

Galaxy evolution in the post-merger regime. V - Atomic gas evolution traced by ALFALFA stacks

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Introduction

- Galaxy mergers → trigger SF, quench SF
- What is the long-term fate of them after the period of elevated SF?
→ Neutral gas reservoir in post-merger
- Molecular gas → Enhanced
Atomic gas → Diverse results
 - Lack rigorously selected control samples
 - Limited statistics (< 10 galaxies)
 - Source confusion
 - Variable detection thresholds
 - Not consider evolution during interaction

Methods

- Multi-Model Merger Identifier (MUMMI; Ferreira+2024, 2026) retrained for DECaLS (Trained with IllustrisTNG100-1)
 - 10 CNN + 10 Vision Transformer
 - Originally trained for UNIONS (less overlap with SDSS)
 - Step 1: merger or non-merger
 - Step 2: pre-coalescence or post-mergers
 - Step 3: predicted time since coalescence (T_{PM}) Catalog is public
- 106,426 mergers, with 23,354 post-merger with reliable T_{PM} (including MUMMI-UNIONS and MUMMI-DECaLS)
- Cross-match MUMMI-DECaLS, GALEX-SDSS-WISE Legacy Catalog 2, and ALFALFA
- 752 post-merger → 531 post-merger with reliable T_{PM} (49, 39, 50 and 393)
- Control sample = stellar mass, redshift, and SFR matched non-interacting
- ALFALFA HI median stacking → HI mass

$$M_{HI} = \frac{2.356 \times 10^5}{1+z} \left(\frac{d_L(z)}{\text{Mpc}} \right)^2 \left(\frac{\int F_{\nu, rest} dv}{\text{Jy km s}^{-1}} \right) M_{\odot}$$

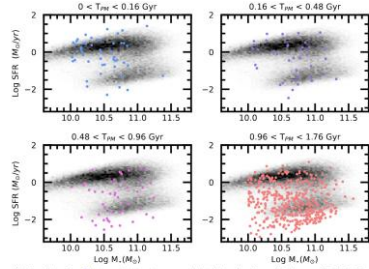
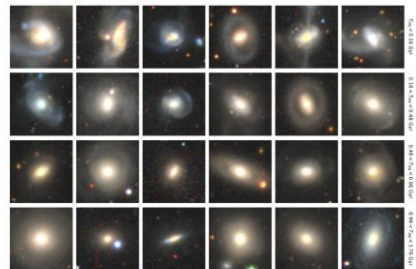


FIG. 4.— As for Figure 3 but separating the post-merger sample into the time bins predicted by MUMMI. The DM < $T_{PM} \leq 1.76$ Gyr time bin is the most populated due to its longer duration compared to earlier bins. The longest time bin is also dominated by low SFR galaxies due to merger-induced quenching (see the example in Fig. 4, Ellison et al. 2026).

Results

- HI deficits
 - Compared with control (matched M^* , SFR, redshift), post-mergers are gas-poor
 - HI is depleted as a result of the merger process
- Variation depending on T_{PM}
 - $M(HI)$ decline with T_{PM}
→ Just a larger fraction of quenched galaxies in high T_{PM}
 - No enhancement/deficit around the time of coalescence
 - Short-lived strong deficit at the second time bin (0.16-0.48 Gyr)
- Separate with sSFR and T_{PM}
 - Results become complex
 - In the first T_{PM} bin,
 - SF post-merger shows excess
 - Quenched one shows deficit
 - Normal in total
 - In SF post-merger
 - Slightly HI-rich soon after coalescence
 - Significant gas poverty that lasts ~a Gyr
 - At the fourth T_{PM} bin, HI recovers
 - In quenched post-merger
 - At the fourth T_{PM} bin, HI remains poor
- Not only T_{PM} , but also whether or not the post-merger is quenched

Discussion

- Comparison with previous works (cf. vs Ellison+2018)
 - Sample selection (definition of post-merger, T_{PM} , SF or quenched)
 - Control sample with enough size
- Limitations, caveats
 - ALFALFA confusion (3 arcmin): No major impact
 - Lack of properties of individual objects → Deep HI with FAST
- Combination with similar measurements in galaxy pairs (Yan+2026)
 - Evolution of atomic gas throughout merger life
 - Need to match control sample and sample selection
- Long-lived HI in merger remnant: $\log(M(HI)) \sim 9$
 - Retains bulk fuel supply sufficient for future star formation

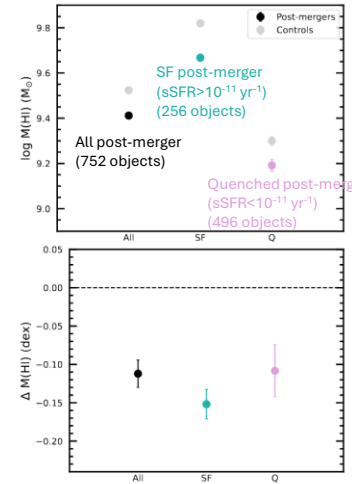


FIG. 6.— Top: Median $M(HI)$ of post-mergers (black, teal and pink) and controls (grey) derived from the stacks shown in Figure 5. Results are shown for stacks of all 752 post-mergers in the ALFALFA footprint, and separated into star-forming and quenched (sSFR above/below 10^{-11} yr^{-1} respectively). Bottom: The excess $M(HI)$ is defined as the HI mass in the post-merger stack compared with its respective control sample. The dashed horizontal line at zero indicates no HI enhancement/deficit in the post-mergers compared to their matched controls. An HI deficit is found for both star-forming and quenched post-mergers.

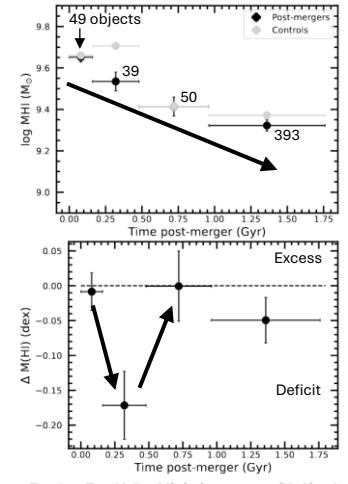


FIG. 8.— Top: Median $M(HI)$ of post-mergers (black) and controls (grey) derived from the stacks shown in Figure 7. Bottom: The excess $M(HI)$ is defined as the HI mass in the post-merger stack compared with its respective control sample. The dashed horizontal line at zero indicates no HI enhancement/deficit in the post-mergers compared to their matched controls. Whereas there is no significant difference between post-mergers and controls immediately after coalescence, by $T_{PM} \sim 0.25$ Gyr there is a ~60% deficit in HI gas mass for post-mergers. Although this gas deficit largely recovers at later times, even at $T_{PM} \sim 1.5$ Gyr post-mergers remain ~10% gas-poor compared with controls.

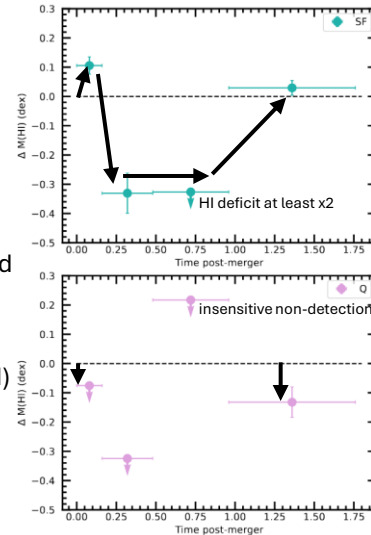


FIG. 10.— As for the lower panel of Figure 8 but for galaxies separated into star-forming (top panel, teal) and quenched (lower panel, pink). If the 21 cm line is not detected with at least 5 σ significance it is considered an upper limit. This S/N threshold is achieved for all control stacks, as well as three time bins for the star-forming post-mergers, but only the final time bin for quenched post-mergers. In the other bins, $\Delta M(HI)$ is shown as an upper limit.