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A Close-Up View of a Merger System: Molecular Gas and Star Formation in the Antennae (NGC 4038/39)

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Abstract. New observations of the Antennae in CO emission reveal extremely massive concentrations of molecular gas ($> 10^8$ $M_\odot$) and a chaotic velocity field. Evidence for cloud-cloud collisions near the strong 15 μm peak seen with ISO may provide an explanation for the unusually strong mid-infrared emission in this region

1. Introduction

As the closest example of a merger of two massive spiral galaxies, the "Antennae" system (NGC 4038/39) offers a unique opportunity to study the physical and dynamical properties of the interstellar medium in an active merger system. The Antennae have one of the largest populations of luminous star clusters known (Whitmore & Schweizer 1995), while observations with the Infrared Space Observatory (ISO) have revealed luminous regions of massive star formation that are completely invisible at optical wavelengths (Vigroux et al. 1996; Mirabel et al. 1998). Studying the properties of the molecular gas from which these star clusters form is important for understanding the triggering of intense star formation in galaxy mergers.

2. Observations

Observations of three overlapping $1'$ fields were obtained at the Caltech Millimeter Array. The synthesized beam is $3.15 \times 4.91''$ or 310×480 pc at the distance of the Antennae (20 Mpc). Individual molecular complexes were identified from the data cube using the algorithm CLFIND (Williams et al. 1994). Further details of the observations and analysis are given in Wilson et al. (in prep.).

3. Discussion

Comparison of the CO data with the ISO 15 μm image shows an excellent correlation between the CO emission and the 15 μm emission, particularly in

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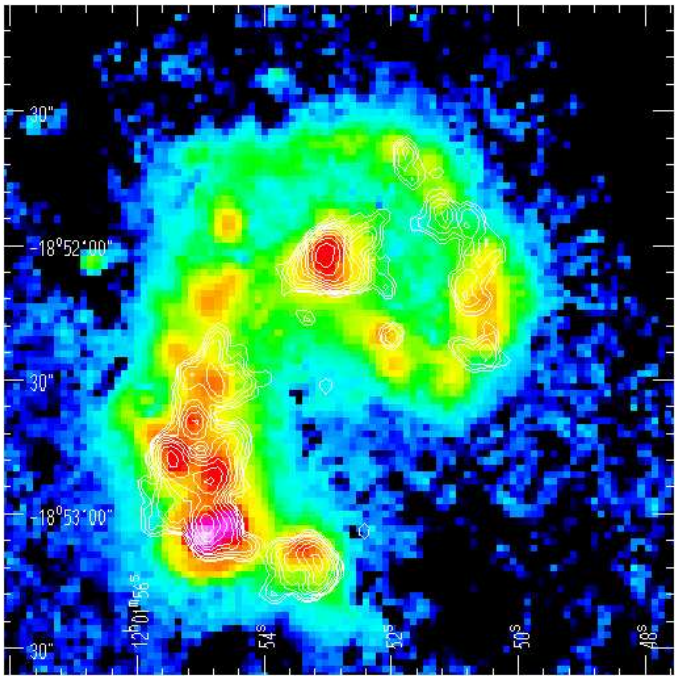

Figure 1. Integrated CO intensity overlaid on the ISO 15 μm image. CO contours are 1,1.6,2.5,4,6,9.5,15,23,37,57,90 Jy beam^{-1} km s^{-1}.

the brightest regions (Figure 1). The strongest 15 μm peak lies in the "overlap region" between the two galaxy nuclei, and has a ratio of 15 μm to CO flux that is a factor of three larger than that of two similar molecular complexes lying just north of it. However, ISO CVF spectra show strong [NeIII]/[NeII] ratios indicative of massive star formation in all the massive molecular complexes in the overlap region. The strong mid-infrared continuum emission in the brightest 15 μm peak is likely due to very small dust grains heated to high temperatures by their close proximity to O stars. Such dust grains should be blown away quite quickly by the massive stars. Thus, we may simply be seeing this region when it is extremely young and has not yet had time to blow away its surrounding dust. However, this region is also unusual in that it contains three separate, massive ($> 10^8$ M$_\odot$) molecular complexes inside an area of just 1 kpc^2. This concentration of molecular material suggests that cloud collisions may be an important process in this region. Such collisions could fuel the strong mid-infrared emission by continuously bringing fresh supplies of very small dust grains into the sphere of influence of the massive stars.

References

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