Tracing HI Gas Cycles and Global Star Formation with the ALFALFA Hα Survey

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Life Cycle of Gas in Galaxies: A Local Perspective
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Galaxy Gas Cycles

**Inflow**

HI reservoir - raw material

**Star Formation**

Radial flows and conversion to H2

**Reaccretion?**

**HI Mass**

**Feedback**

Ionization, Outflows, Photodissociation

ESA- AOES Medialab

NASA/ESA
- HI mass traces
  - total gas supply
  - potential for future SF
  - recent accretion (e.g. Moran et al. 2012)
- More HI = more total SF
  (e.g. Catinella et al. 2010, Huang et al. 2012)
HI at high SFR

- Starbursts are HI-rich?
  - Gordon & Gottesman 1981; Catinella et al. 2010

- Starbursts are HI-poor?
  - Oey et al. 2007

- May reveal disturbances
**ALFALFA Hα**

- **ALFALFA**: Arecibo Legacy Fast ALFA Survey
  - Blind, volume-limited 21 cm HI survey; R. Giovanelli, P.I.
  - > 30,000 detections, 7000 square degrees

- **ALFALFA Hα**
  - Volume-limited subset of ALFALFA
  - 20-100 Mpc

- **KPNO**: Hα and R-band imaging

- **Fall sample (565 galaxies) complete**

- **Starbursts**: Hα equivalent width (EW) > 80 Å
From HI to Stars

See talk by Saintonge
The HI and SFR Connection

1. Link between HI and long-term averaged SF?
2. Link between HI and dust extinction?

Weak… or strong?

e.g., Catinella et al. 2010; Huang et al. 2012
The HI and SFR Connection

Following Wen et al. 2014

Mass-Metallicity-HI Relation (Bothwell et al. 2013)
The HI and SFR Connection

Mass-Metallicity-HI Relation (Bothwell et al. 2013)

Following Wen et al. 2014
HI and Metallicity

- Mass-metallicity relations
  - e.g., Mannucci et al. 2010; Davé et al. 2011; Lilly et al. 2013
- Gas consumption
- Metal retention
- Dilution from accreted HI

- Shielding of $H_2$ (e.g., Krumholz et al. 2009; Bolatto et al. 2011)
HI Consumption Timescales

Higher $P = \text{Higher } H_2/H_I$

e.g., Blitz & Rosolowsky 2006

See talks by Hughes, Schruba, Bonnell

GASS galaxies from Catinella et al. 2010; 2013
Higher P = Higher H2/HI

See talks by Hughes, Schruba, Bonnell

Morphological fits from Simard et al. 2011
HI Consumption Timescales

\[ \log \Sigma_*(M_\odot \text{kpc}^{-2}) \]

\[ \log \frac{M_{\text{HI}}}{M_*} / \text{SFR} \] (Gyr)
Are Mergers Enhancing SFE?

- Asymmetry (Conselice et al. 2000)
- Major mergers: $A > 0.35$

- Full sample median: $A=0.14$
- Asymmetry peaks before peak SF (Lotz et al. 2010)

Most HI-rich for their mass

AGC 112546
5 kpc
AGC 330517
$A=0.24$
AGC 122866
AGC 120193
$A=0.18$

AGC 333529
AGC 330500
$A=0.68$
AGC 122187
AGC 331191
$A=0.18$

AGC 333529
AGC 330500
$A=0.43$
HI Regulation

- Starbursts maintain moderate HI gas fractions
  - HI inflow and H$_2$ formation as merger progresses
  - In starburst regions, photodissociation replenishes HI (e.g., Stacey et al. 1991)
- HI fuel available for future bursts
  (see also: Stierwalt et al. 2014; Ellison et al. 2015)
Mergers and HI Kinematics

Starbursts

Higher W20/W50 indicates excess of high-velocity HI
Mergers and HI Kinematics

Non-Starbursts
Low-Mass Starbursts

- Are the low-mass starbursts mergers?
- Periodic bursts due to feedback
  - e.g., Lee et al. 2007; Verbeke et al. 2014; Hopkins et al. 2014
- Initial disturbance may no longer be detectable
- Results in variable SFRs and delayed HI consumption

\[
\text{Log } \frac{\text{M}_{\text{HI}}}{\text{SFR}} \quad (\text{Gyr})
\]

\[
\text{Log } s\text{SFR} \quad (\text{yr}^{-1})
\]

\[
\text{Log } M_*
\]
Summary

- HI weakly linked to sSFR, closely coupled with dust extinction
  - Gas cycles and metallicity
- HI/SFR correlates with stellar surface density for disks
  - Role of mid-plane pressure?
- Spheroids may differ in access to HI
- Starbursts may maintain approximately constant HI
- Bursts in low-mass galaxies may be cyclical