InDark

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Loc. Coord.: Prof. Antonaldo Diaferio

INFN GR4 Retreat
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Arianna Gallo &
Michele Pizzardo

InDark's numbers

As 2020:

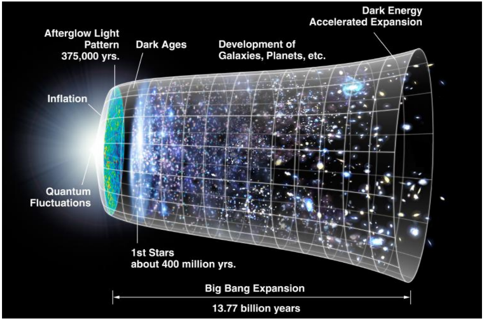
- 8 institutes
- 93 scientists: 45 staff, 13 PDs, 35 PhDs
- 140 publications
- 151 collaborations (80% international, including large projects, e.g. *Euclid, SKA, DESY*)
- top rank evaluation

InDark's aim

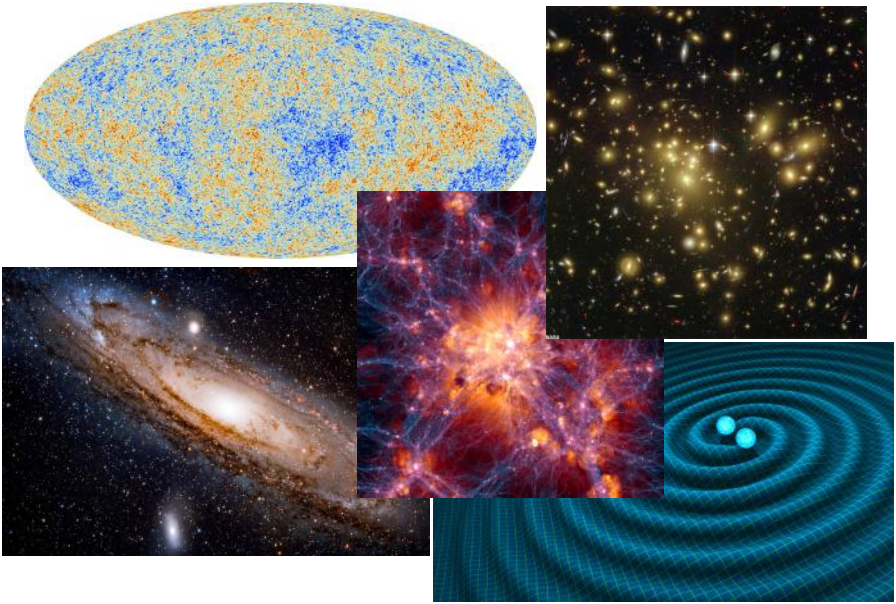
⟶ studying crucial aspects of the standard **cosmological model** and its extensions
⟶ attention to connection with particle physics

Main topics:

- inflationary models for the early universe
- nature of dark matter and dark energy
- properties of neutrinos and light relics
- feasibility of alternative models of gravity



InDark's probes



InDark in Torino

In Torino: **6 associates**

Coordinator: A. Diaferio

Staff members: A. Diaferio, L. Ostorero, S. Camera

PD: S. S. Chakrabarty

PhDs: A. Gallo, M. Pizzardo

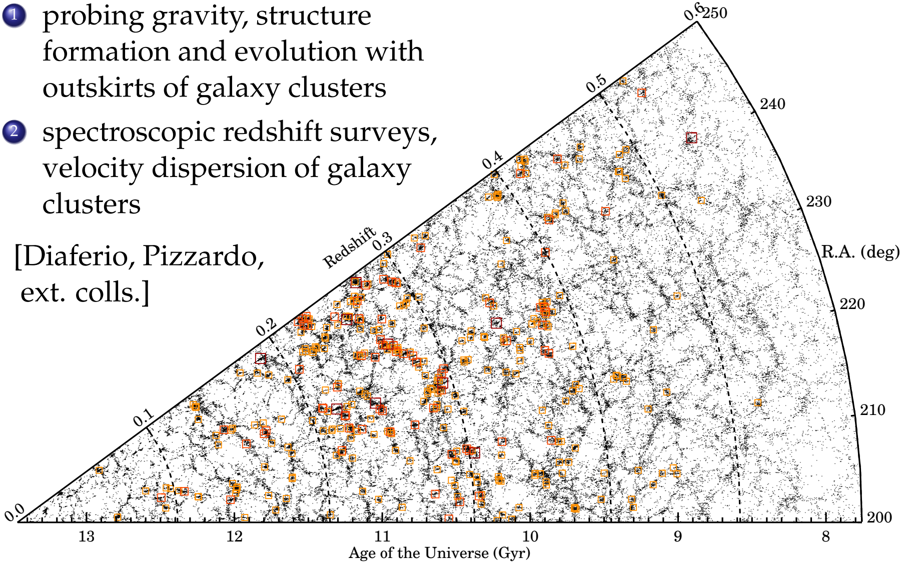
⟶ **Primary focus on intermediate and small scales**

- clusters of galaxies
- Milky Way and other galaxies

InDark in Torino (1): Galaxy clusters

1. probing gravity, structure formation and evolution with outskirts of galaxy clusters
2. spectroscopic redshift surveys, velocity dispersion of galaxy clusters

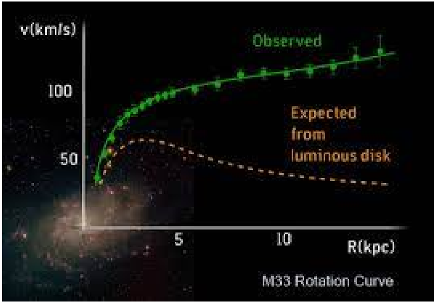
[Diaferio, Pizzardo, ext. colls.]



InDark in Torino (2): Milky Way and galaxies

1. probing dark matter halo shape of MW with HVSs
2. ΛCDM/MOND with HVSs in MW
3. galaxy velocities in refractive gravity
4. dwarf galaxies: core/cusp problem; MOND
5. radio galaxies in LOFAR collaboration.

[Ostorero, Chakrabarty, Gallo, Diaferio, ext. colls.]

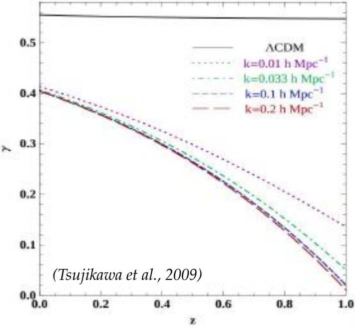


Mass accretion of galaxy clusters

Growth of structures at large scales:

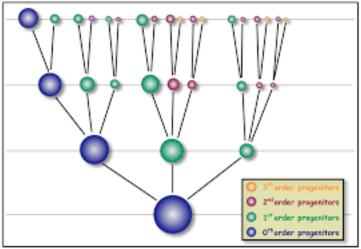
- correlation functions
- redshift distortions
- halo abundance (mass function)

  $\longrightarrow$ linear growth rate



At small scales:

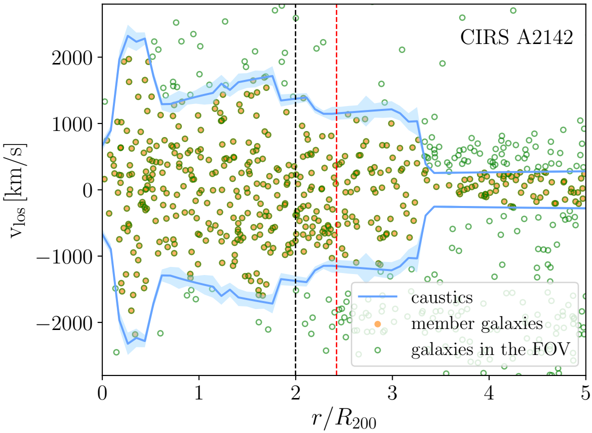
1. Theoretical expectations are not observable
2. Observative results limited well within R_{200}



My MARs are **observable, comparable with simulations**, unaffected by baryonic effects

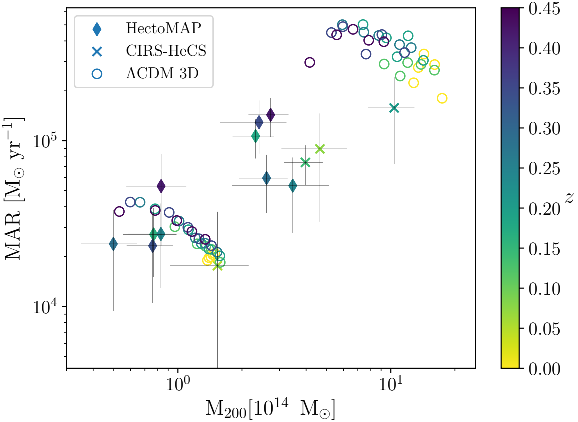
Data

Dense spectroscopic redshift catalogues of clusters allow to study the clusters outskirts robustly



Unique catalogues: CIRS+HeCS (129 cl.) and HectoMAP (346 cl.)

MAR: First measurement up to $z \sim 0.42$



- MAR vs M_{200} vs z agree with hierarchical formation model within ΛCDM
- Future developments: estimation at higher redshifts ($z \sim 1$), joint WL + CT to obtain better mass profiles, use of Illustris TNG for a closer consistency with observations

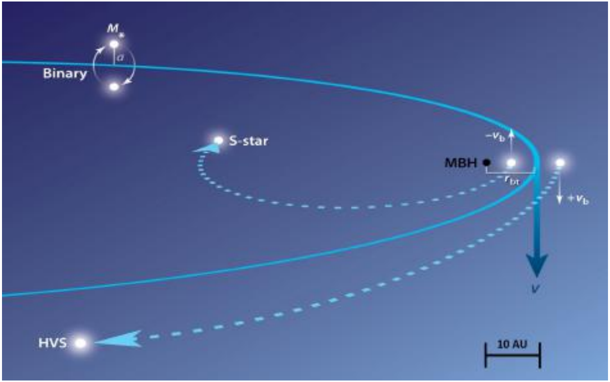
Hypervelocity stars: excellent probe of the Milky Way gravitational potential

They can be used:

1) To constrain the shape of the MW dark matter halo potential.
2) To discriminate between Newtonian gravity and modified theories of gravity.

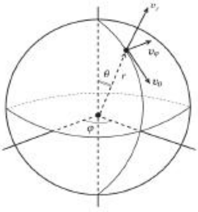
The existence of hypervelocity stars (HVSs) was:

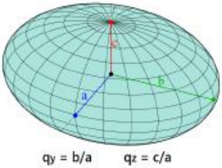
- predicted by Hills in 1988
  1) super-massive black hole (SMBH) ejection origin;
  2) $v > v_{\mathrm{escape}}$;
- confirmed by Brown et al. in 2005

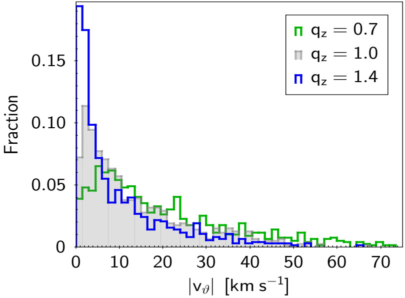


Current sample of candidate HVSs: ~ 90 stars

Probing the shape of the Milky Way dark matter halo with HVSs: a new method



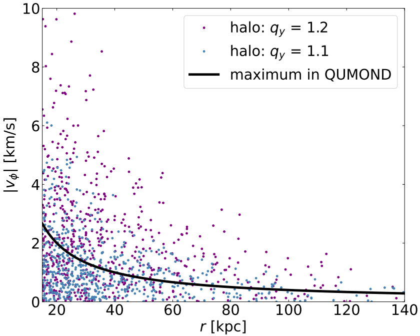




	Axisymmetric Galactic potential:	**Non-axisymmetric Galactic potential:**
Method success rate:	$\gtrsim$ **89%**	> **96%**

Probing modified Newtonian dynamics with HVSs

$$|v_\phi^{\max}(r)| \sim 4\left(\frac{10\ \mathrm{kpc}}{r}\right)\mathrm{km\ s^{-1}}$$



The max HVS v_φ's in MOND are smaller than in ΛCDM.

⇒ **Detecting even few HVSs with velocities above this limit would thus disprove MOND.**

Future astrometric missions (e.g. Theia) reaching $\sim 1\mu$arcsec uncertainty will allow to test this prediction with high significance.