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X-ray Emitting Hot Gas Production in Nearby Merging Galaxies

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Abstract

Using 8 micron infrared images from the Spitzer telescope we determine the half-light radius (the radius that contains half of the total light) for a sample of 49 nearby merging and merged pairs of galaxies. We compared this with other properties of the galaxies including a) the mass of X-ray emitting hot gas $M_x(\text{gas})$, b) the star formation rate (SFR), c) the large scale environment the galaxies reside in, and d) the chemical composition of the galaxies. Our goal is to better understand the processes that produce hot gas in galaxies.

Procedure

We used the daophot routine (Stetson 1987) in the IRAF software package to measure the 8 micron flux of each galaxy within a set of 30 concentric round apertures, with radii centered on the galactic nuclei starting very small and increasing outward. These fluxes are then compared with the total light of the galaxy, to determine the radius that contains half the light. For pre-merger pairs of galaxies, the half-light of each galaxy was determined separately. Using this half-light radius as an approximate measure of the spatial extent of young stars we calculated SFR/area . SFR was calculated from the IR data combined with the ultraviolet data from the GALEX telescope.

Hot interstellar gas in galaxies (millions of degrees Kelvin) is produced from massive young stars and supernova explosions of those stars. This gas is bright in x-ray wavelengths. In an earlier study, images from the Chandra x-ray telescope were used to measure the diffuse x-ray light from the hot gas in the sample of 49 merging galaxies (Smith et al. 2018). $M_x(\text{gas})/\text{SFR}$ is constant with SFR but varies with the infrared (IR) colors of the galaxies (Smith et al. 2019). Long-wavelength IR light from galaxies comes from interstellar dust heated by young stars. The IR colors are a measure of the temperature of the dust grains and therefore a measure of density of young stars. This implies that $M_x(\text{gas})/\text{SFR}$ depends upon the density of young stars. To test this hypothesis, in the current study we directly measured the spatial extent of the young stars using 8 micron IR images, and calculate the SFR per surface area of the galaxies. We then compared this with $M_x(\text{gas})/\text{SFR}$.

Results

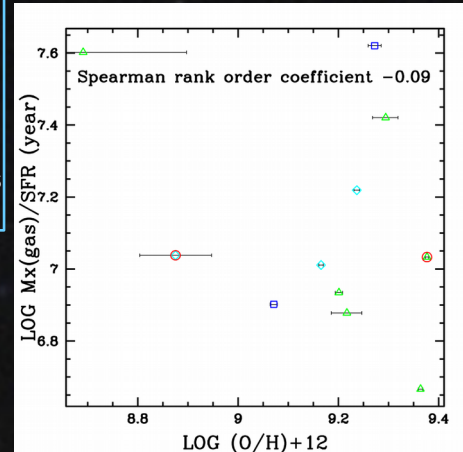
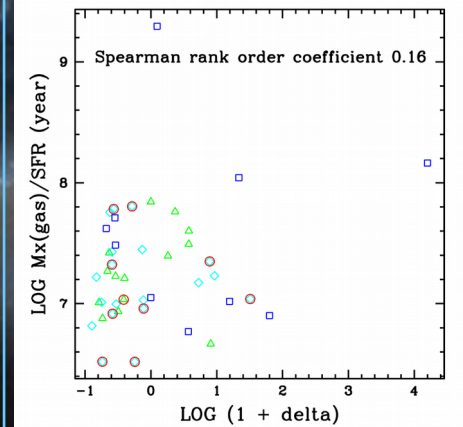
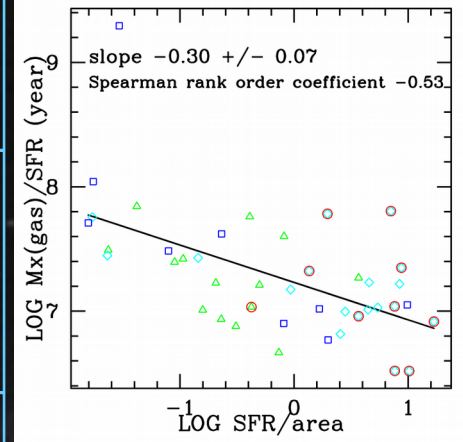
$M_x(\text{gas})/\text{SFR}$ is not correlated with either oxygen abundance or the large-scale environment of the galaxy. However when compared with SFR/area we see an anti-correlation having a Spearman rank order coefficient value of -0.53. This shows only a ~0.1% probability of happening by chance. This supports the hypothesis that the amount of hot gas produced, per SFR, depends upon the density of young stars.

References

Smith et al., *Astronomical Journal*, 155, 81 (2018)
Smith et al., *Astronomical Journal*, Submitted (2019)
Stetson, P. N. 1987, *PASP*, 99, 191

Acknowledgements

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Left: Green open triangles represent galaxies in merger stages 1 and 2. Cyan open diamonds represent galaxies in merger stages 3, 4, and 5. Blue open squares represent galaxies in merger stages 6 and 7. Galaxies with active galactic nuclei are represented with red open circles.

Top: Shows $M_x(\text{gas})/\text{SFR}$ vs $\log(\text{SFR}/\text{area})$. The line represents a best fit line. An anti-correlation is seen.

Center: Shows $M_x(\text{gas})/\text{SFR}$ vs $\log(1+\delta)$. Delta is a measure of the local environment of a galaxy. A large delta means the galaxy lies in a dense cluster of galaxies. No correlation is seen.

Bottom: Shows $M_x(\text{gas})/\text{SFR}$ vs $\log(\text{O}/\text{H})+12$. Here $\log(\text{O}/\text{H})+12$ refers to the oxygen abundance of a galaxy (determined with spectra data from the Sloan Digital Sky Survey). No correlation is seen.



Above: The green highlighted regions show the half-light radii of the two galaxies in the Arp 240 pair.