Sweating the small stuff:
simulating dwarf galaxies, ultra-faint dwarf galaxies, and their own tiny satellites

Coral Wheeler
UC Irvine
@coralrosew

James Bullock (UCI)
Jose Oñorbe (MPIA)
Shea Garrison-Kimmel (UCI)
Mike Boylan-Kolchin (UMD)

Oliver Elbert (UCI)
Phil Hopkins (Caltech)
Dusan Keres (UCSD)
Currently \(~30\) known MW satellites
Occupy halos of similar mass: \(~3 \times 10^9 \, M_\odot\)
100’s - 1000’s of undetected “stealth galaxies” in low-mass halos? Bullock 2010
$M_{\text{vir}} \sim 10^{10} \ M_{\odot}$
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$M_\star \sim 10^6 \, M_\odot$
$M_{\text{vir}} \sim 10^{10} \ M_\odot$

$M_{\text{vir}} \sim 10^{8.5} \ M_\odot$

$M_\star \sim 10^6 \ M_\odot$
DWARF GALAXIES ON FIRE

Hopkins et al. 2014

Oñorbe et al. 2015

\[ m_{dm} \sim 1000 \, M_\odot \]
\[ m_{gas} \sim 250 \, M_\odot \]
\[ DM \, f_{res} \sim 25 \text{pc} \]
\[ \text{Gas } f_{res} = 1-3 \text{pc} \]

4 Halos:
- 2 ‘Dwarfs’: \( M_{\text{HALO}} \sim 10^{10} \, M_\odot \)
- \( M_\star \sim 10^6 \, M_\odot \)
- 2 ‘UFDs’: \( M_{\text{HALO}} \sim 10^9 \, M_\odot \)
- \( M_\star \sim ? \)

1 Dwarf run 3 times
- Identical ICs
- Small changes to subgrid energy injection method and force softening

\[ z=30.0 \]
DWARF GALAXIES ON FIRE

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Garrison-Kimmel et al. 2014 AM

\[ M_\star (M_\odot) \]

\[ M_{\text{halo}} (M_\odot) \]

- Central
- 1st Sat
- 2nd Sat

Garrison-Kimmel et al. 2014 AM
UFDs have ancient stellar pops
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Infall times

Simulated UFDs

Simulated Classical Dwarfs

Cumulative SFH

Redshift

Age (Gyr)

$M_\star$ ($M_{\odot}$)

$M_{\text{halo}}$ ($M_{\odot}$)
UFDs have ancient stellar pops
Can they be detected?
Phoenix Dwarf Galaxy

ELVIS: ~ 35% chance to host UF sat
Phoenix Dwarf Galaxy

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50-65% chance that UFD is somewhere in Phoenix field
• In the $\Lambda$CDM paradigm, dark matter halos of Local Group field dwarfs should be filled with subhalos. Some of them should form stars.

• Isolated dwarf galaxies ($M^* \sim 10^6$ M$\odot$) in the Local Group should host ultra-faint galaxies ($M^* \sim 3000$ M$\odot$) as satellites.

• These galaxies form most of their stars in the first billion years after the Big Bang, suggesting a dividing line in halo mass ($M_{\text{halo}} \sim 10^{9.5}$ M$\odot$) below which galaxies at $z = 0$ will have entirely ancient stellar populations.

• The extended ~50 kpc regions around Local Group “field” dwarfs may provide efficient search locations for discovering new ultra-faint dwarf galaxies. Phoenix is a good target.
Thank you!