HI in Void Galaxies: probing the lowest density environments

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The complex picture of galaxy formation in $\Lambda$CDM

- Star Formation rate
- Halo formation Bias
- Void Environment
  - Merging rate
  - Reionization & Feedback
  - Tidal Field & Torques
- Baryon Fraction
- Angular Momentum
- Cold accretion
The Trouble with Void-Galaxies

- Voids are inhabited by small faint Galaxies restricted to nearby distances

Selecting/Finding Void galaxies requires both deep and large fraction of the sky.

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Optical Surveys:
- SDSS-DR7 or 6dF-DR3

HI Surveys:
- ALFALFA, APERTIF
SDSS Density Reconstruction

Spatial Point Distribution → Density Field

Watershed Void Finder (Platen et al. 2007 MNRAS 380, 551)
Cosmic Spine formalism (Aragon-Calvo et al. 2007 A&A 474, 315)
SDSS density reconstruction
SDSS environments

R = 300 Mpc/h
Void-Galaxy Sample

- Using the SDSS redshift catalogue
- Within a redshift range from 0.01 < z < 0.025
- 250 galaxies with the lowest density values ~0.2 x cosmic mean
- Avoid galaxies that lie in front or behind clusters of galaxies (fingers of god)
- Ranked them according to the distance of the void-centers. Pick the most centrally located
HI Observation of Void Galaxies

- Westerbork Synthesis Radio Telescope
- 12h integration, 25” resolution, 0.5 mJy/beam rms
- Voids within z < 0.025 [50-85 Mpc]
- Void galaxies: near the centers of voids
- 50 galaxies were selected out 250 candidates
- 38 have been observed
- Pilot sample (15) reduced
Pilot Project

14 out of 15 galaxies detected

\begin{align*}
M_{\text{stellar}} &\quad 5 - 40 \ 10^8 \, M_{\odot} \\
M_{\text{HI}} &\quad 5 - 40 \ 10^8 \, M_{\odot} \\
M_{\text{dyn}} &\quad 5 - 40 \ 10^9 \, M_{\odot}
\end{align*}

5 new companions with \( M_{\text{HI}} \sim 5 \ 10^7 \, M_{\odot} \)

1 non-detection

13 Rotating Galaxies: 1 polar disk, 1 warped, 2 interacting, 2 with close companions
Interacting Void Systems

Stanonik et al (2009), in preparation
Interacting Void Systems

Stanonik et al (2009), in preparation
Optical Properties of the Selection

Comparison to other VG samples:
Blue boxes:
Sample from Szomoru (1996)
Average redshift of z~0.05

Red crosses
Optical Selected sample of Grogin & Geller (2000). Same average distance
<Mr> = -20, here <Mr> = -18
A Void galaxy in an 'Empty' Wall

Galaxies within a distance of 10 Mpc
A void galaxy with a polar disk

Cold Accretion out of Voids??

Galaxies within a distance of 10 Mpc
Summary

- The SpineWeb method was developed for finding Voids, Walls and Filaments
- The Method is based on Morphology & Topology of the density field; (almost) Parameter Free
- SDSS Density Field has been reconstructed (DTFE)
- SDSS Galaxies were Classified according to the Spine Web environment
- HI observation were carried out of void galaxies
- Pilot Data suggest that Void galaxies are building up their stellar component from remaining and infalling cold HI gas
- Polar Disk Galaxy found within a Large Scale Wall in between two large voids
Preliminary Conclusions

- Global properties such as HI-mass content, Tully-Fisher, etc relations seem to be no different than the trends in denser environments.

- Despite having selected the most (globally) isolated galaxies, nearly half show signs of perturbed HI disks or signs of merging events. (Warp, Polar Disk, Merging)

- Five very faint nearby HI detected companion were discovered:
  \[
  M_r = [-11.5, -14., -14.1, -14.9, -16.2] \\
  M_{HI} = [ 0.6, 0.6, 3.7, 1.4, 4.5 ] \times 10^8 M_\odot
  \]