Disturbed HI gas in nearby void population: probes of two scenarios affecting galaxy evolution

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3D view on interacting and post-interacting galaxies from clusters to voids

Progress report. Outline

- Motivation
- Brief overview of our on-going project: “Study of nearby void galaxies”
- Clustering properties of void galaxies
- Examples of tentative void filaments
- Illustrations of isolated void galaxies with disturbed

outer HI gas

- Summary of available data and preliminary conclusions
- Prospects and plans

Motivation. Galaxy interactions and accretion as factors of evolution

1. Various types of galaxy interactions are known to play an important role in acceleration of galaxy evolution due to induced SF. The denser environment the oftener galaxy collisions occur and sufficiently strong disturbances and induced gas collapse take place. This standard scheme is elaborated theoretically and in N-body simulations long ago (GalMer in particular). Observational evidences as well.

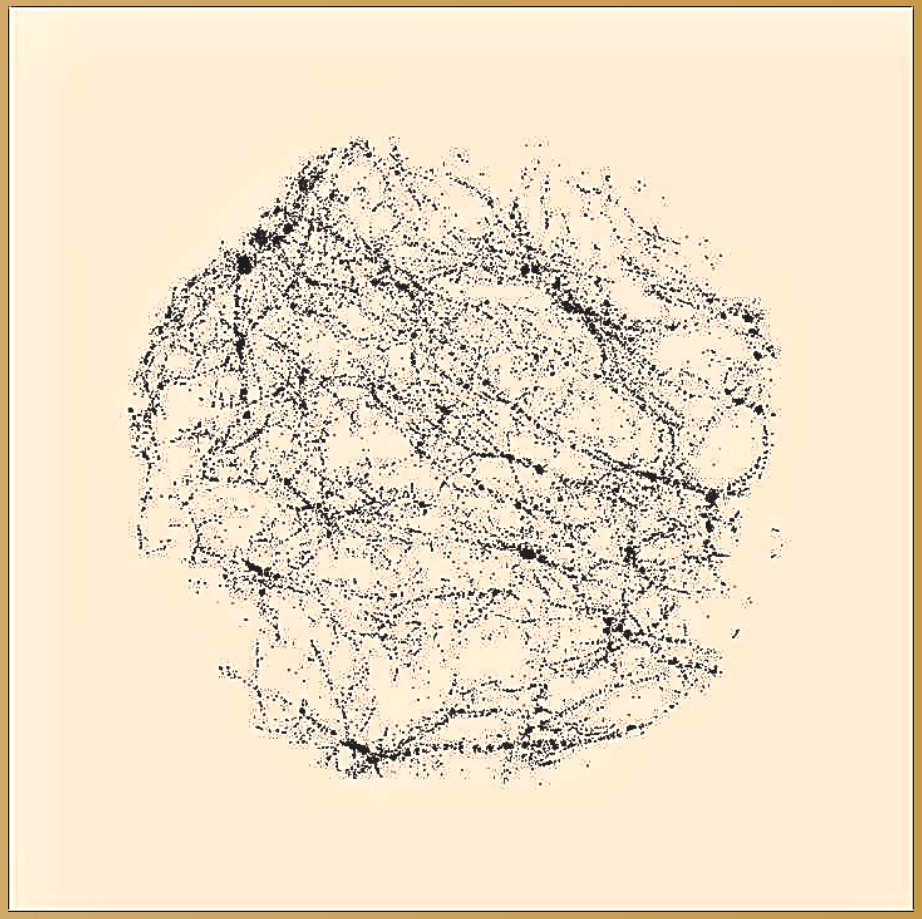
2. Results of many theoretical works and numeric simulations during the last decade show (e.g., Birnboim, Dekel 2004; Keres et al. 2005; Codis et al. 2012; Rieder et al. 2013), that **accretion of dark matter mixed with the `cold'** (T~10^4-10^5 K) baryon gas from the intergalactic medium onto galaxiss should define their secular evolution when effects of galaxy interactions are minimized (as one expects for 'field', and especially in **void-like** environment). Several indirect indications are known. However, due to very low density of cold accretion gas, its observational appearances are hard to observe directly (review by Sanchez Almeida et al. 2014, AAR; F.Combes in yesterday review). The **accretion is expected to occur in wide streams related to the filamentary** structure of dark matter.

Motivation

3. One expects that cold accretion (in particular as blobs) can appear directly via disturbance of outer HI galaxy disc, where its density is low.

Also due to mixture of very low-Z intergalactic gas with the original enriched gas, the induced star burst should display HII region with the lower metallicities.

*Void N-body simulations with high mass resolution (~2*10^6 Mo on DM particles) Gottlöber et al (2003)*



Filaments of dark matter particles in a void are well seen in simulations. But only sufficiently large haloes filled with gas and stars will be identified in ***observations***

Nearby void galaxies as probes of evolution

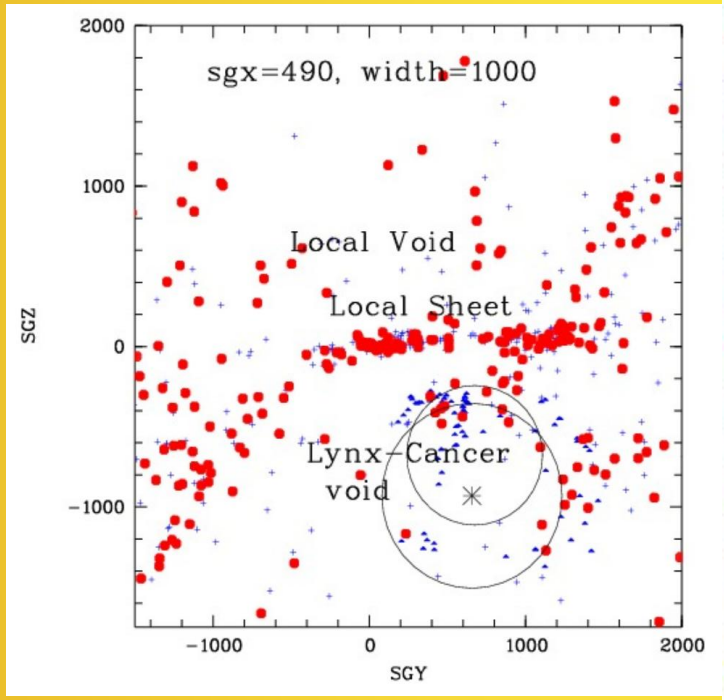
1. Search for **evidences for cold accretion** can be more efficient when the filament geometry is known. In **voids** confusing effects of massive aggregates are minimal. But … to identify void filaments one needs large void galaxy samples. First attempts to identify filaments in voids: Zitrin & Brosch, 2008; Beygu et al., 2012. Also 'tendrils' in voids (Alpaslan et al. 2014). But all them for larger void galaxies.

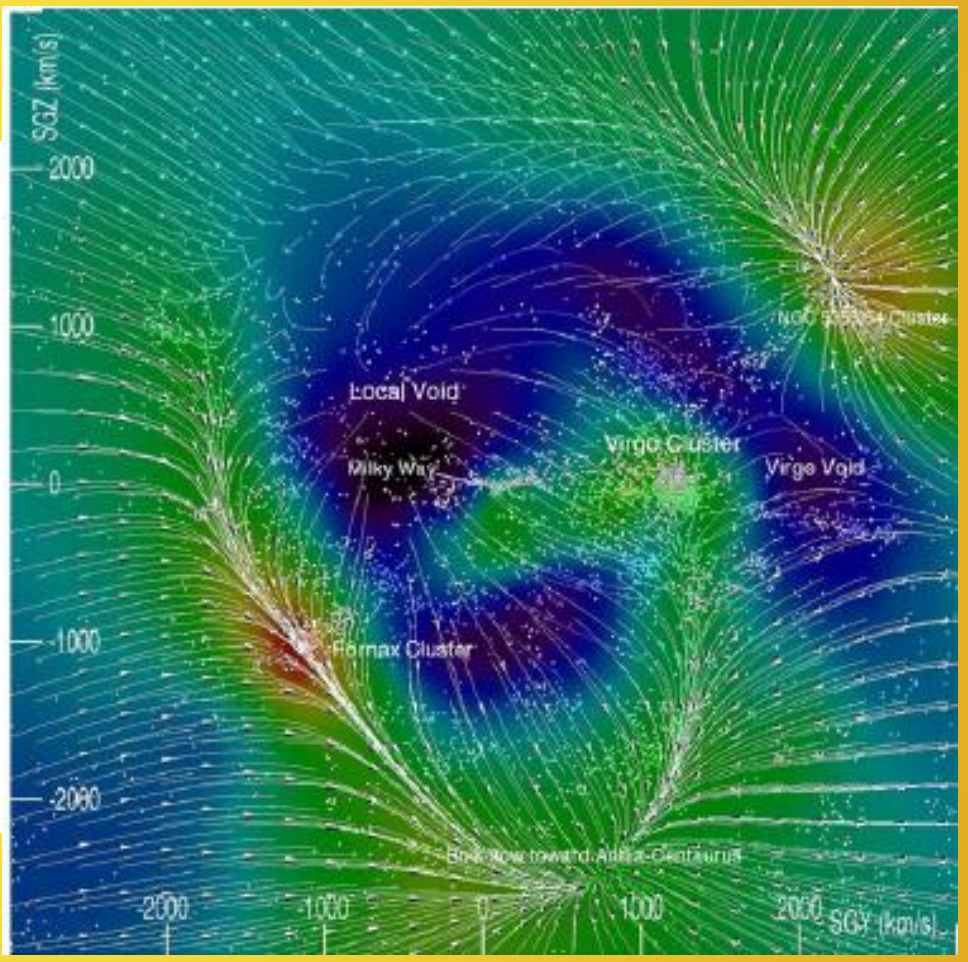
2. The smaller galaxies the more significant is effect of environment. For intrinsically faint galaxies (e.g., M_B = -10 to -14) one needs voids adjacent the Local Volume. Several such voids are known. The number of cataloged nearby void galaxies is small, however.

3. We deal with galaxies in **nearby void in Lynx-Cancer: D(cent) ~18 Mpc, 2R > 16 Mpc**. It has good coverage by the SDSS photo- & spectral databases, by blind HI survey ALFALFA , etc.

4. The void sample: by Pustilnik & Tepliakova (2011), Includes 107 galaxies, with d > 2 Mpc to 'luminous' galaxies. Range of M_B [-9.7, -18.4], with median -14.5. Almost all are of late types, half of the sample -- in the LSB regime.

Environment of Lynx-Cancer void (SGY-SGZ projection, after Pustilnik, Tepliakova 2011) and related density field from Courtois et al. (2013) (SGX slice -1500 to +1500 km/s)





Lynx-Cancer void sample: brief summary

The study of this sample included: determination of gas O/H, of photometric parameters, of integrated HI parameters, and their comparison with similar galaxies in denser environments. The main conclusions of this study:

a) void galaxies show lower gas metallicity, in average by ~40%.

b) small fraction of void galaxies show strong metal deficiency: by a factor of 2 to 5.

c) Void galaxies are gas-richer, in average by ~40% (on M(HI)/L_B)

d) The least evolved galaxies: with the large metal deficiency, very high gas mass fractions (95%-99%) and 'delayed' main SF episodes (1-5 Gyr ago) are predominantly found among the least luminous LSB dwarfs (M_B > -13.5).

Preliminary: clustering properties of Lynx-Cancer void galaxies:

Bound aggregates: 12 pairs (24 galaxies) and 4 low-mass triplets (12 galaxies) with typical extent of tens kpc. Total 36 galaxies, or ~33%.

Tentative unbound `correlated' structures (quasi 1D filaments) with typical extent of 0.5 to a few Mpc. 96 galaxies, including 30 entering also to bound systems. Total ~90%.

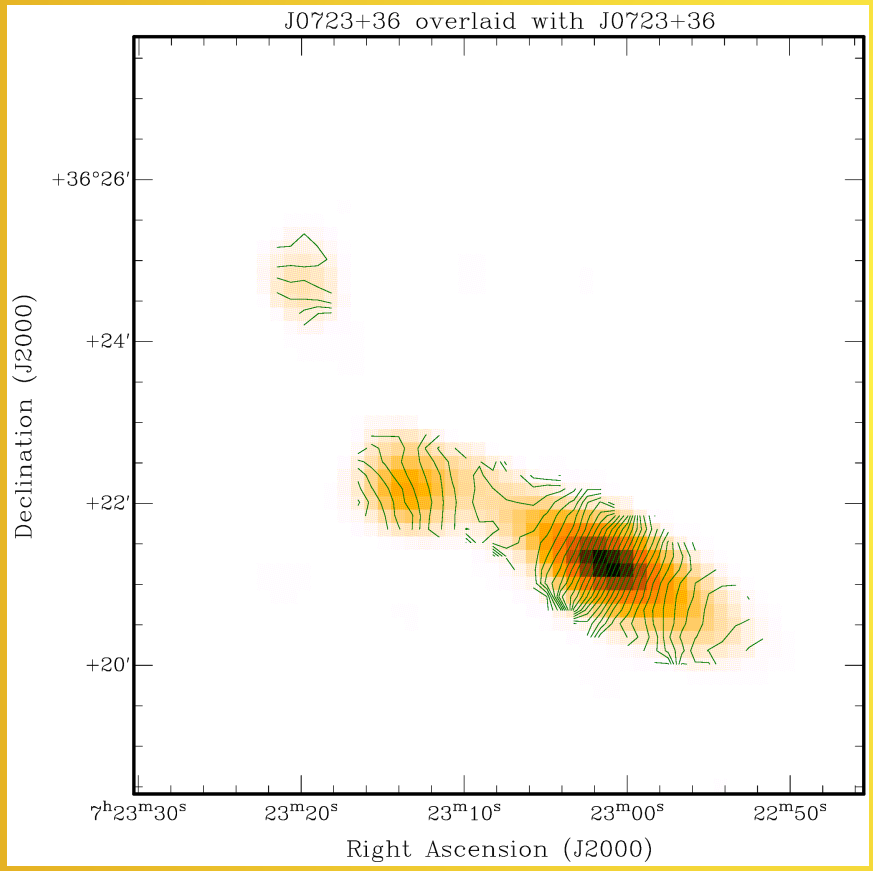
Not(?) in filaments: 11 galaxies, or 10%.

Ongoing project at GMRT (India): HI mapping of gas-rich subsample of the Lynx-Cancer void galaxies

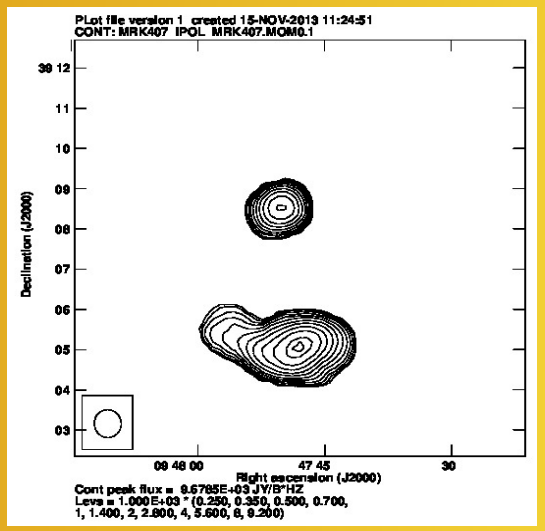
Subsample of gas-rich (MHI/L_B > 1.2 solar units): 53 objects to be mapped in 21-cm HI line with angular resolution of ~40” to ~6”. They represent all types of clustering. The data are under analysis (including published in the literature): for about 1/3 of them.

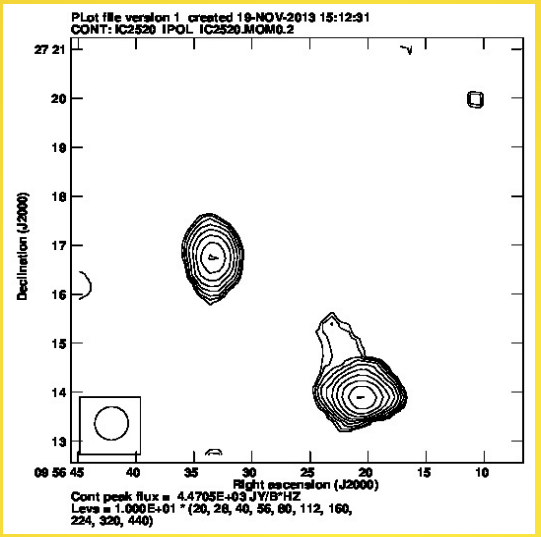
Below: overview of preliminary results on HI morphology and velocity field.

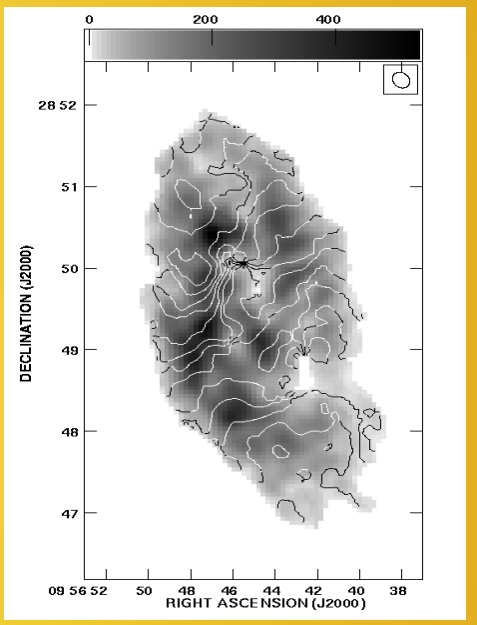
Extremely gas-rich dwarf triplet J0723+36 near the centre of Lynx-Cancer void with M(HI)/L_B of ~3, 10 and 26. Hint to possible hidden void population of very gas-rich low mass galaxies (Chengalur, Pustilnik, 2013)

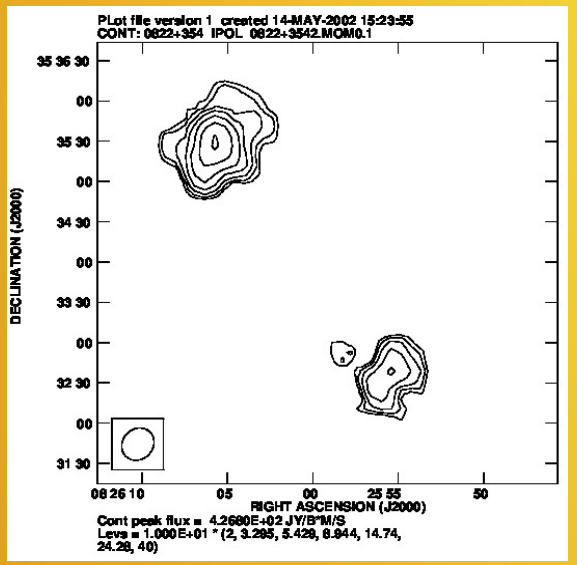


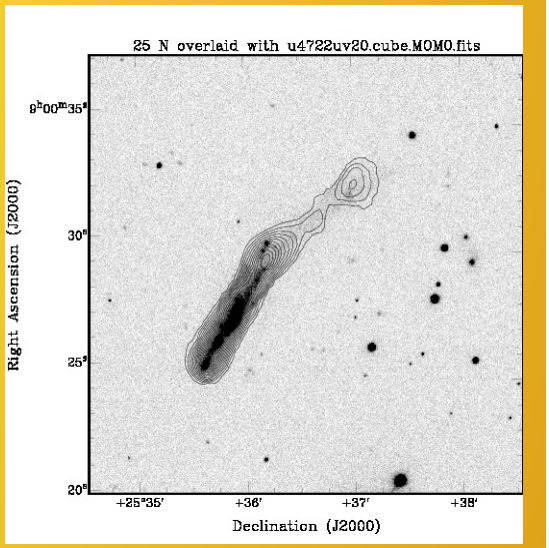
More examples of disturbed HI morphology in void galaxies. Reliable interacting or merging systems



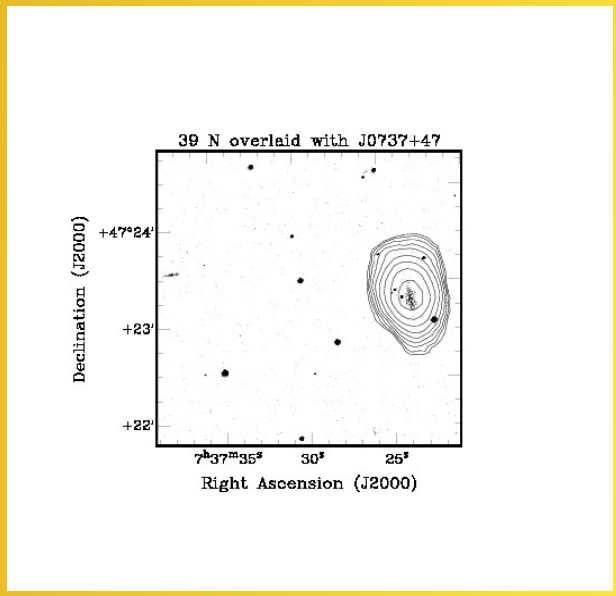


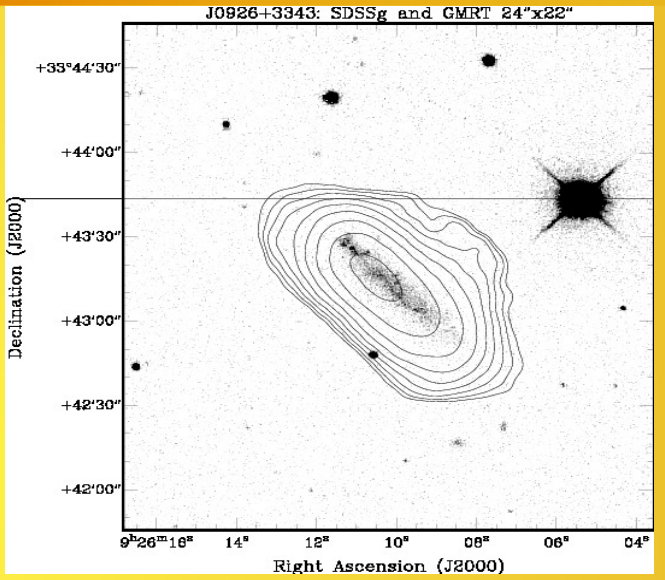


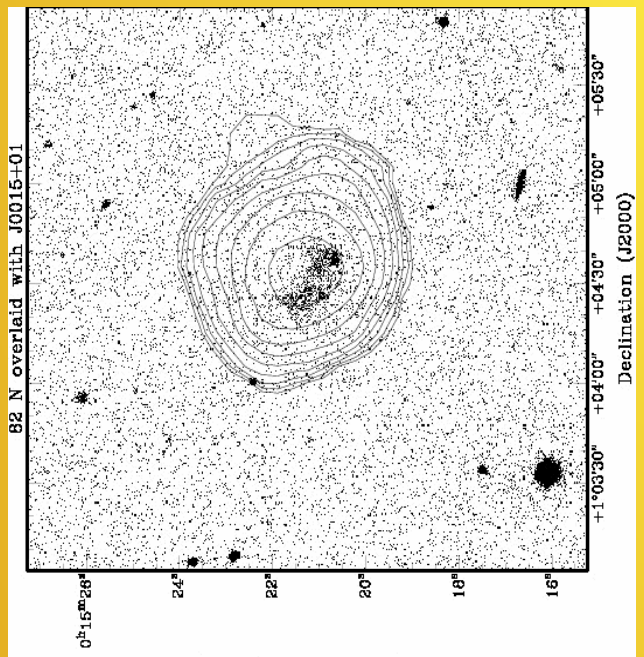




Disturbed HI morphologies in isolated most metal-poor void LSBD galaxies: J0737+4724, J0926+3343, J0015+0104 (Chengalur et al. In prep. 2015)







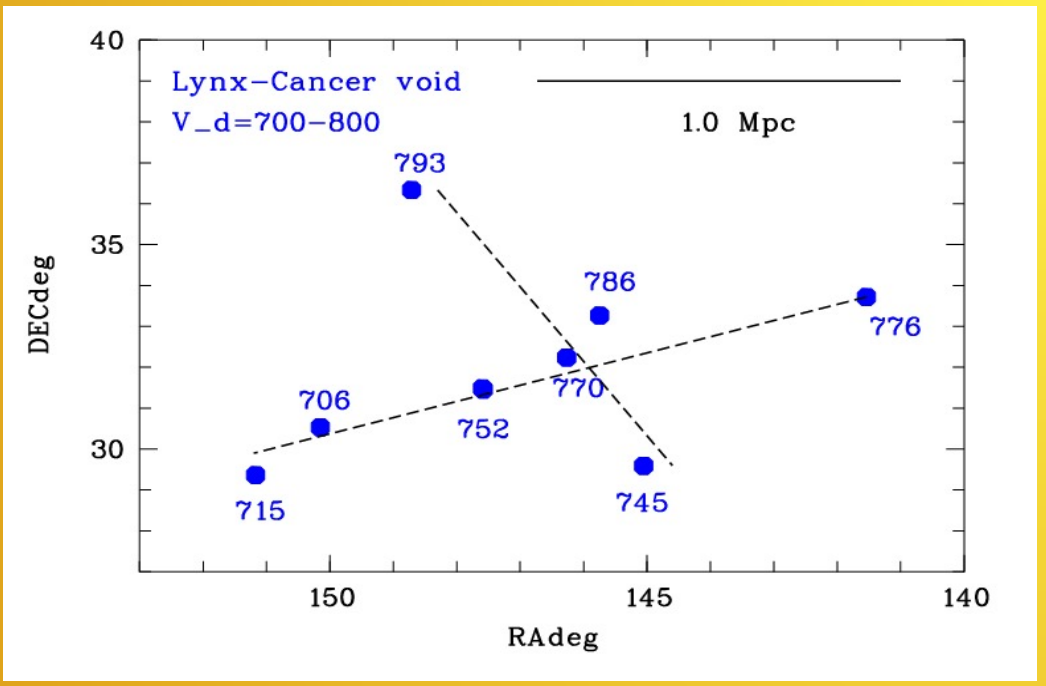
Evidence for cold accretion?

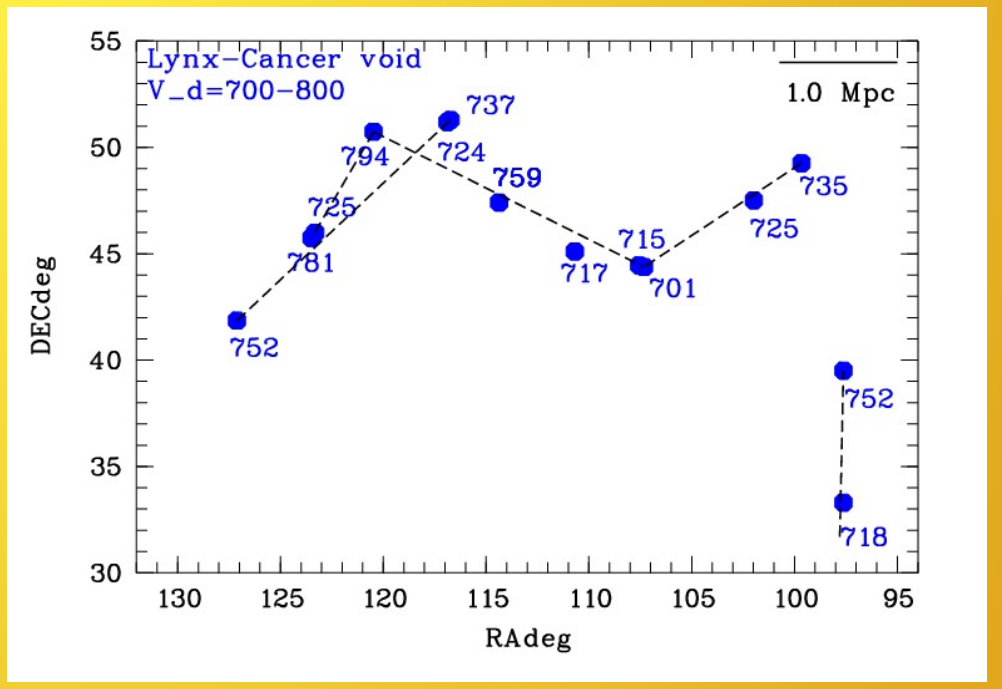
Wind of previous SF episode? *Rather unlikely for LSBDs.*

Study connection of galaxies and filaments to confront N-body simulation predictions of cold accretion.

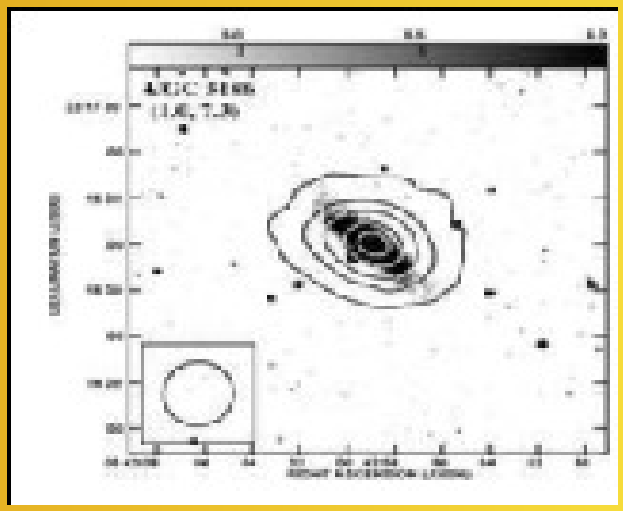
Voids are a suitable place. We need two types of data. 1. Galaxy morphology and kinematics. 2. Geometry of void filaments.

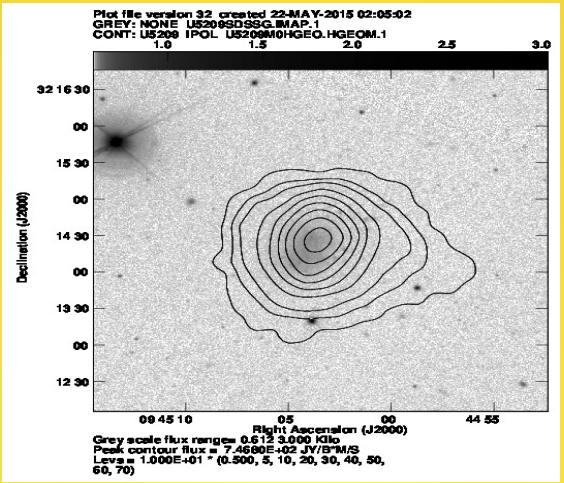
Examples of several Lynx-Cancer void filaments (at distance ~10 Mpc) situated 'close' to the sky plane

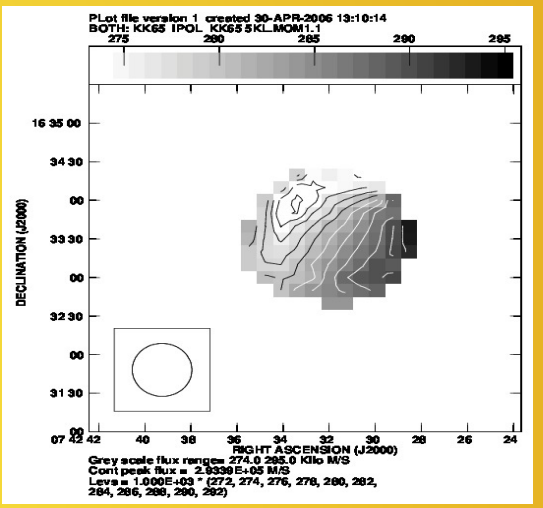


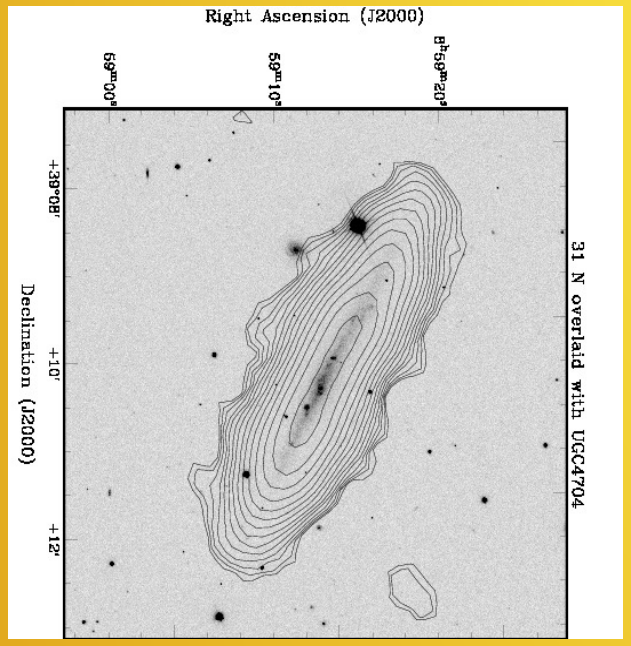


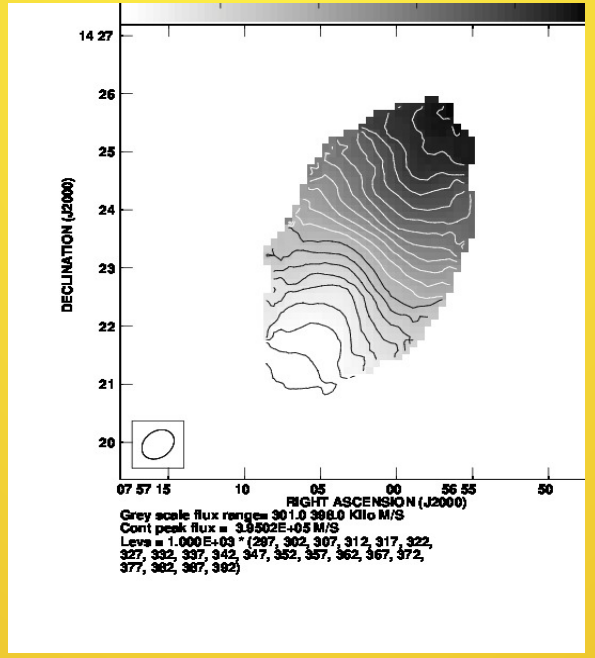
More examples of disturbed morphology and/or kinematics in isolated void galaxies

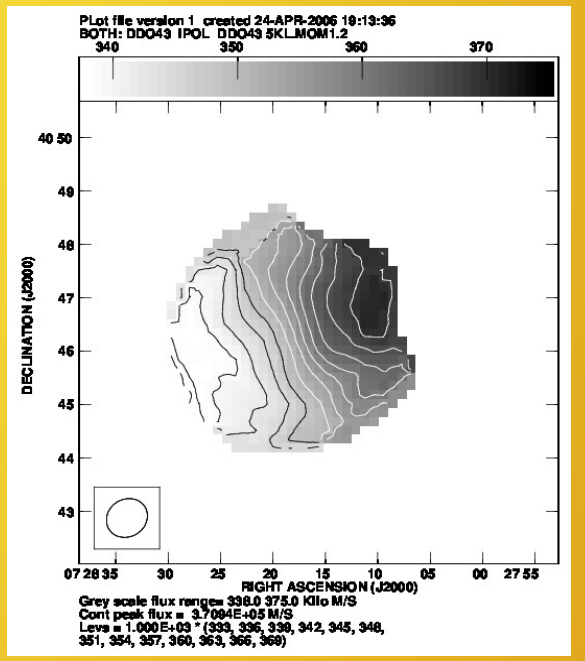












Preliminary results and prospects

Available to date HI maps for a fraction of the void gas-rich galaxies provide various evidences (outer HI appendages, morphology vs kinematic misalingments, gas vs stellar body misalingnent) that cold gas accretion can be inferred **in at least ~30%** of 1.5 dozen of examined objects.

Probable indication for **effect of accreted blobs**?

But statistics is small. Need in several times larger. Need better separation of observed filaments.

Also, to address the observational search for cold accretion appearances, one needs in more detailed simulations and predictions of specific effects to exclude alternative interpretations.

Future

1. ***Increase statistics of nearby void galaxy with mapped HI gas***: to understand better properties, diversities, evolutionary status, to provide basement for comparison with state-of-art cosmological simulations.
2. Search for new least evolved low-mass galaxies and study of their properties: they can be crucial objects to test modern theories of galaxy formation.
3. Establishing the nearby voids' filamentary structure and study its relation to the cold accretion.

Void filaments themselves can be important to confront them with the structure formation for various (Dark vs Warm) options of Dark Matter.

THANK YOU FOR ATTENTION! Stay tuned.