ABSTRACT: We present the results of an extensive observational study of the active star-forming complex W51. We observed this region in the J = 2 - 1 transition of the 12CO and 13CO molecules over a 1.25° x 1.00° region with the University of Arizona Heinrich Hertz Submillimeter Telescope. We use a statistical quadratic code to estimate physical properties of the molecular gas. We compare the molecular cloud morphology with the distribution of infrared (IR) and radio continuum sources, and find associations between molecular clouds and young stellar objects (YSOs) listed in Spitzer IR catalogs. We estimate that about 1% of the cloud mass is currently in YSOs by comparing the total gas masses to total masses of YSOs in the active star-forming region of W51.

1. INTRODUCTION

Establishing the properties of molecular clouds is essential in understanding the formation and evolution of star-forming regions. Newly formed massive stars can affect the parental molecular clouds through ionization, heating, and expansion of the HII region, stellar winds, and supernova-driven shocks. These mechanisms are either compressing or dispersing the surrounding clouds. For a better understanding of the Star-Formation process, detailed observations of the molecular clouds and identification of embedded young stellar objects (YSOs) are required. W51 is one of the most luminous star-forming regions in the first quadrant of the Galactic plane. The high luminosity comes from a large number of O-type stars that are within the molecular cloud.

2. OBSERVATIONS

2.1. 12CO and 13CO J = 2 - 1 and 12CO J = 1 - 0

We present new observations of W51 in the J = 2 - 1 transition of 12CO and 13CO lines with the 10 m Heinrich Hertz Telescope (HHT) on Mount Graham, Arizona. Our on-the-fly (OTF) maps are fully sampled in two lines simultaneously with an angular resolution of 32″ and with an rms noise per velocity channel of +1.1 K in antenna temperature. We obtained 12CO J = 1 - 0 data for the same region from the Galactic Ring Survey.

2.2. Spitzer Data

- Glimpse I (IRAC 3.6, 4.5, 5.8, and 8.0 μm)
- MIPSGAL (24 μm)
- Kang et al. (2009a) identify and classify YSOs near the W51 H II region.

3. RESULTS

3.1. Molecular Clouds

1. CO emission in the 1.25° x 1.00° area divides into three velocity components, 30-55, 56-65, and 66-85 km s⁻¹. We adopt a distance of 6 kpc and use that to calculate the gas masses of the selected regions shown in Table 1. In Table 1, we list the size of the regions, velocity range, masses, life times and YSO candidates.

2. Cross symbols (green dots) for the boxed areas in Figure 1. Two average spectra of 12CO and 13CO line ratios are useful indicators of trends in gas temperature. The ratio of R_{CO} = ν_{12} / ν_{13} is age dependent and the photodissociation model to our treatment of the CO molecular excitation to the escape probability radiative transfer and the photodissociation model to our estimate the gas temperature of the selected regions shown in Figure 1.

3. The contour levels are 30, 90, 150, 210, and 270 K km s⁻¹. Squares are compact radio continuum sources, are smaller than 0.7 arcsec. We apply the escape probability radiative transfer and the photodissociation model to our estimate the gas temperature of the selected regions shown in Figure 1. In Table 1, we list the size of the regions, velocity range, masses, life times and YSO candidates.

4. Physical Parameters

We use a new LTE statistical equilibrium treatment of the CO molecular excitation to the escape probability radiative transfer and the photodissociation model to our estimate the gas temperature of the selected regions shown in Figure 1. In Table 1, we list the size of the regions, velocity range, masses, life times and YSO candidates.

Reference:


4. Triggered Star Formation

We argue that triggered star formation resulted from HII region expansion into clouds in the shell structure near W51A (Kang et al. 2009a) and in the region around G49-0.1 and G49-0.3. We also present evidence of star formation triggered by cloud-cloud collisions in G49-0.4 and G49-17.6-21.