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ALFALFA Hα Reveals How Galaxies Use Their HI Fuel

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Abstract. Atomic hydrogen traces the raw material from which molecular clouds and stars form. With 565 galaxies from the ALFALFA Hα survey, a statistically complete subset of the ALFALFA survey, we examine the processes that affect galaxies' abilities to access and consume their HI gas. On galaxy-wide scales, HI gas fractions correlate only weakly with instantaneous specific star formation rates (sSFRs) but tightly with galaxy color. We show that a connection between dust and HI content, arising from the fundamental mass-metallicity-HI relation, leads to this tight color correlation. We find that disk galaxies follow a relation between stellar surface density and HI depletion time, consistent with a scenario in which higher mid-plane pressure leads to more efficient molecular cloud formation from HI. In contrast, spheroids show no such trend. Starbursts, identified by Hα equivalent width, do not show enhanced HI gas fractions relative to similar mass non-starburst galaxies. The starbursts' shorter HI depletion times indicate more efficient consumption of HI, and galaxy interactions drive this enhanced star formation efficiency in several starbursts. Interestingly, the most disturbed starbursts show greater enhancements in HI gas fraction, which may indicate an excess of HI at early merger stages. At low galaxy stellar masses, the triggering mechanism for starbursts is less clear; the high scatter in efficiency and sSFR among low-mass galaxies may result from periodic bursts. We find no evidence for depleted HI reservoirs in starbursts, which suggests that galaxies may maintain sufficient HI to fuel multiple starburst episodes.

Keywords. galaxies: evolution, galaxies: general, galaxies: interactions, galaxies: ISM, galaxies: starburst, radio lines: galaxies, surveys

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The ALFALFA Hα survey (Van Sistine *et al.*2015) probes the HI content, star formation rates (SFRs), and Hα and R-band morphologies of a statistically complete subset of HI-detected galaxies from the ALFALFA survey (Giovanelli *et al.*2005). Here, we present results from the 565 "Fall-Sky" ALFALFA Hα galaxies (Jaskot *et al.*2015).

Starburst galaxies, identified by Hα equivalent width, have HI gas fractions comparable to similar mass non-starbursts and show no signs of HI depletion. Galaxy interactions may lead to efficient HI-to-H_2 conversion in several of the starbursts. Only two starbursts have M_{HI}/M_* more than 2σ above the mean value for their stellar mass, and these starbursts also exhibit the strongest morphological disturbances. During an interaction, inflowing HI may initially raise galaxies' HI gas fractions. After coalescence, as morphological disturbances weaken, H_2 conversion may eliminate any HI excess.

For the full "Fall-Sky" sample, M_{HI}/M_* correlates weakly with specific SFR (sSFR). In contrast, the strong correlation of color with M_{HI}/M_* (Fig. 1) implies a link between HI and recent star formation (e.g., Catinella *et al.*2010; Huang *et al.*2012). However, after correcting for dust (Fig. 1), the HI-color trend noticeably weakens. The mass-metallicity-HI relation (Bothwell *et al.*2013) may explain the HI-color trend. High-mass galaxies tend to have high metallicities (and high dust reddening), low sSFRs, and low M_{HI}/M_*.

Disk galaxies with higher stellar surface densities (Σ_*) have shorter HI depletion times

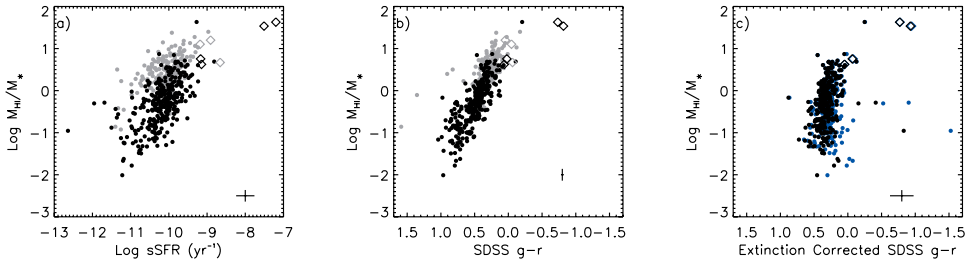

Figure 1. (*a*) M_{HI}/M_* vs. sSFR with WISE 12 μm detections in black and non-detections in gray. Diamonds indicate starburst galaxies. (*b*) M_{HI}/M_* vs. SDSS $g-r$. (*c*) M_{HI}/M_* vs. SDSS $g-r$ color, after correcting for extinction using the WISE 12 μm luminosities (Wen *et al.*2014) and extinction laws from Calzetti (2000; black) and Cardelli *et al.*(1989; blue).

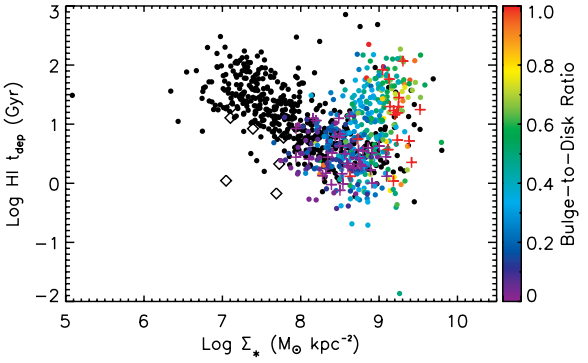

Figure 2. HI depletion time vs. Σ_* for the ALFALFA Hα non-starbursts (black circles) and starbursts (diamonds) and the higher mass GASS sample (Catinella *et al.*2010; colored circles and crosses). The GASS galaxies are colored from the Simard *et al.*(2011) SDSS fits by bulge-to-disk ratio (circles), Sérsic index $\geqslant 2$ (red crosses), and Sérsic index < 2 (purple crosses).

(M_{HI}/SFR; Fig. 2), but spheroids do not follow this trend. In disks, higher mid-plane pressure at higher Σ_* may promote molecular cloud formation from HI (Blitz & Rosolowsky 2006). Low-mass galaxies show more scatter in both HI depletion time and sSFR, which may indicate cyclical bursts of star formation.

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