

Ultra-compact High Velocity Clouds: Candidate Local Group Galaxies?

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PHISCC
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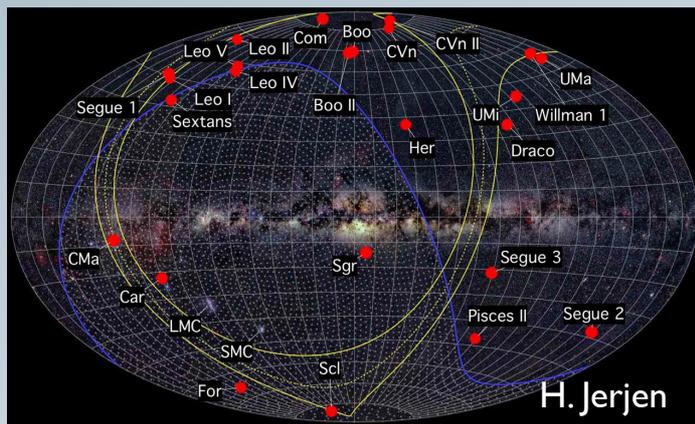
Martha Haynes, Riccardo Giovanelli, John Cannon, Tom
Oosterloo, Kathy Rhode, John Salzer, Ricardo Munoz

The End

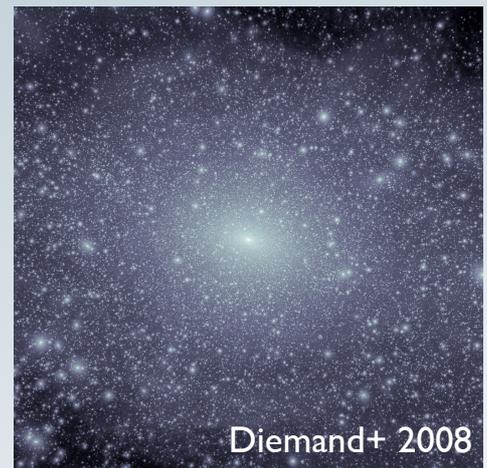
- Undiscovered gas-bearing Local Group galaxies are key for understanding (low mass) galaxy formation and evolution
- Ultra-compact high velocity clouds are good LG galaxy candidates
 - Leo P: Extreme low mass galaxy discovered as a HI detection
- Distances are key
 - Future HI surveys to detect in other galaxy groups

Why More Local Group Galaxies?

Known Milky Way Satellites



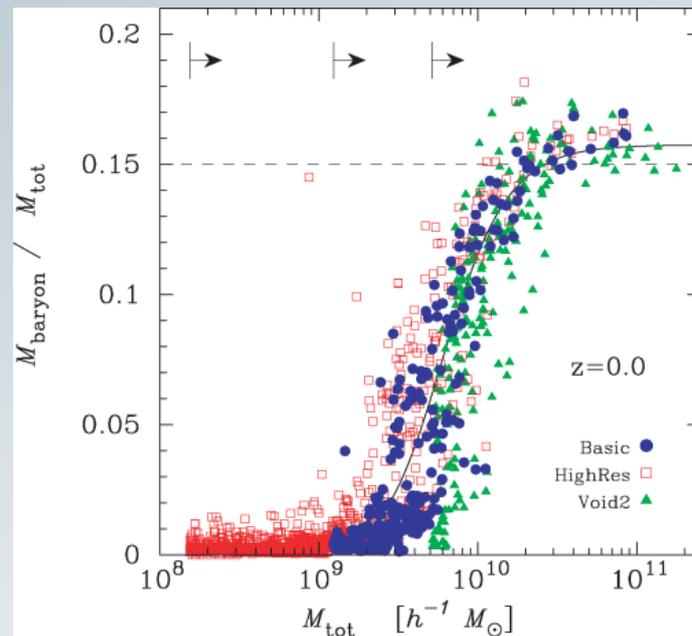
Dark Matter Simulations



- Small scale crisis in cosmology
 - missing satellites problem
 - cusp vs. core

Why More Local Group Galaxies?

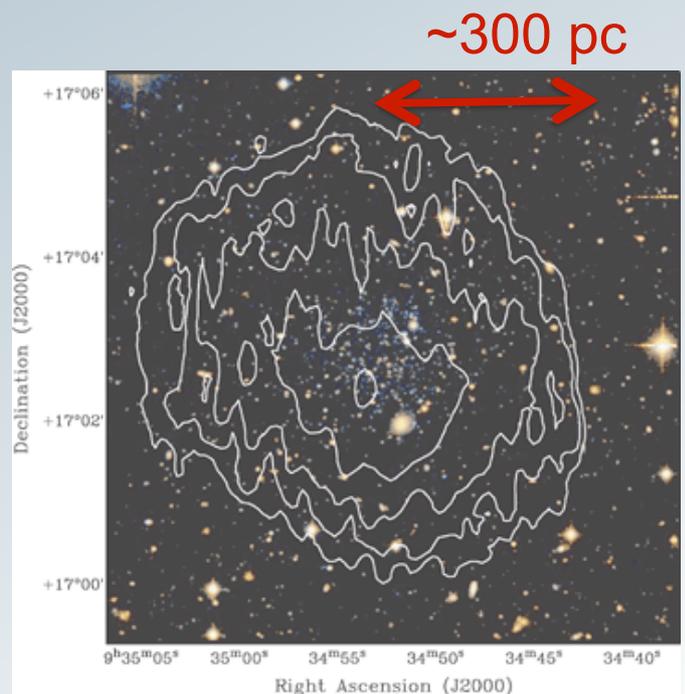
- Baryons vs. Dark Matter
 - low mass potential wells
 - Baryon loss from DM halos
- Discovery of ultra-faint dwarf galaxies
 - but evolution vs. environment



Hoeft et al. 2006

Leo T: A Gas-Rich UFD

- $d=420$ kpc
- $M_{\text{HI}} \sim 3 \times 10^5 M_{\text{sun}}$
- $W=18$ km/s
- $M_{\text{dyn}} > 3.3 \times 10^6 M_{\text{sun}}$
- At detection limits for SDSS
 - Most distant UFD found by SDSS



Ryan-Weber+ 2008

ALFALFA

- Arecibo Legacy Fast ALFA Survey
 - Arecibo L-band Feed Array
- Blind survey for extragalactic neutral hydrogen (HI)
- 7000 square degrees, > 4400 hours of observing time
 - Observations completed!
- -2000 to 18,500 km/s
 - ~10 km/s resolution
- 3.5' beam
- $10^5 M_{\text{sun}}$ out to 1 Mpc

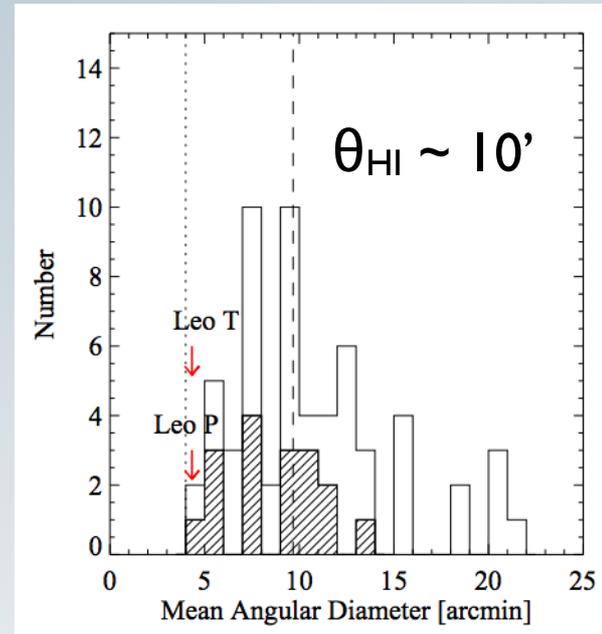


High Velocity Clouds as "Dark" Galaxies

- Originally considered by Oort (1966)
- More recently by Blitz et al. 1999 and Braun and Burton 1999 with compact HVCs
 - ~ 1 deg in size
 - $M_{\text{HI}} \sim 10^7 M_{\text{sun}}$, $R_{\text{HI}} \sim 10$ kpc at 1 Mpc
 - Should be detectable in other galaxy groups (summary in Filipo's talk)
- NO direct distance information

UCHVCs as LG Galaxies

- Ultra-compact high velocity clouds: gas-bearing LG dwarfs?
 - At 1 Mpc:
 - $M_{\text{HI}} \sim 10^5 M_{\text{sun}}$
 - $R_{\text{HI}} \sim 1\text{-}2 \text{ kpc}$
 - HI mass not detectable in current HI surveys of other galaxy group
 - Consistent with theoretical expectations (Faerman+ 2013)
- NO direct distance information

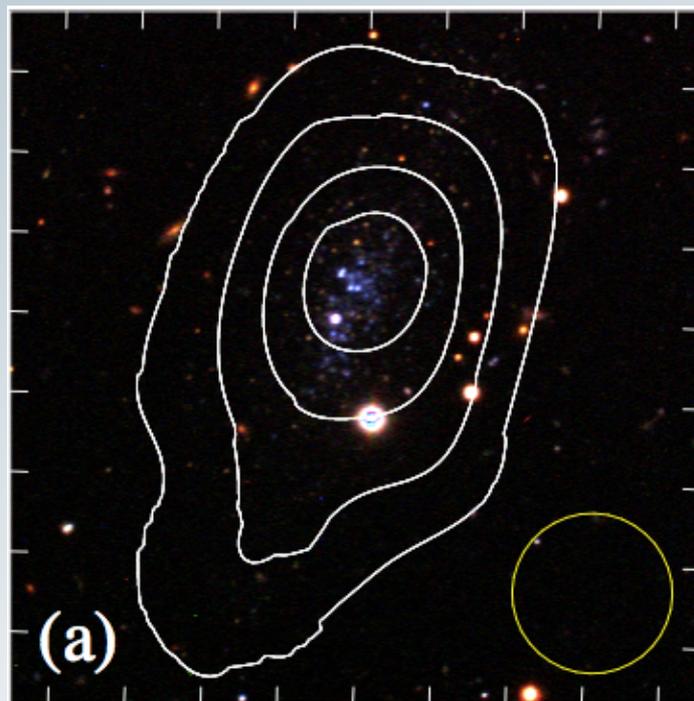


Adams+ 2013

Leo P: A New Galaxy



- $d = 1.75$ Mpc
- $W_{50} = 24$ km/s
- $R_{\text{HI}} = 0.5$ kpc
- $M_{\text{HI}} = 9.5 \times 10^5 M_{\text{sun}}$
- $M_{\text{dyn}} > 2.6 \times 10^7 M_{\text{sun}}$
- $M_{\text{HI}}/M_{\text{star}} = 2.6$
- $12 + \log(\text{O}/\text{H}) = 7.17 \pm 0.04$
 - extremely metal poor



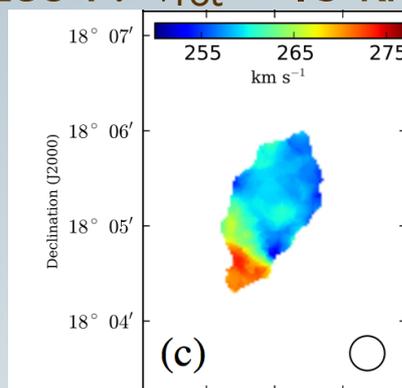
Giovanelli+ 2013

What are the UCHVCs?

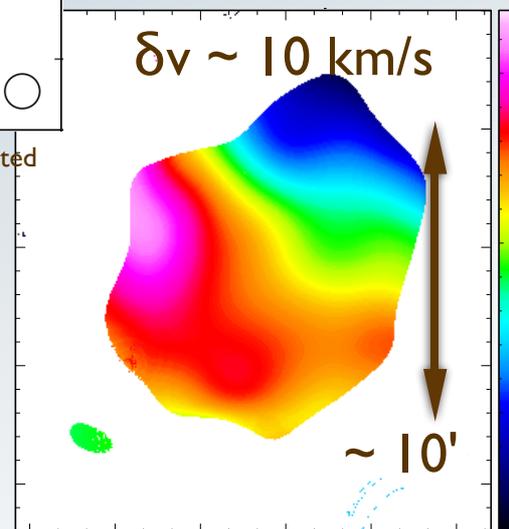
High Resolution HI Imaging

- HI morphology as indicator of environment
- HI kinematics as indicator of hosting dark matter halo
- Comparison to theoretical models

Leo P: $v_{\text{rot}} \sim 15 \text{ km/s}$



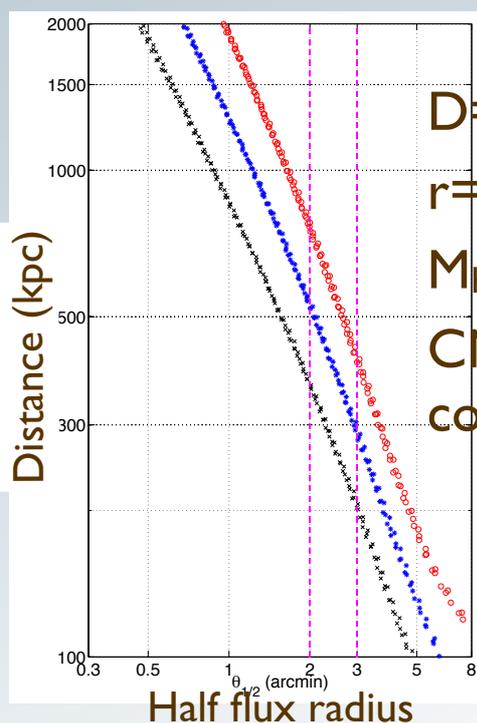
Bernstein-Cooper+, submitted



What are the UCHVCs? High Resolution HI Imaging

- HI morphology as indicator of environment
- HI kinematics as indicator of hosting dark matter halo
- Comparison to theoretical models

- Flux ~ 6.7 Jy km/s
- Half flux radius $\sim 2-3'$



Faerman, priv. comm.

UCHVCs as "Dark" Galaxies

- What if UCHVCs are "dark" galaxies?
 - What is the breaking point for gas- \rightarrow stars conversion?
 - Distances!
- Detect in galaxy groups
 - Need wide-field sensitive surveys
 - $10^5 M_{\text{sun}}$
 - Separation > 1 Mpc from dominant group galaxies

The End

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