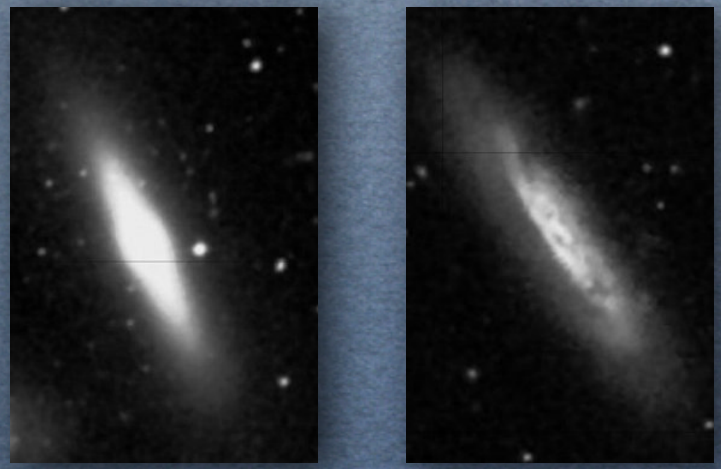
HI as the Probe of Environment-Driven Galaxy Evolution



Aeree Chung
YonSei University

Tales of Two Galaxies

- Accretion vs. Stripping

Accretion from a neighbor

Edge-on So
at ~20 Mpc
D*~20 kpc
Barred

NGC 1596

Stripping due to the ICM Pressure

NGC 4522

Highly inclined Sp
at ~16 Mpc
D*~18 kpc
Virgo member

HI Gas Stripping

- Mechanisms

- Impact of Intra-cluster medium (ICM)

1. Ram pressure stripping (Gunn & Gott 1972)
2. Thermal evaporation (conduction, Cowie & Songalia 1977)
3. Turbulent Viscous stripping (Nulsen 1982)

- Tidal interactions

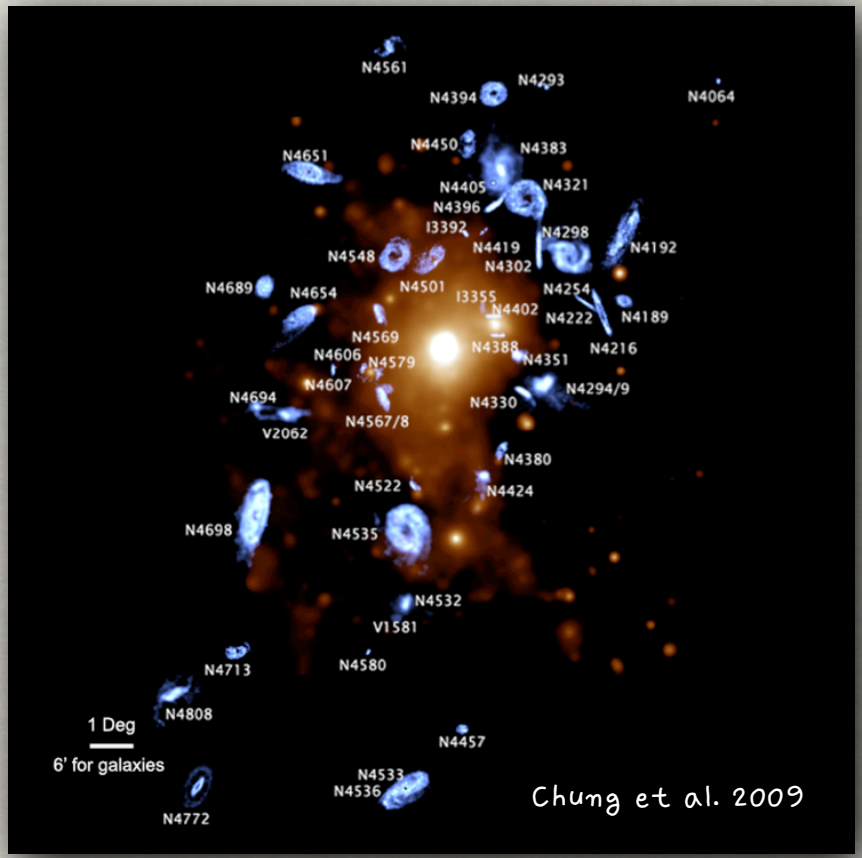
1. Encounters between galaxies (Mihos 2004, Moore et al. 1996)
2. Tidal truncation due to the cluster potential (Byrd & Vatonent 1990)

✔ Virgo, as a nearby and kinematically young galaxy cluster, is an ideal laboratory to study details of ISM stripping

HI Gas Stripping

- VIVA, VLA Imaging of Virgo galaxies in Atomic gas

- VIVA Study: High resolution HI study of 53 late type galaxies (representative of late type population in the Virgo cluster, a dynamically young and rich galaxy cluster)

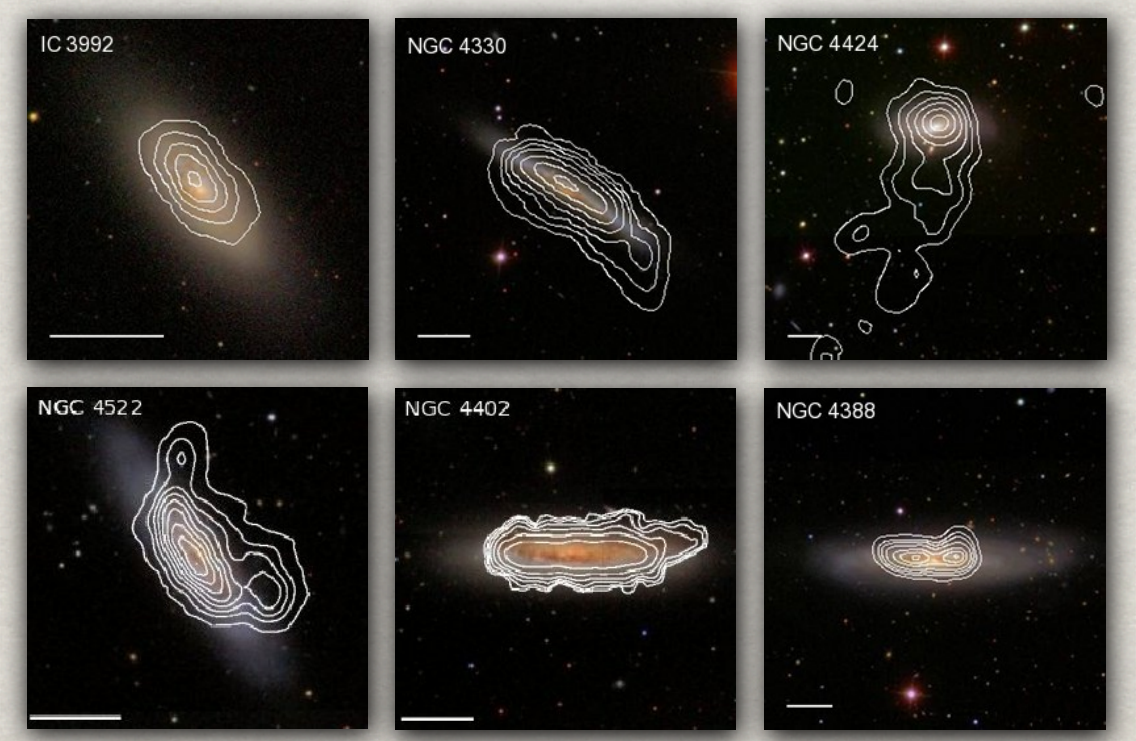


HI Atlas of 52 late type Virgo galaxies (blown up by a factor of 10) on the ROSAT x-ray image

HI Gas Stripping

- ICM-ISM Interaction

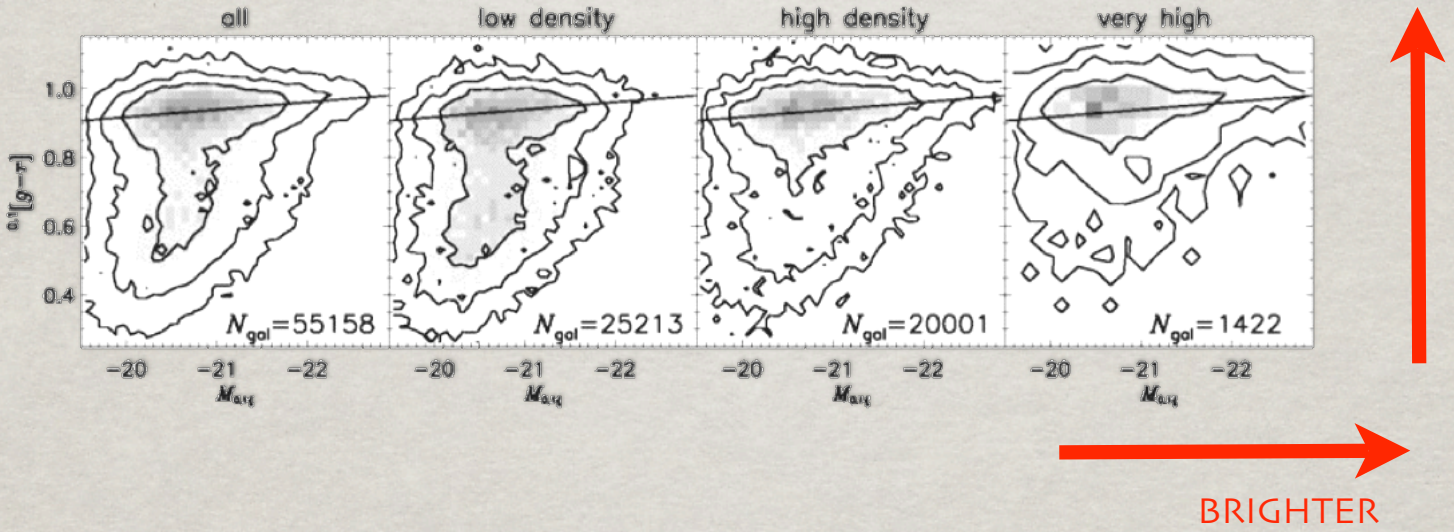
- ~50% of the galaxy shows the evidence for ISM stripping due to the ICM (e.g. HI truncation within to the stellar disk gas, at least on one side with undisturbed stellar morphology, long one sided gas tail; Chung et al. 2007, 2009)



HI Gas Stripping

- Consequence of ISM Stripping

- Color-magnitude diagram in a range of density regions of Sloan galaxies
  (Hogg et al. 2004, contours enclose 96.6, 84.3, 52%,)

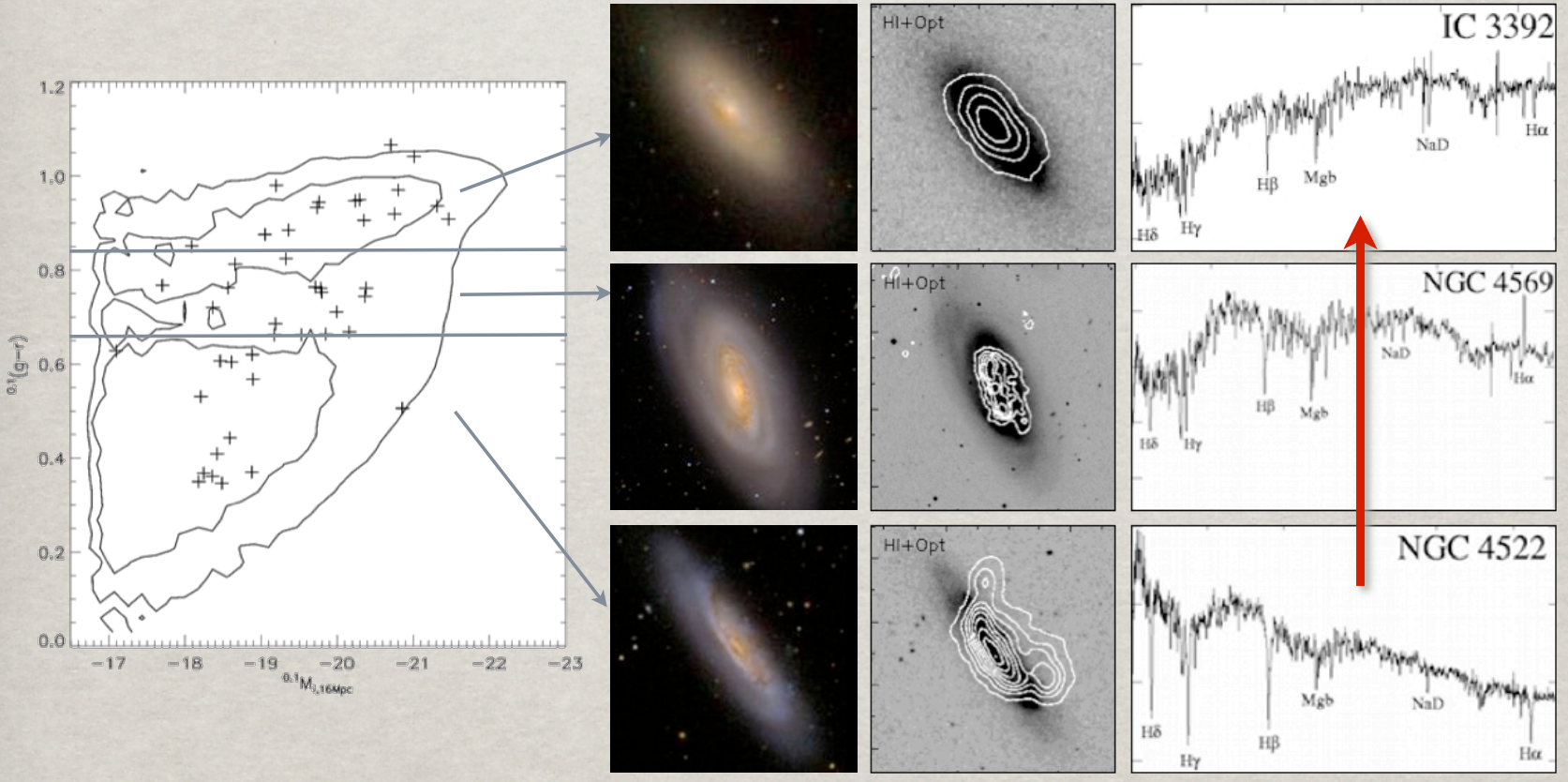


✔ Does ISM stripping play any role in this trend?

HI Gas Stripping

- Consequence of ISM Stripping

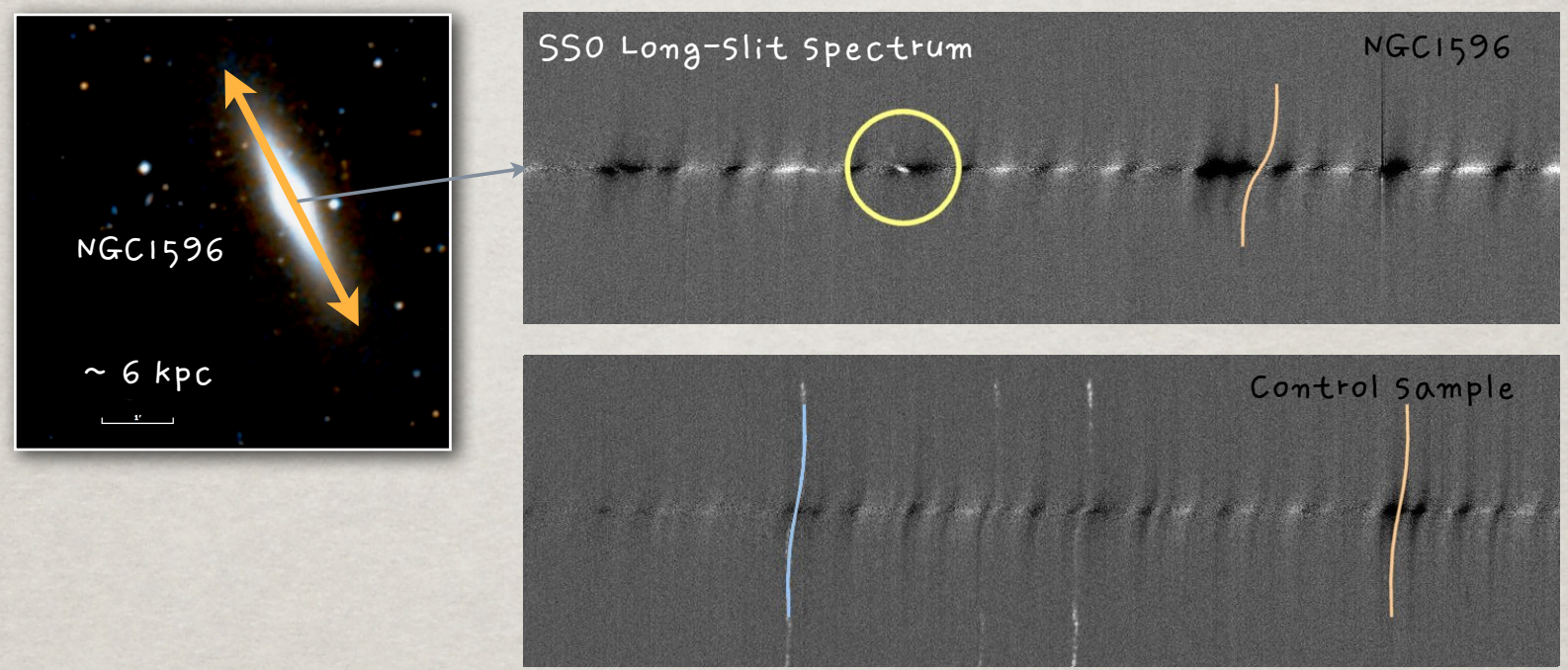
- CMD of VIVA Sample on the Sloan sample
  - Crowl, Chung, Kenney, van Gorkom, Schiminovich, Blanton 2011, submitted



HI Gas Accretion

- Serendipitous discoveries

- Galaxies with kinematically decoupled components?

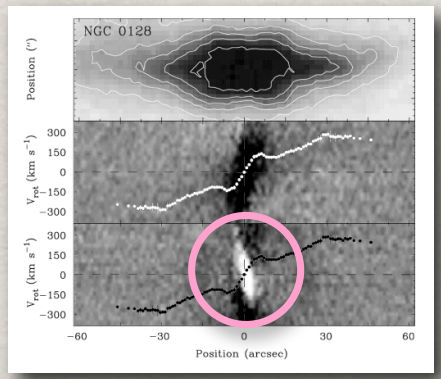


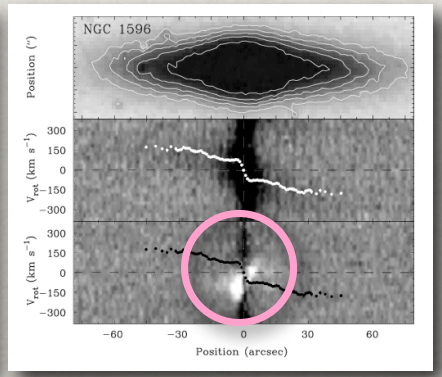
Accreted from outside...?

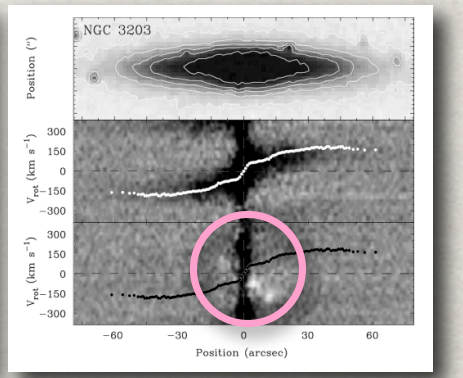
HI Gas Accretion

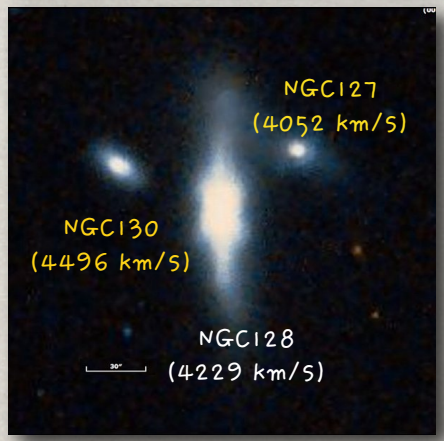
- Galaxies found with kinematically decoupled gas

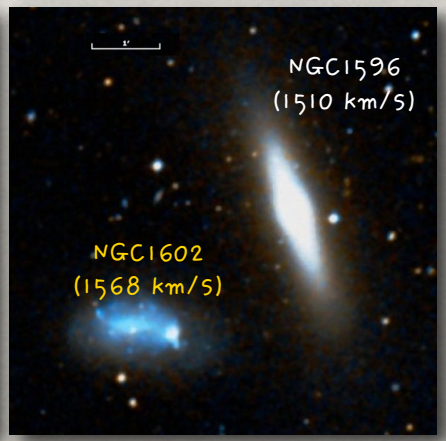
Long-slit spectra of edge-on galaxies analyzed by Chung & Bureau 2004

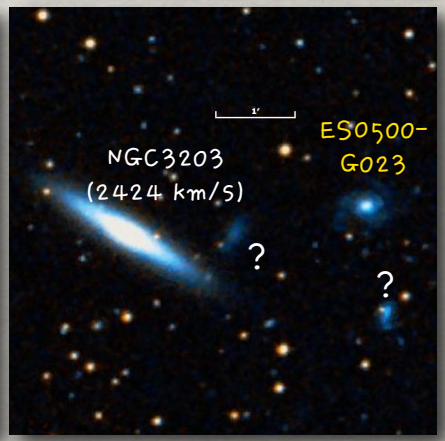










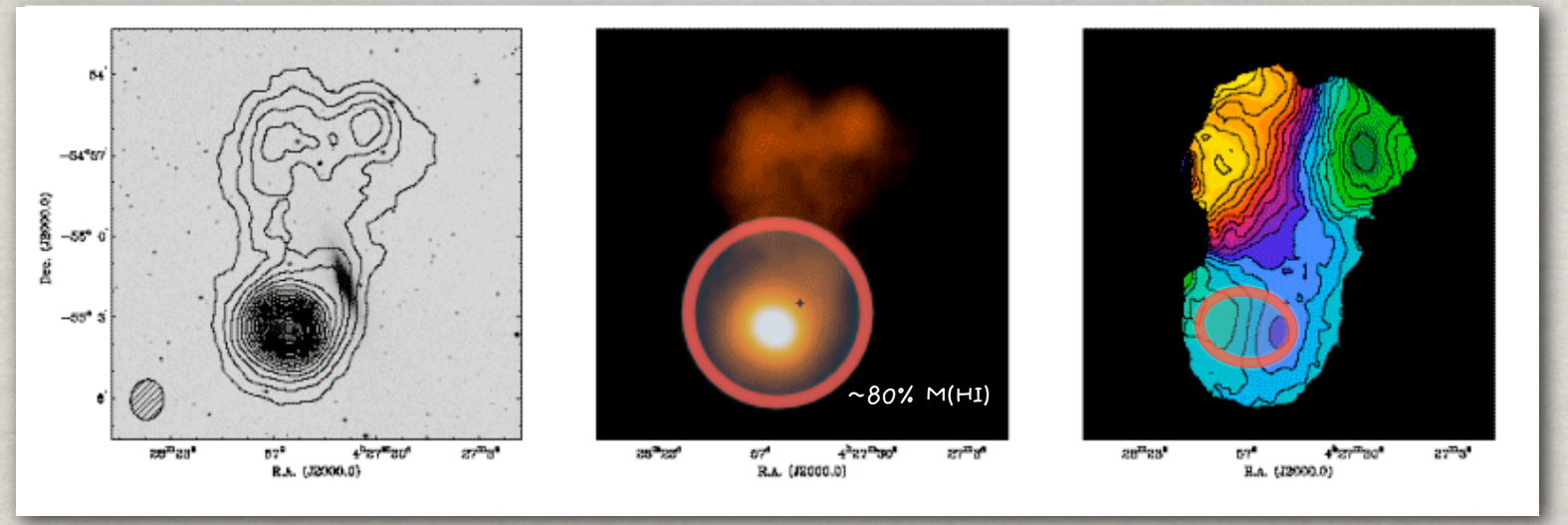


Accreted from neighbors? (Chung et al. 2006, Chung & Bureau 2006) -> HI Imaging

HI Gas Accretion

- Movie of the ATCA HI Cube: N1596 & N1602 pair

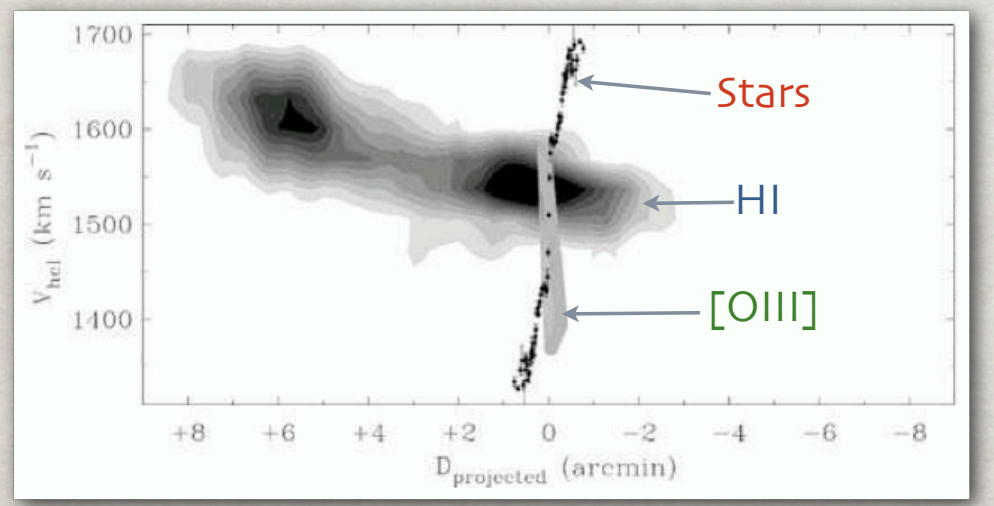
- 2.5×10^9 solar of HI gas envelope covering both
- Most gas concentrated on N1602
- Kinematically centered on N1602



HI Gas Accretion

- Movie of the ATCA HI Cube: N1596 & N1602 pair

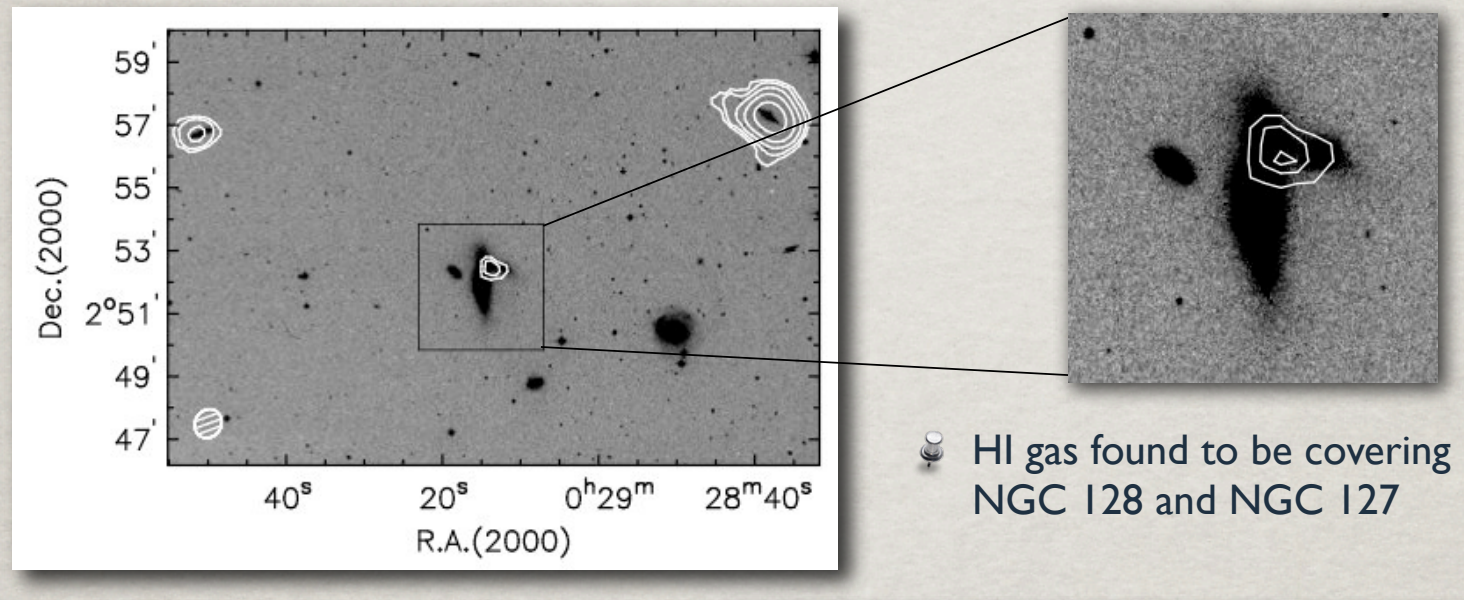
- 2.5×10^9 solar of HI gas envelope covering both
- Most gas concentrated on N1602
- Kinematically centered on N1602
- HI and [OIII] with the same velocity gradient



Velocity cut (HI cube)
at the center of N1596
Chung et al. 2006,
MNRAS, 370, 1565

HI Gas Accretion

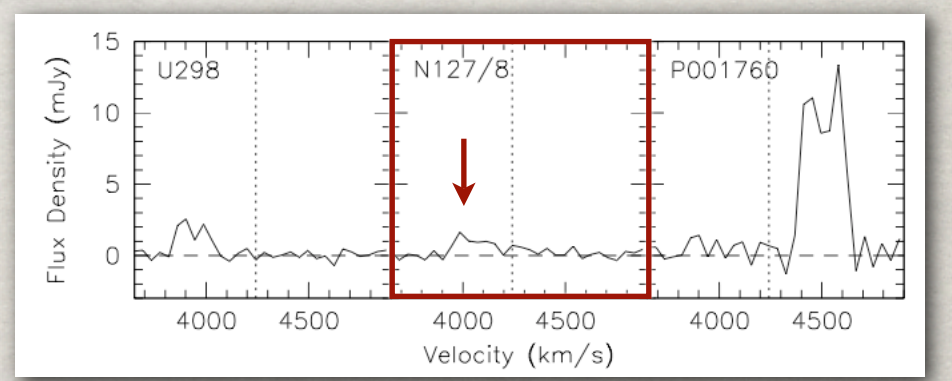
- NGC 128 and neighbors (VLA)



- HI gas found to be covering both NGC 128 and NGC 127

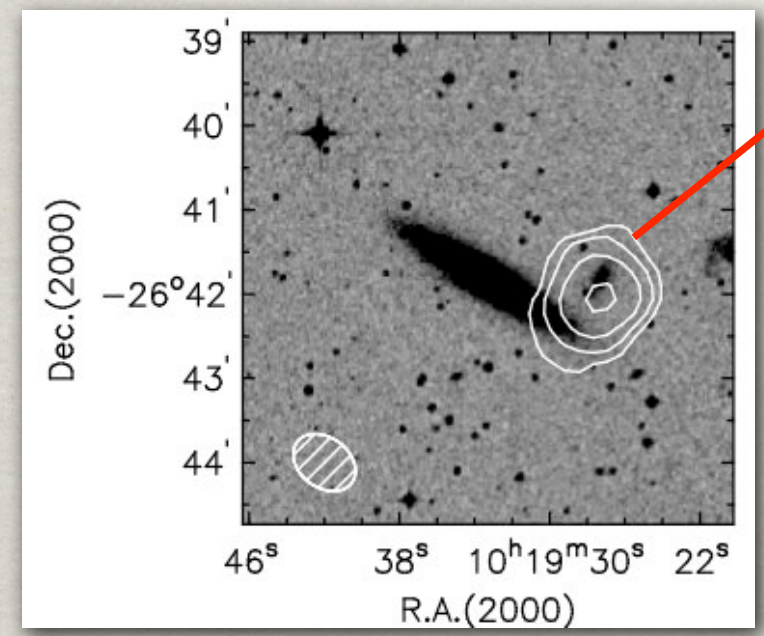
- The HI gas associated the pair coincides better with NGC 127 spatially and kinematically

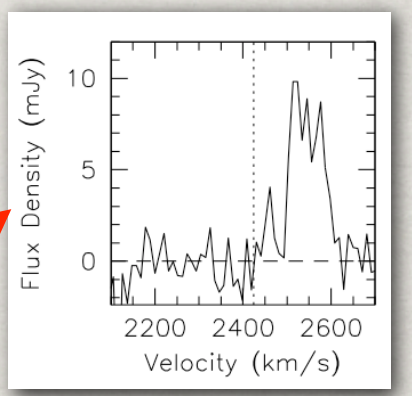
Chung et al. 2011 submitted

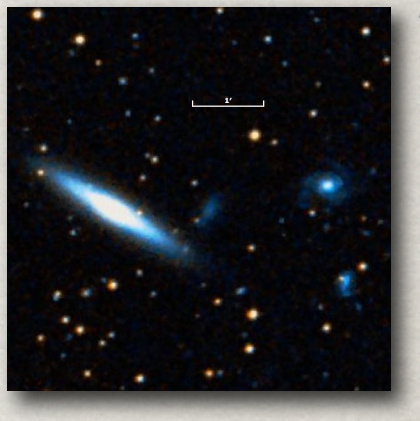


HI Gas Accretion

- NGC 3203 and its dwarf neighbor (VLA)







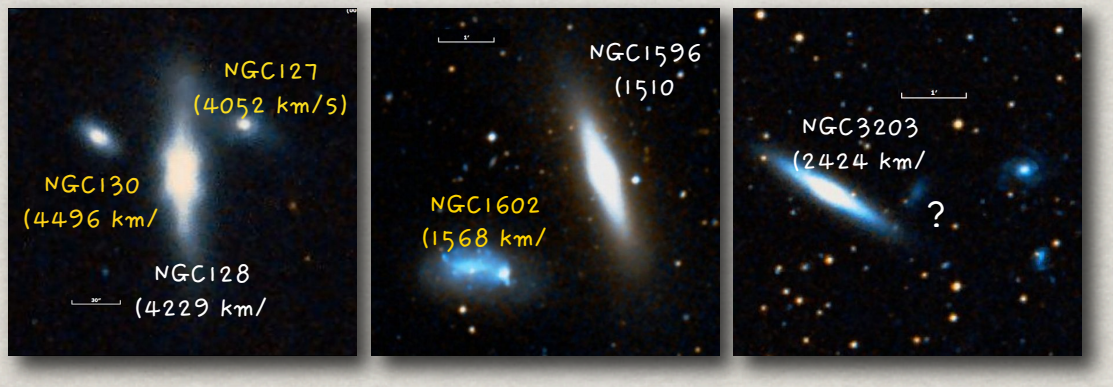
Chung et al. 2011 submitted

- HI gas is found around a dwarf galaxy with yet no optical identification, covering one end of NGC 3203's disk.
- The dwarf companion looks disky and the HI appears to be elongated along the major axis of the dwarf.

HI Gas Accretion

- Consequence of ISM accretion

- A non-negligible fraction of galaxies are experiencing gas accretion (~27% when only S0 galaxies with counter-rotating ionized gas, Bureau & Chung 2006), which is likely to increase considering the observational limitations on the classification of such occurrences.



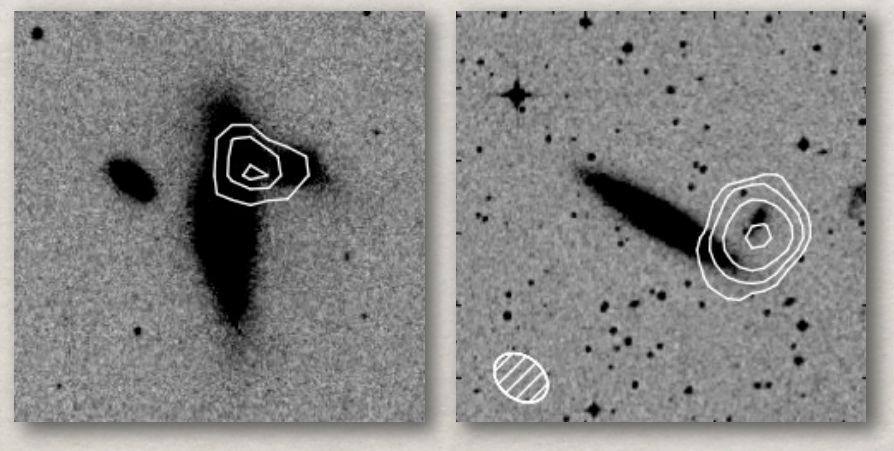
- Replenishing galaxies with gas: continue on star formation, trigger various activities such as bar formation, AGN, etc.

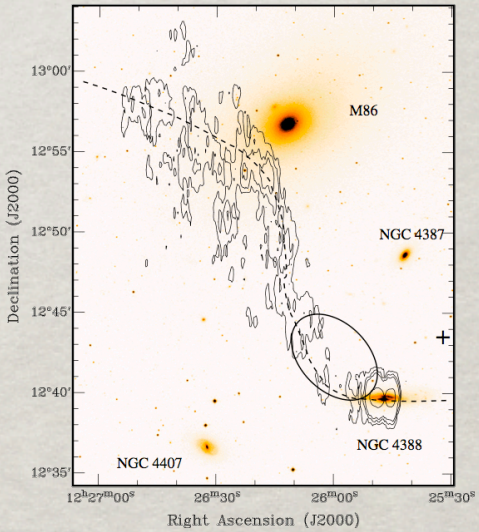
Summary

- Probing Galaxy Environment & Evolution Using HI

- HI studies are essential to understand galaxy evolution, particularly in probing the influence of their surroundings

- Both the sensitivity and the resolution are required to get a full picture



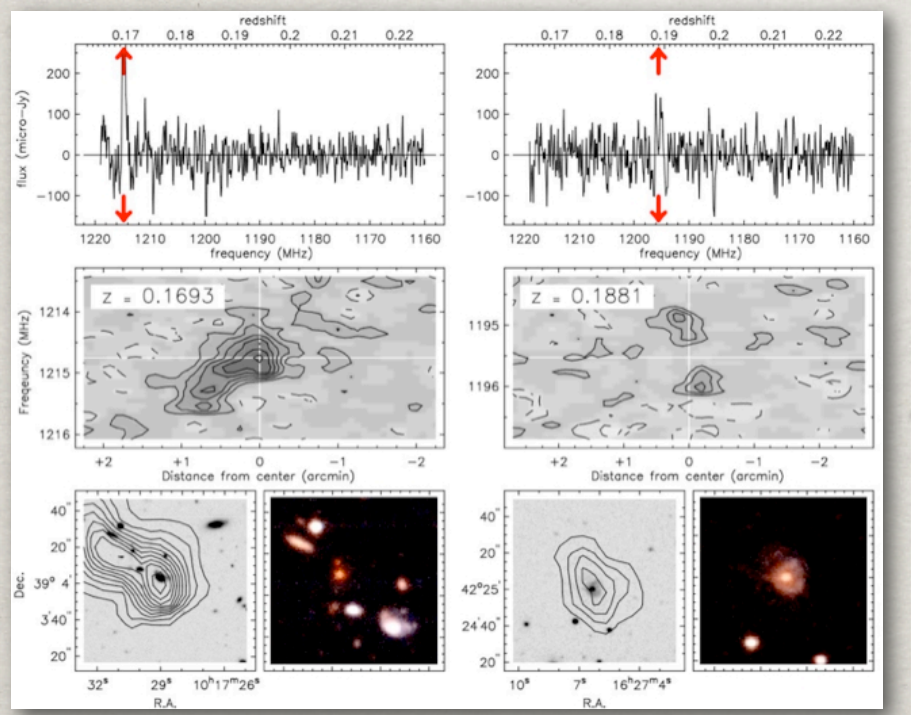


Oosterloo & van Gorkom
2005, ApJ, 437, L19

Summary

- State-of-Art HI Imaging Study & Future

- WSRT HI imaging of cluster galaxies at z~0.2 (M.Verheijen, B. Deshev+; see Verheijen et al. 2007, ApJ, 668, L9 for preliminary result)



- The SKA will allow direct HI imaging studies out to z>1 (cf. z~0.5 with the EVLA) where significant galaxy evolution due to the environment is likely to take place!