Evidence for the non-destruction of the Most Massive Molecular Clouds even after they have given Birth to Massive Star Clusters

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Abstract. We have combined observations of the Antennae galaxies from the radio interferometer ALMA and from the optical interferometer GHαFaS (Galaxy Hα Fabry-Perot System). The two sets of observations have comparable angular and spectral resolutions, enabling us to identify 142 giant molecular clouds (GMCs) and 303 H$\textsc{ii}$ regions. We have measured, and compared, their basic physical properties (radius, velocity dispersion, luminosity). We study the mass functions of H$\textsc{ii}$ regions and GMCs, where a double population of H$\textsc{ii}$ regions due to a double population of GMCs is found. Using the velocity dispersion measurements, we claim that the difference between the regimes is the nature of the dominant binding force. For the regions in the lower mass range, the dominant force is the external pressure, while in the higher mass range it is the internal gravity of the clouds. We have applied the same method to similar observations (GHαFaS & ALMA) of Arp 236 and NGC 1614 finding similar results.

**Keywords.** Interacting galaxies, star formation, H$\textsc{ii}$ regions, GMCs.

1. Introduction

The process of star formation enhancement in interacting galaxies is postulated but not very well understood. The study of the kinematics of the star forming regions in galaxy mergers turns out to be crucial to clarify if star formation is indeed enhanced, how the extra-nuclear star forming regions are caused, and to characterize the physical parameters of the gas in these regions. Star formation occurs largely inside molecular clouds, and H$\textsc{ii}$ regions trace recent star formation. The study of both types of clouds gives us crucial clues to understand the star formation process. The kinematical properties of these clouds help us to clarify what are the drivers of the turbulence, and the connection with the star formation.

Using ASTRODENDRO (Rosolowsky *et al.* 2008) Zaragoza-Cardiel *et al.* (2014) were able to measure the radius (R), the velocity dispersion (σ_v) and the luminosity for each H$\textsc{ii}$ region and GMC observed in the Antennae galaxies. The data used in Zaragoza-Cardiel *et al.* (2014) is already publicly available.† Based on the luminosity functions, and the virial parameter of H$\textsc{ii}$ regions and GMCs in the Antennae galaxies, Zaragoza-Cardiel *et al.* (2014) conclude that the most massive GMCs are not dissolved after the birth of massive star clusters, but remain as gravitationally bound H$\textsc{ii}$ regions.

† http://vizier.cfa.harvard.edu/viz-bin/VizieR?-source=J/MNRAS/445/1412
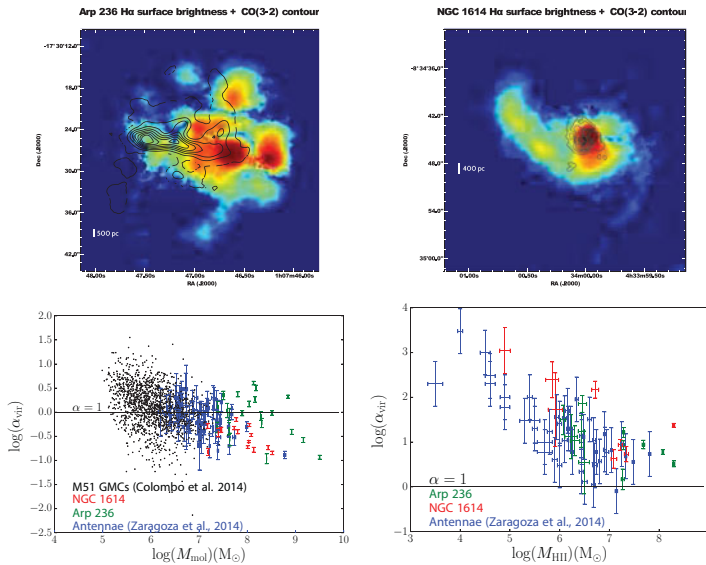
Figure 1. Top left: Arp 236 Hα surface brightness + CO(3-2) contours. Top right: NGC 1614 Hα surface brightness + CO(3-2) contours. Bottom left: Virial parameter, $\alpha_{\rm vir}$, versus molecular gas mass, $M_{\rm mol}$, of GMCs. Bottom right: $\alpha_{\rm vir}$ versus ionized gas mass, $M_{\rm HII}$, of HII regions.

2. HII regions and GMCs in Arp 236 & NGC 1614

We have observed Arp 236, and NGC 1614 with GHαFaS and combined these observations with public ALMA data, Saito *et al.* (2015) for Arp 236, and Sliwa *et al.* (2014) for NGC 1614. The comparison between Hα and CO(3-2) observations is shown in Fig. 1 top. Using ASTRODENDRO we have extracted the properties of HII regions and GMCs in those galaxies.

The virial parameter decreases with the mass of the star forming regions (Fig. 1 bottom), which implies that the more massive the region, the more important is the gravity rather than the external pressure (Bertoldi & McKee 1992). Thus, the massive population of gravitationally bound HII regions is probably due to the massive population of GMCs.

3. Conclusions

We found a population of massive gravitationally bound GMCs and HII regions probably connected based on the luminosity functions and the virial parameter in the Antennae galaxies, Arp 236, and NGC 1614.

References

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