A first modeling of globular clusters in fuzzy dark matter universe: In-situ population of Milky Way-like galaxies

Boldrini, Di Matteo, et al.+25, in prep. ; Szpilfidel, Boldrini, Bovy, Di Matteo.+25, in prep.

Credits: Gaia collaboration

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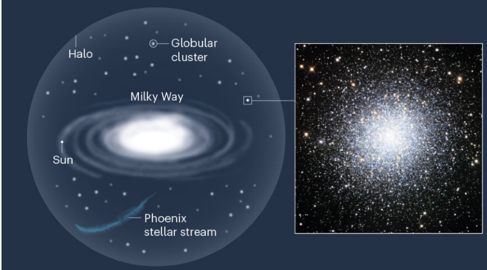
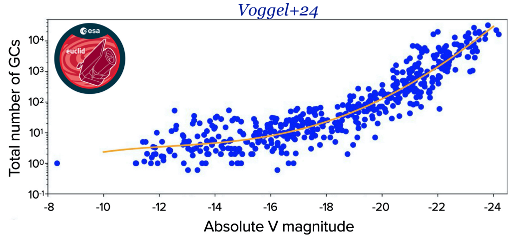
Constraining the nature of dark matter with Gaia and Euclid



6D phase space for the 171 Milky-Way GCs

Gaia Collaboration+18,+21, Vasiliev & Baumgardt+21

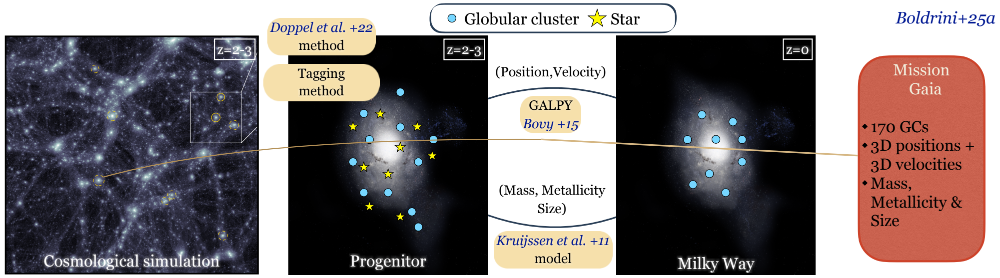
Voggel+24



Half a million extragalactic GCs within 100 Mpc in 10 000 nearby galaxies with stellar masses between 10^9 and 10^{12} M⊙

Our post-processing GC model

Boldrini+25a

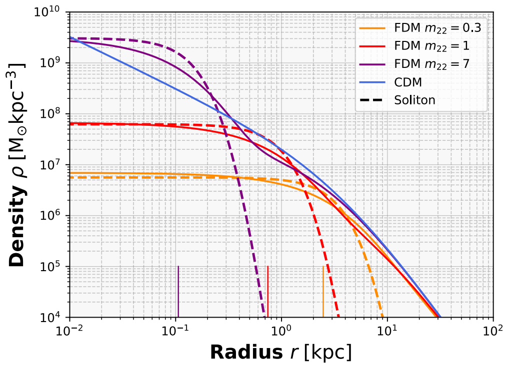


Combining existing cosmological simulations (TNG50) and orbital integration (GALPY) to study the hierarchical assembly of in-situ GC populations in the MW, which tracks the GC populations across various galactic environments

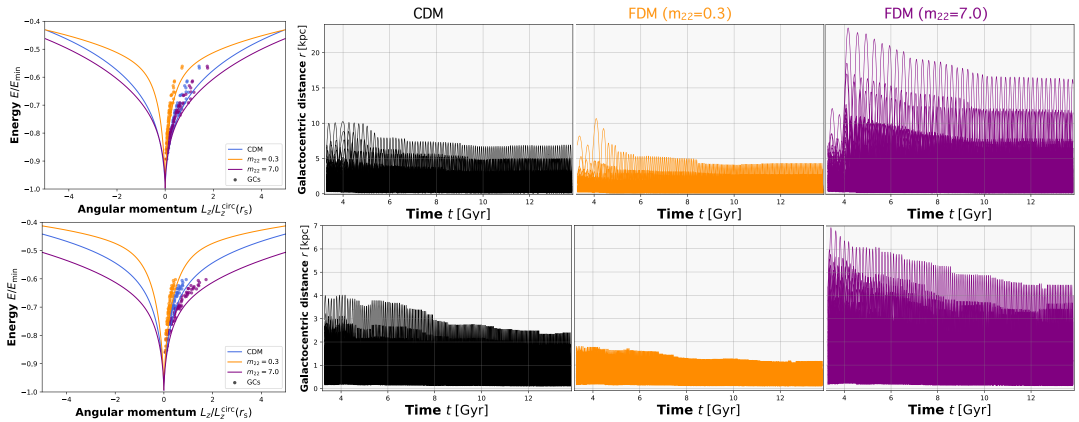
Modeling fuzzy dark matter galactic dynamics

DM as an ultra-light scalar field with no self-interaction in the non-relativistic limit, is known as Fuzzy Dark Matter. This scalar field is assumed to be made up of very light particles with a mass of 0.1 – 30 × 10^{-22} eV

- A difference in the density profile of DM halos (core instead of cusp)
  —> Approximation of soliton + NFW profiles
- A substantial modification of dynamical friction due to the wave-like nature of FDM and its intrinsic density fluctuations
  —> Dynamical friction is inefficient over our timescale (11 Gyr) as the mass ratio between MW enclosed mass and in-situ GC masses is large.
- A significantly reduced population of low-mass subhalos
  —> Neglected as we assume the halo and stellar mass evolution predicted by TNG50 (CDM).

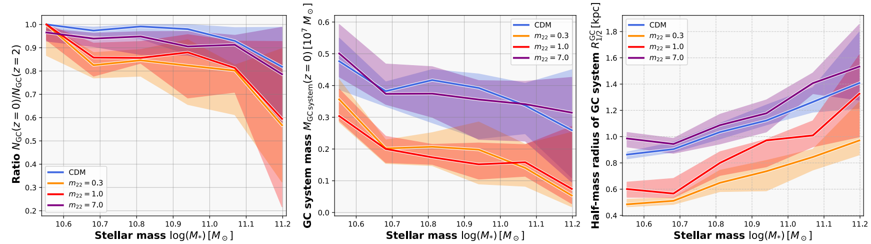


GC INITIAL CONDITIONS: globular cluster population distributed uniformly in terms of relative gravitational binding energy (E/E_{min}) and orbital circularity L_z/L_z^{circ} from a sample of the CDM phase-space distribution of stellar particles computed with AGAMA.



Key results

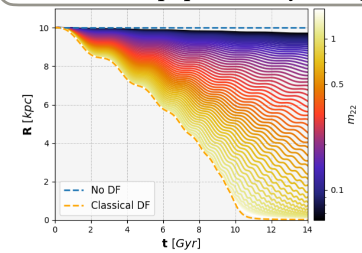
The lower the value of m_{22}, the more the galactic potential tends to confine globular clusters within the FDM core, where tidal effects are stronger, thereby enhancing their mass loss over time.



Future works

- Ex-situ GC population by taking into account FDM dynamical friction

Szpilfidel, in prep.



Fuzzy-dark-matter dynamical friction

```
class galpy.potential.FDMDynamicalFrictionForce(amp=1.0, GMs=0.1, gamma=1.0, rhm=0.0,
m=1e-99, dens=None, sigmar=None, const_lnLambda=False, const_FDMfactor=False, minr=0.0001,
maxr=25.0, nr=501, ro=None, vo=None)
```
[source]

Implements the fuzzy dark matter (FDM) dynamical friction force.

The force is given by:

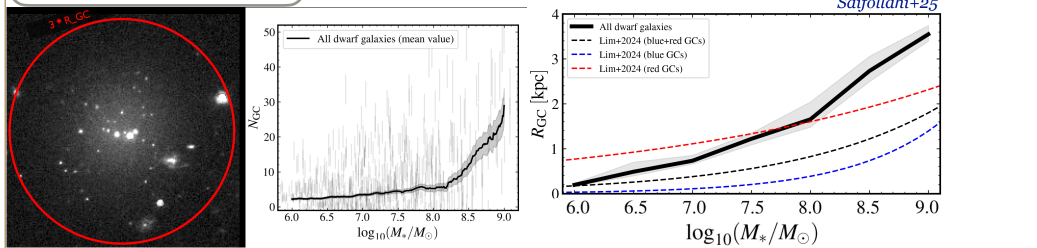
$$\vec{F}_{\rm FDM} = -\frac{4\pi\mathcal{G}^2 M_{\rm obj}^2\rho}{v^3} C_{\rm FDM}(kr)\vec{v}$$

where the coefficient $C_{\rm FDM}(kr)$ depends on $kr = \frac{mvr}{\hbar}$ and is given by

$$C_{\rm FDM}(kr) = {\rm Cin}(2kr) + \frac{\sin(2kr)}{2kr} - 1$$

- Predictions for Euclid

Saifollahi+25



2 key metrics for Euclid: GC number and GC half-number radius