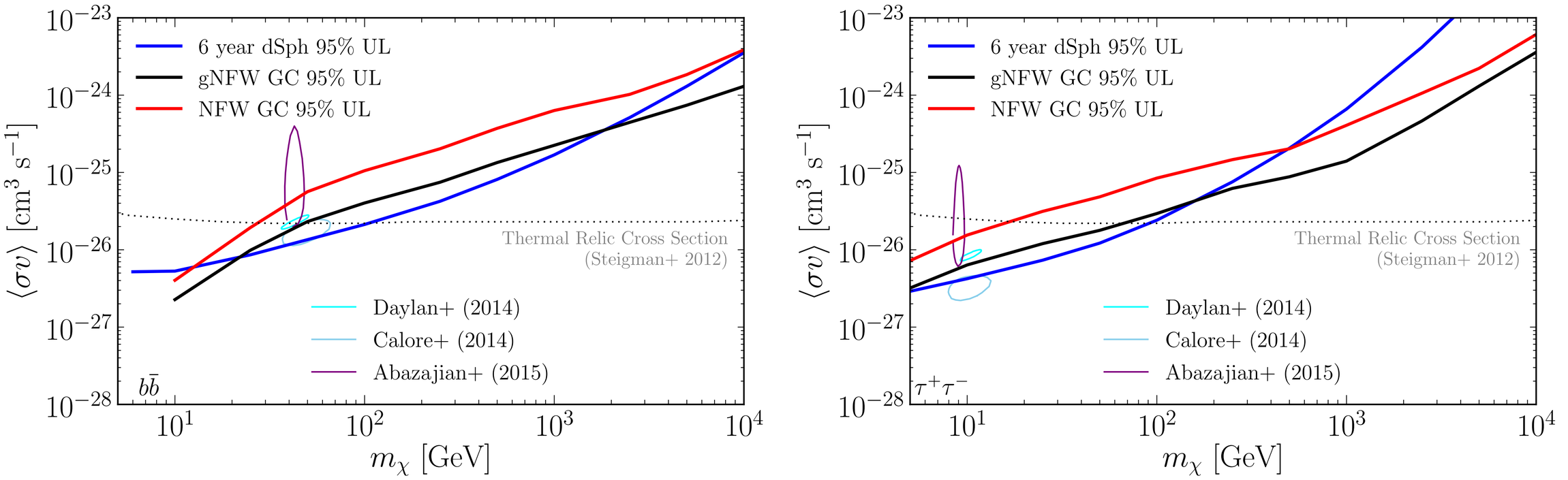

FIG. 4: Constraints on the dark matter annihilation cross section from Fermi's observations of the Galactic Center as a function of mass, for annihilations to $b\bar{b}$ (left) and $\tau^+\tau^-$ (right) final states. Results are shown for the case of an NFW profile ($\gamma = 1$) or a generalized NFW profile with $\gamma = 1.25$ (in each case with $R_s = 20$ kpc and a local density of 0.4 GeV/cm^3). These results are compared to the constraints derived from the stacked observations of Milky Way dwarf galaxies. From Ref. [120].

Direct detection - spin independent