Warm dark matter chills out

Dark matter halos smaller than previously known

present:
Daniel Gilman (UCLA)
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Us and everything we’ve ever known.

- Dark matter: 26.8%
- Dark energy: 68.3%
- Atoms: 4.9%
We know about dark matter:

1) Forms the invisible scaffolding on which visible structures like galaxies form

2) All galaxies live in ‘halos'

Image credit: Mansfield and Diemer
LOW MASS HALOS (SUBHALOS)

Galaxy
Different dark matter theories make unique predictions for the number of subhalos

Cold dark matter only
‘Cold’ dark matter predicts an abundance of substructure.
‘Cold’ refers to the particles’ speed: slow-moving particles clump together to form halos more easily.
In ‘warm’ dark matter, there is a dearth of structure below a certain scale.
‘Warm’ refers to the particles’ speed: fast-moving particles cannot form structure below a characteristic scale that depends on the dark matter particle mass.
EVERY GALAXY IS IN A DARK MATTER HALO, BUT NOT EVERY HALO NECESSARILY HOSTS A GALAXY.

WHAT WE SEE

WHAT COULD BE THERE

COLD

WARM

credit: Bullock, Geha, Powell
The problem:

The most pronounced differences between various dark matter theories lurk on scales where halos contain no stars, making them invisible.
Gravitational lensing lets you see invisible dark matter halos.

Perturbations due to invisible dark matter halos.

Hubble Image
Credit: STSCI

WGD J0405-3308
HST WFC3/IR
F140W
F160W
Anatomy of a strong gravitational lens
The relative brightness of the images is extremely sensitive to low-mass dark matter structure 10,000 times less massive than the main lensing galaxy.

strong lensing = gravity vision
We use HST spectroscopy to measure image brightness in one color, circumventing contamination at other wavelengths.

Nierenberg et al. 2017, 2020

HST GO 15177, 13732, PI Nierenberg
Simulated dark matter map

strong lensing = gravity vision
Our results

Using state of the art measurement and analysis methods, we were able to directly probe dark matter structures at lower mass scales than ever before.

‘Warm’ dark matter has definitely ‘chilled out’
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Future

- Thousands of these systems will be discovered by the Rubin telescope (formerly LSST) and WFIRST

- JWST, and next generation ground based observatories will enable rapid follow up and unprecedented constraints on the nature of dark matter