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An Unbiased Survey for Outflows in the W3 and W5 Star-Formation Regions

Derek E. Bretherton & Toby J.T. Moore

Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead, CH41 1LD, UK

Naomi A. Ridge

FCRAO, Department of Astronomy, University of Massachussetts, Amherst, MA 01003, USA

1. Introduction

During their birth all stars undergo periods of copious mass loss, frequently characterized by the occurrence of bipolar outflows. These outflows are believed to play a fundamental role in the star formation process. However the exact outflow generating method is obscure at present. To elucidate this problem we are investigating whether the flow properties are correlated over the entire protostellar mass spectrum.

Progress in this area requires that we assemble a statistically valid sample of high-mass outflow systems. This is necessary since existing catalogues of such objects are heterogeneous and statistically incomplete.

2. Target Selection and Observations

In order to produce a representative outflow sample a new ^{12}CO survey of the W3 and W5 molecular clouds was initiated at the 14-metre Five College Radio Astronomy Observatory (FCRAO) to look for high velocity gas. W3/5 are intermediate- to high-mass star-forming regions located at a distance of 2 kpc in the Perseus arm.

Survey observations were carried out during April 1999, April 2000, and November 2000. Position-switched ^{12}CO 1–0 emission mapping observations were obtained with beam-width ($44''$ at 115 GHz) sampling, using the SEQUOIA spectral plane array.

3. Preliminary Results

Since the youngest sources may emit insufficiently in the infrared to be detected by IRAS, the whole data-set was examined for high-velocity gas, indicative of molecular outflows, *independent* of IRAS data.

Due to the large volume of data an automated potential outflow detection routine was developed. Potential outflow candidates were identified on the basis of line wings present in their spectra. A Gaussian profile was fitted to each spectrum, and then subtracted to leave a residual. The presence of a line wing manifests itself as excess emission (above the noise level) in the residual after subtraction of the Gaussian. (For a more detailed discussion of the potential outflow detection routine see the forthcoming series of papers by Ridge, Bretherton & Moore and Bretherton, Ridge & Moore).

The outflow detection routine successfully identified all known outflows in W3 and W5 (W3-IRS5, W3 (OH), IC1805-W, AFGL 4029 & AFGL 437). In addition it flagged ∼40 regions which might harbour molecular outflows.

Follow-up Nyquist sampled observations of 24 of these outflow candidates were carried out at FCRAO during Spring 2001. Position-switched ^{13}CO observations were also obtained at the central position in order to derive the ^{12}CO optical depth, and to check for multiple-velocity cloud components, which might confuse the outflow detection algorithm. Seven of the potential outflows were discarded on the basis of the ^{13}CO observations.

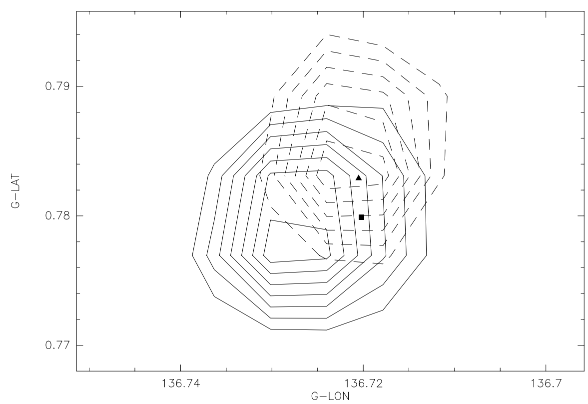

Figure 1: Contour map of the integrated ^{12}CO 1–0 emission from a new outflow source in W5. (This source was confirmed as a *bona fide* outflow by observations at the Nobeyama 45m Radio Telescope). This fully-sampled map was made at the FCRAO during the follow-up observations. Spectra corresponding to this region were flagged by the outflow detection routine during reduction of the preliminary programme data. The solid-line contours show the red-lobe emission integrated between -40.8 and -35.8 kms^{-1}. Dashed contours show the blue-lobe emission integrated between -50.8 and -45.8 kms^{-1}. Base contour is 1.8 K kms^{-1} with contour intervals of 0.5 K kms^{-1}. The triangle indicates the position of an IRAS source, whilst the square indicates the presence of a MSX source.

4. Further Work

The next stage of the programme (currently in progress) is the acquisition of high-resolution maps of those outflow candidates not rejected by the FCRAO follow-up observations. High-resolution maps will confirm whether the targets are *bona-fide* outflows.

Once we have assembled a statistically significant outflow sample we will be able to comment on the applicability of current theories of outflow generating mechanisms. Furthermore the variation of mass and momentum in outflows with source luminosity will be examined, thus enabling stronger constraints to be placed on the actual physics of specific flow models.