STAR FORMATION IN THE GEM OB1 MOLECULAR CLOUD COMPLEX

JOHN M. CARPENTER

Institute for Astronomy, University of Hawaii

AND

RONALD L. SNELL AND F. PETER SCHLOERB

Five College Radio Astronomy Observatory,
University of Massachusetts

Abstract. We have undertaken a study of the global star formation activity in the Gem OB1 molecular cloud complex using a combination of molecular line, near-infrared, and far-infrared data. The most striking features in the molecular line images are the numerous arc and ring structures which we believe to have been formed by the interactions of expanding HII regions and wind blown bubbles with the ambient molecular gas. The most massive cores in this complex are found within these arcs of gas and most show signs of star formation. We suggest that these cores have been formed by gravitational instabilities in the swept up shells of molecular gas, and that star formation proceeds rapidly after the massive dense cores are formed.

1. Introduction

We have conducted a detailed study of the molecular gas and star formation activity in the Gem OB1 molecular cloud complex. The primary goal of this study is to determine the large scale properties and structure of the molecular gas, and to determine how this structure is related to both the past and current star formation activity. The salient results of this analysis are presented here. A more detailed description of the conclusions from this work can be found in Carpenter, Snell, & Schloerb (1995a,b).

2. Large Scale Structure of the Gem OB1 Complex

The Gem OB1 complex was mapped in ^{12}CO(J=1–0) and ^{13}CO(J=1–0) using the focal plane receiver QUARRY at FCRAO. The beam size of the FCRAO telescope at these transitions is $45''$ and $47''$ for ^{12}CO and ^{13}CO respectively. In Figure 1, we present a grey scale image of the observed peak ^{12}CO antenna temperature. The map covers over 32 deg^2 of the sky, which corresponds to a physical scale of 177 pc x 221 pc for the adopted distance of 2.0 kpc. The ^{13}CO map covers a comparable area. The most striking features in the Gem OB1 cloud complex are the series of arc and ring shaped structures found on spatial scales from $\sim$ 1 pc to $>$ 35 pc. We have concluded that these structures have resulted from the interactions of relatively massive stars with the ambient molecular material based upon:

- The morphology of the structures.
- The association of some of these structures with optical HII regions.
- In some instances, the kinematics of the arcs and rings.
- Comparison of the sizes, masses, and kinetic energies of the arcs and rings with models of expanding HII regions and wind blown bubbles.

3. Dense Cores in the Gem OB1 Complex

We searched for dense cores within the Gem OB1 complex by mapping regions with extended ^{13}CO emission in CS(J=2–1). From this CS survey we identified 11 dense cores with masses ranging from 96 $M_\odot$ to 2200 $M_\odot$. Most of these cores are contained within the arc and ring shaped structures found in the ^{12}CO images. We examined the star formation content within these dense cores using the IRAS point source catalog and near–infrared imaging surveys. At least 8, and possibly 10, of these cores are associated with IRAS point sources, and many of these cores already contain a substantial cluster of stars. The high fraction of massive cores with star formation suggests that stars form rather quickly after the formation of a massive core. Assuming that we are not observing the last episode of star formation in the Gem OB1 complex, this implies that dense cores are continuously formed throughout the lifetime of a molecular cloud complex.

4. Synthesis

Based on our molecular line observations we propose the following overall picture for the evolution of the Gem OB1 molecular cloud complex. While we cannot say how the previous generation of stars in this region formed, it is apparent that they have left their imprints within the molecular gas as evidenced by the prevalent “arcs” and “rings” of molecular material. These structures are the preferential location of the more massive cores

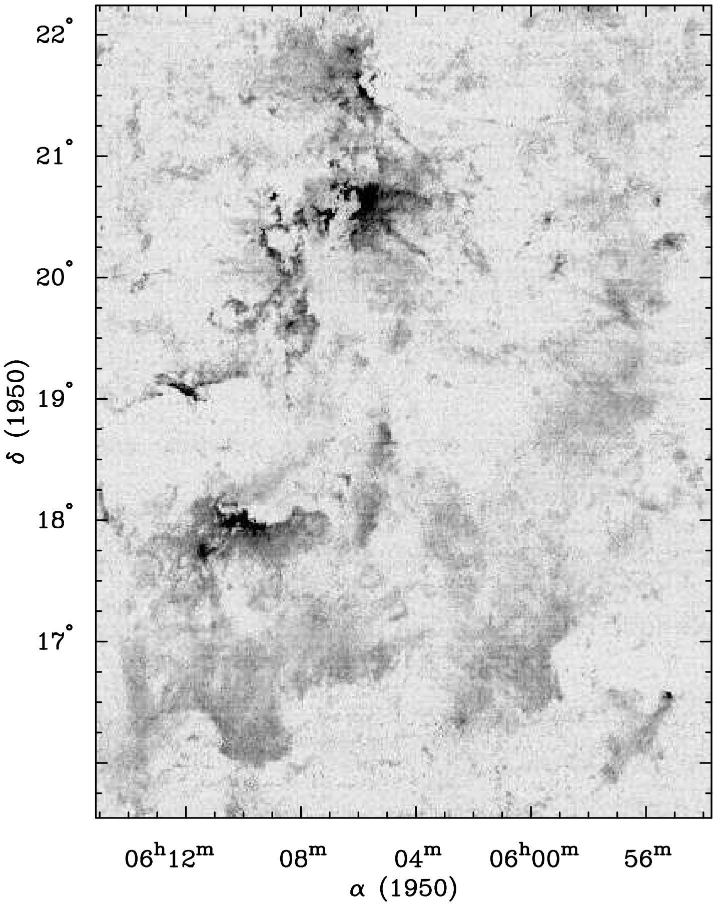

Figure 1. Map of the observed peak ^{12}CO(J=1–0) antenna temperature.

(mass > 100 $M_\odot$) within the Gem OB1 complex. Thus we suggest that the current population of massive dense cores in the Gem OB1 complex have formed primarily in swept up shells of molecular gas. Since most of the cores already contain substantial signatures of star formation activity, we further suggest that the onset of star formation in *massive* dense cores occurs rather quickly after the core is formed.

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References

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