

Submillimeter-wave observations of outflow and envelope around the low mass protostar IRAS 13036-7644

Kazuhisa Kamegai¹, Masaaki Hiramatsu², Takahiro Hayakawa³,
Ken'ichi Tatematsu³, Tetsuo Hasegawa³, Toshikazu Onishi⁴
and Akira Mizuno⁵

¹Institute of Astronomy, The University of Tokyo, 2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan, email: kamegai@ioa.s.u-tokyo.ac.jp

²Department of Astronomy, The University of Tokyo, Bunkyo, Tokyo 113-0033, Japan

³National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan

⁴Department of Astrophysics, Nagoya University, Chikusa, Nagoya 464-8602, Japan

⁵Solar-Terrestrial Environment Laboratory, Nagoya University, Toyokawa, Aichi, 442-8507, Japan

1. Introduction and Motivation

The interaction between molecular outflow from a protostar and ambient molecular cloud would play an important role in dissipating circumstellar envelope, changing chemical composition, and triggering next generation star formation. In order to investigate the interaction in submillimeter wavelength, we have made line observations toward the low mass protostar IRAS 13036-7644 (Class 0/I) in the Cha II dark cloud. Although millimeter observations found CO outflow and evidence of mass infall toward the protostar (e.g. Lehtinen 1997), no submillimeter observation has been reported so far.

2. Observations and Results

The observations were carried out with ASTE 10 m telescope at Atacama, Chile in June 2005. The CO $J = 3 - 2$ (345 GHz) and HCO⁺ $J = 4 - 3$ (356 GHz) lines were mapped in a $10' \times 6'$ area including the protostar position with a grid of $10''$ around the protostar and $20''$ in the other region. The CO $J = 3 - 2$ map shows a pair of molecular outflows which extend 0.12 pc westward and 0.08 pc eastward around the protostar. The directions of red and blue lobes are consistent with the outflow in the CO $J = 1 - 0$ line. A dense circumstellar envelope traced by the HCO⁺ $J = 4 - 3$ line is distributed around a 0.08 pc region centered at the protostar. It is interesting that both lines have opposite velocity gradient across the protostar. Furthermore the HCO⁺ channel map seems to show expanding motion. These velocity structures can be interpreted as an expanding circumstellar envelope which is entrained outward by the molecular outflow.

The optically thin H¹³CO⁺ $J = 4 - 3$ (346 GHz) line has been also detected successfully at the protostar position. The mass of circumstellar medium is estimated to be $4.8 \times 10^{-2} M_{\odot}$ from the H¹³CO⁺ intensity, which is consistent with the previous result that IRAS 13036 - 7644 is in a relatively late evolutionary stage of Class 0 protostar.

Reference

Lehtinen, K. 1997, *A&A* 317, L5