Molecular hydrogen deficiency and star formation in HI-poor galaxies*

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Abstract

- We use a sample of 47 local spirals to demonstrate that 40% of HI-poor galaxies are also poor in molecular hydrogen.
- H_2 reduction is associated with the removal of HI inside the galaxy optical disk.
- This finding is consistent with theoretical models in which the molecular fraction is determined primarily by the gas column density.
- H_2 deficient galaxies form stars at a lower rate and have dimmer far infrared fluxes than gas rich galaxies.
- We speculate that this process might be a first step in the transition between the blue and red sequence observed in the color-magnitude diagram.

Molecular gas deficiency

Our sample of 47 local spiral galaxies is selected based on the criterion of high sensitivity CO and HI images ([1],[2],[3]). Comparing the H_2 mass in a sample of isolated galaxies with that in perturbed galaxies (Fig. 1), we detect molecular deficiency in ~40% of the galaxies which are HI poor.

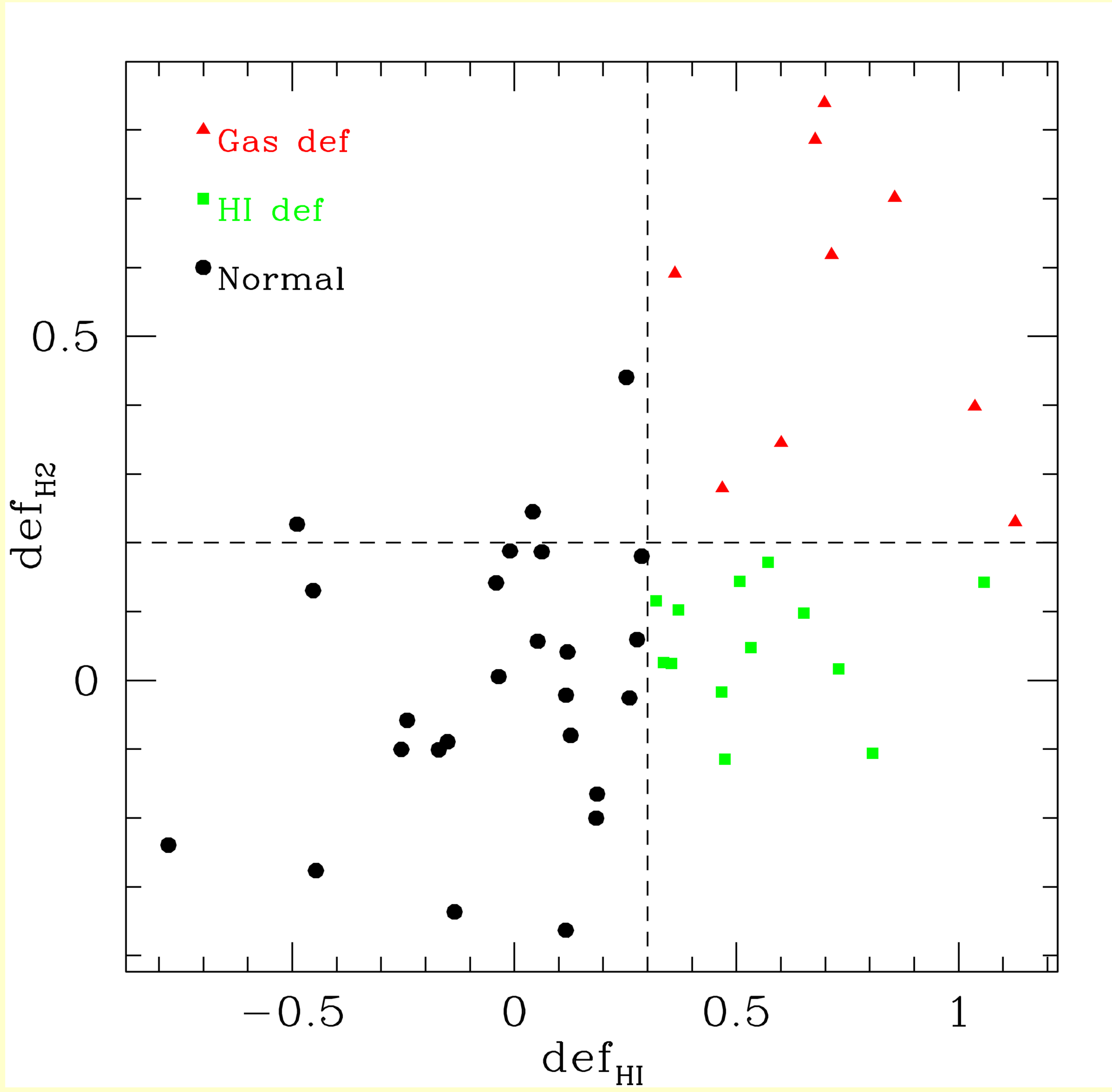

Figure 1: Comparing the integrated molecular and atomic hydrogen content, 40% of HI poor galaxies ($def_{HI} > 0.3$) appear to be also deficient in molecular hydrogen ($def_{H2} > 0.2$).

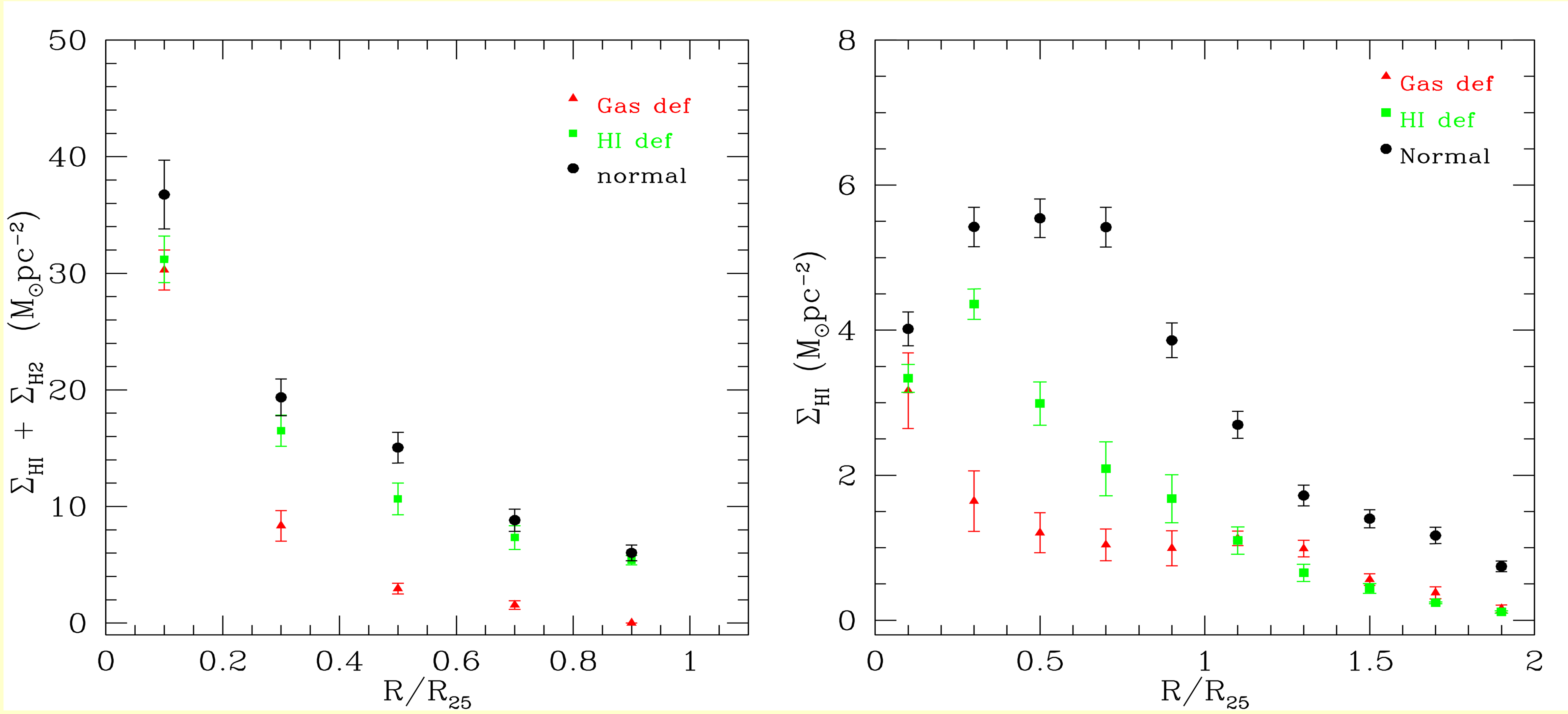

Figure 2: Average total gas (left) and HI (right) surface density profiles in bins of normalized radius. Gas-deficient galaxies (red) have in the disk a gas column density below the values required to form molecular hydrogen. In contrast, galaxies which are only HI-deficient (green) have in the inner part of the disk an HI column density large enough to form molecular hydrogen.

Theoretical interpretation

In the model by Krumholz et al., ([4],[5]) the molecular fraction in a galaxy is determined by the product of its hydrogen column density and metallicity. Fig. 2 suggests that a galaxy moves from HI-deficient to gas-deficient when it loses enough gas inside its optical disk to bring the gas column density below a critical value (~10 M pc^{-2}) required for H_2 formation (See Fig. 4).

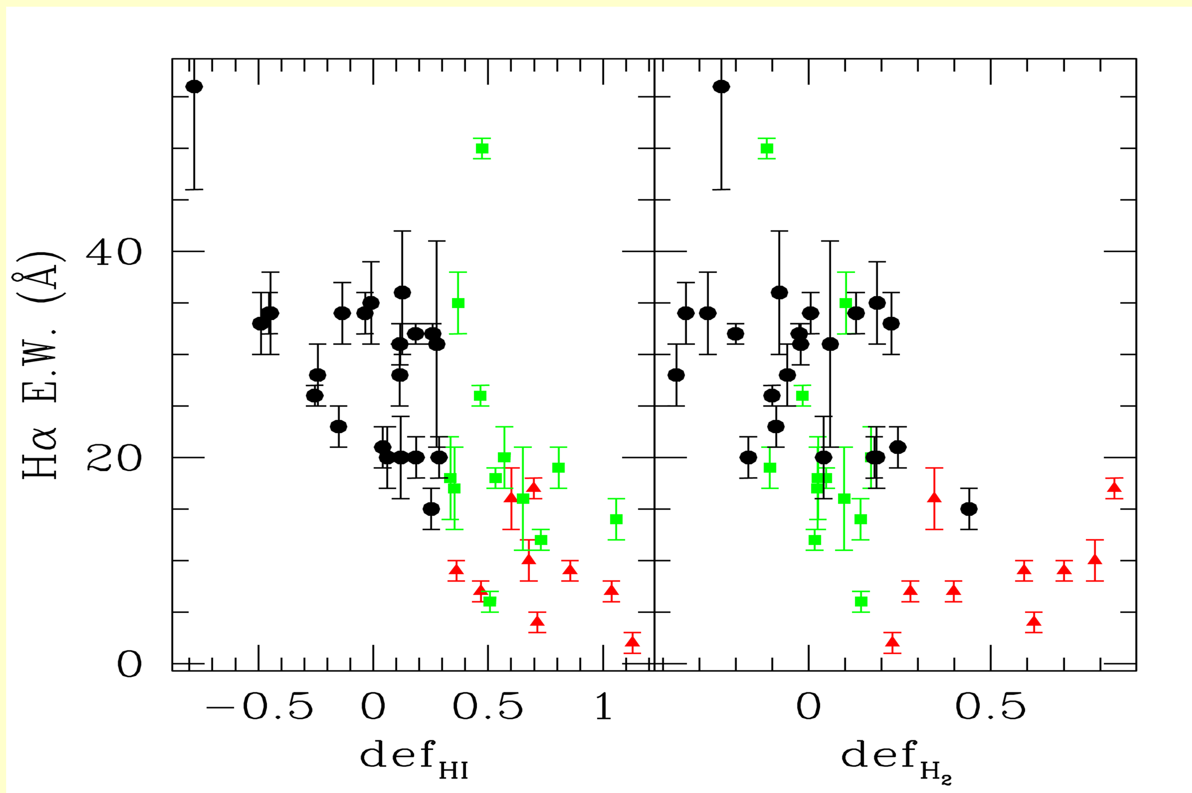

Figure 3: Comparison between a star formation indicator and gas deficiency. Gas-deficient galaxies (red) have the lowest absolute specific star formation rate, as expected if stars form in molecular rich regions.

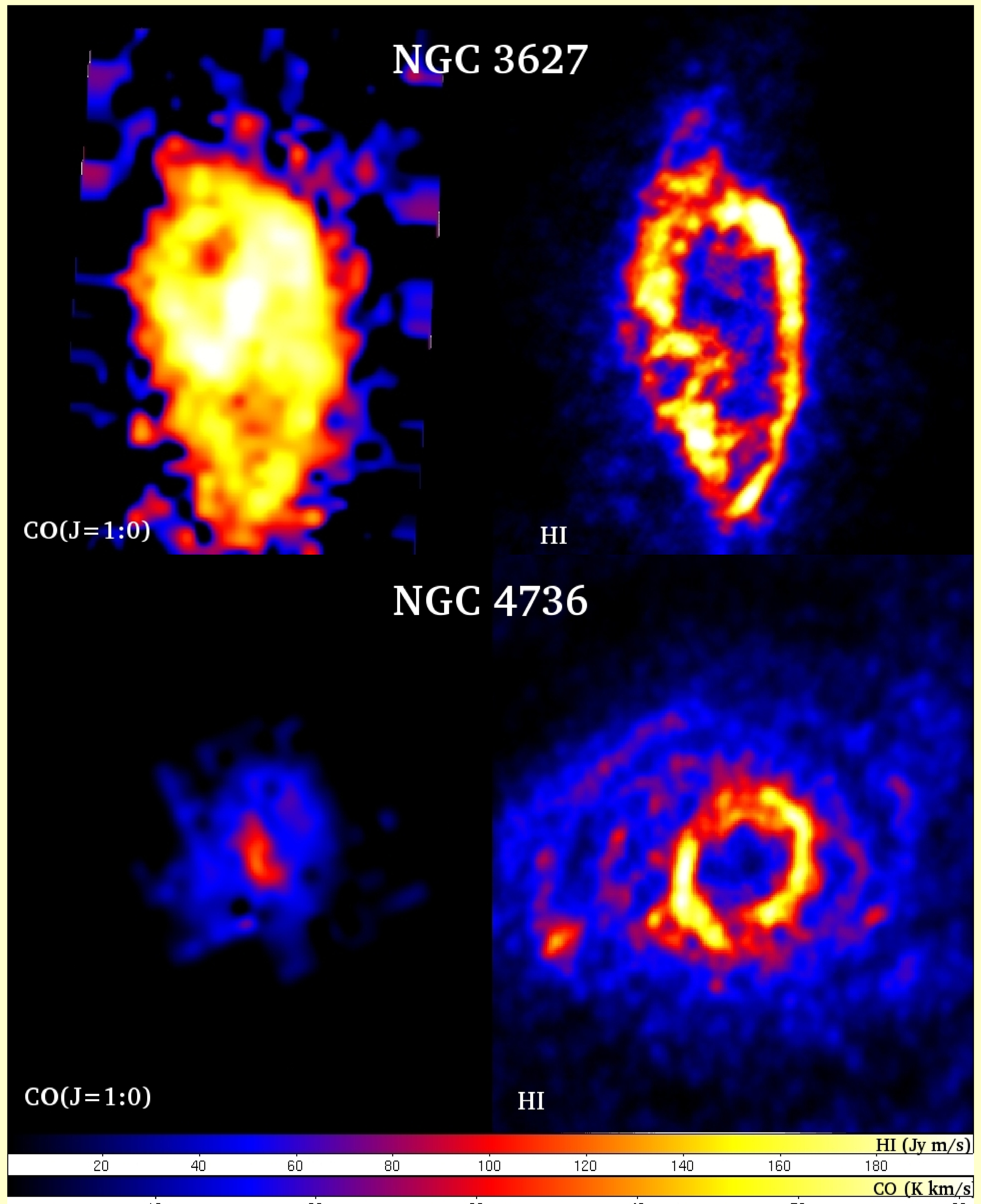

Figure 4: Top: The HI-deficient galaxy NGC3627, imaged in CO(J=0-1) (left) and HI (right). Bottom: The gas-deficient galaxy NGC4736, imaged in CO(J=0-1) (left) and HI (right). Images are on the same flux and spatial scale. Both of these galaxies are HI deficient and show HI emission mainly concentrated inside the optical disks. NGC3627 has an HI column density high enough to form molecules in the center. On the contrary, NGC4736 has lower HI column density and therefore a lower content of molecular gas.

Effects on the star formation

When perturbations reduce the atomic hydrogen column density below the threshold required to produce H_2, star formation is suppressed. Studying the Hα+[NII] E.W., we show in Fig. 3 that H_2-deficient galaxies have less star formation than what is observed in H_2-normal galaxies.

Conclusion

H_2 reduction is associated with the removal of HI inside the galaxy optical disk, a finding consistent with theoretical models in which the molecular fraction is determined primarily by its gas column density. Molecular deficient galaxies form stars at a lower rate, a possible first step in the transition from the blue to the red sequence.

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