3. CARMA observations of IRAS 19312+1950

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3.1. Introduction

IRAS 19312+1950 is an interesting object that has both properties of a young stellar object (a bipolar outflow) and an evolved star (an extended expanding envolope). It has been previously observed at millimeter wavelengths by Nakashima & Deguchi (2004), who have suggested that the interesting molecular emission line profiles and their spatial distributions arise from the complex structure of the star's environment. The aim of our observations was to investigate the connection between the its morphology and the molecular line profiles in order to better understand the structure of this object and its immediate neighbourhood.

3.2. Observations and Data Reduction

We have used CARMA in the E configuration during the nights of July 13 and 14. Our total observing time was 9 hours, with 6.8 hours on target. This was more than enough to obtain very good signal to noise ratio for all the molecular emission lines that we targeted and for a solid detection of the continuum as well. We have configured the correlator bands to have seven 62-MHz bands and one 500-MHz band, which provided velocity resolution of 0.4 km/s and 14.4 km/s respectively. The narrow bands were aimed at detecting ^{12}CO (J=1-0), ^{13}CO (J=1-0), C^{18}O (J=1-0), SO (J$_k$=3$_2$-2$_1$), HCCCN (12-11 and 11-10) and CN (1-0 J=3/2-1/2 F=5/2-3/2) lines, while the wide band was used for calibration and continuum detection. Due to a technical problem, the phase centers of the two tracks were slightly different: 19h33m24.4s, 19°56'54.8" for the first and 19h33m24.0s, 19°56'55.0" for the second one (both given in J2000.0 coordinates). We had to pay special attention to this fact in our data reduction because the MIRIAD software package automatically considers such an observation to be a two-pointing mosaic image. Data reduction was performed with MIRIAD and a general reduction script provided in the School.

3.3. Results, Discussion and Outlook

Our first result is that we have detected all the molecular lines that we aimed for. In the observation time given to this project even the weakest emission line achieved a signal-to-noise ratio in excess of 10. When plotting spectra, we binned two channels per bin, which further reduced S/N and gave us $\sim$0.8 km/s resolution. As expected from earlier observations, all lines were redshifted to the systemic velocity of the star, $\sim$37 km/s. In Figure 1 we show the spectral line profile and the integrated velocity map for the strongest detected line, the ^{12}CO (J=1-0). It is worth noting that the profile we observed is even richer in features than the one observed by Nakashima & Deguchi (2004), for example, in the weak apsorption features probably imprinted by the intervening interstellar medium.

CARMA E-configuration gave us just enought spatial resolution to marginally resolve some of the extended structure. As we detected all 7 molecular lines with high S/N, we were able to resolve their spatial dependence and associate some spatial features to the ones in the spectrum. This was achieved by plotting channel maps, similar to the ones in Figure 2. It can be clearly seen from the figure that the positional origin of the broad CO emission line component is quite different from the spatial distribution of the narrow-line emitting gas. We belive that this is a signature of the broad-line emitting expanding spherical shell and a directed, possibly biploar, outflow component which produces the narrow emission.

Although in this report we do not show the rest of the molecular emission lines and their channel maps, it is important to stress that they also seem to follow the broad/narrow line profile pattern displayed in channel maps for the CO line. Namely, lines ^{13}CO (J=1-0), C^{18}O (J=1-0), HCCCN(12-11) and HCCCN(11-10) appear to be narrow and emerge from a significantly elongated region in the NE-SW direction, while the SO (J_k=3_2-2_1) and CN (1-0 J=3/2-1/2 F=5/2-3/2) lines have broad components that emerge from the central region consistent with a point source, given the size of the E-array synthesized beam.

At last, in Figure 3 we plot two instances of what appear to be regions Doppler-shifted with respect to each other, for the ^{13}CO and the C^{18}O lines (more accurately, their shifted narrow components). In both cases the spatially-dependent Doppler shift hints at interesting properties of the moving gas around IRAS 19312+1950, but the details of its structure are just beyond the reach of the CARMA E-configuration. Therefore, in our future research of this object we will propose to image it at a higher resolution in order to be able to explore it in greater detail.

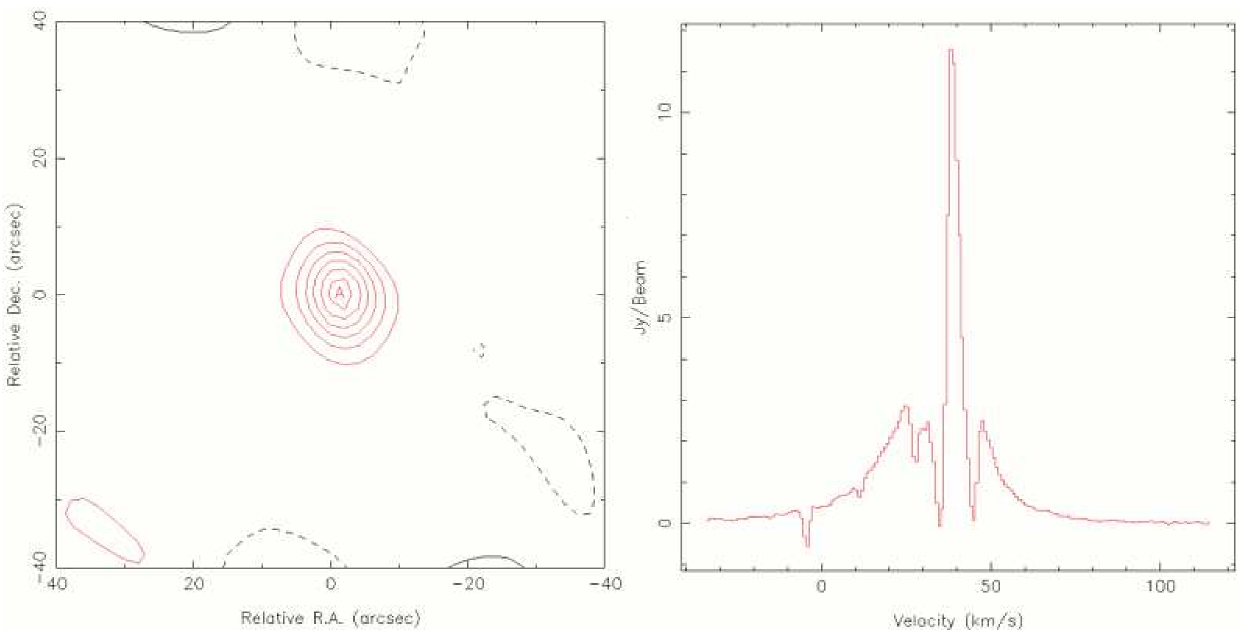

Fig. 1.— In the left panel of this image we display a high signal-to-noise integrated velocity map for the ^{12}CO line observed at the position of IRAS 19312+1950. The spectrum at the peak of the CO image is plotted in the right panel. Note the narrow and the broad components of the emission and the minor absorption features blueward of the emission peak.

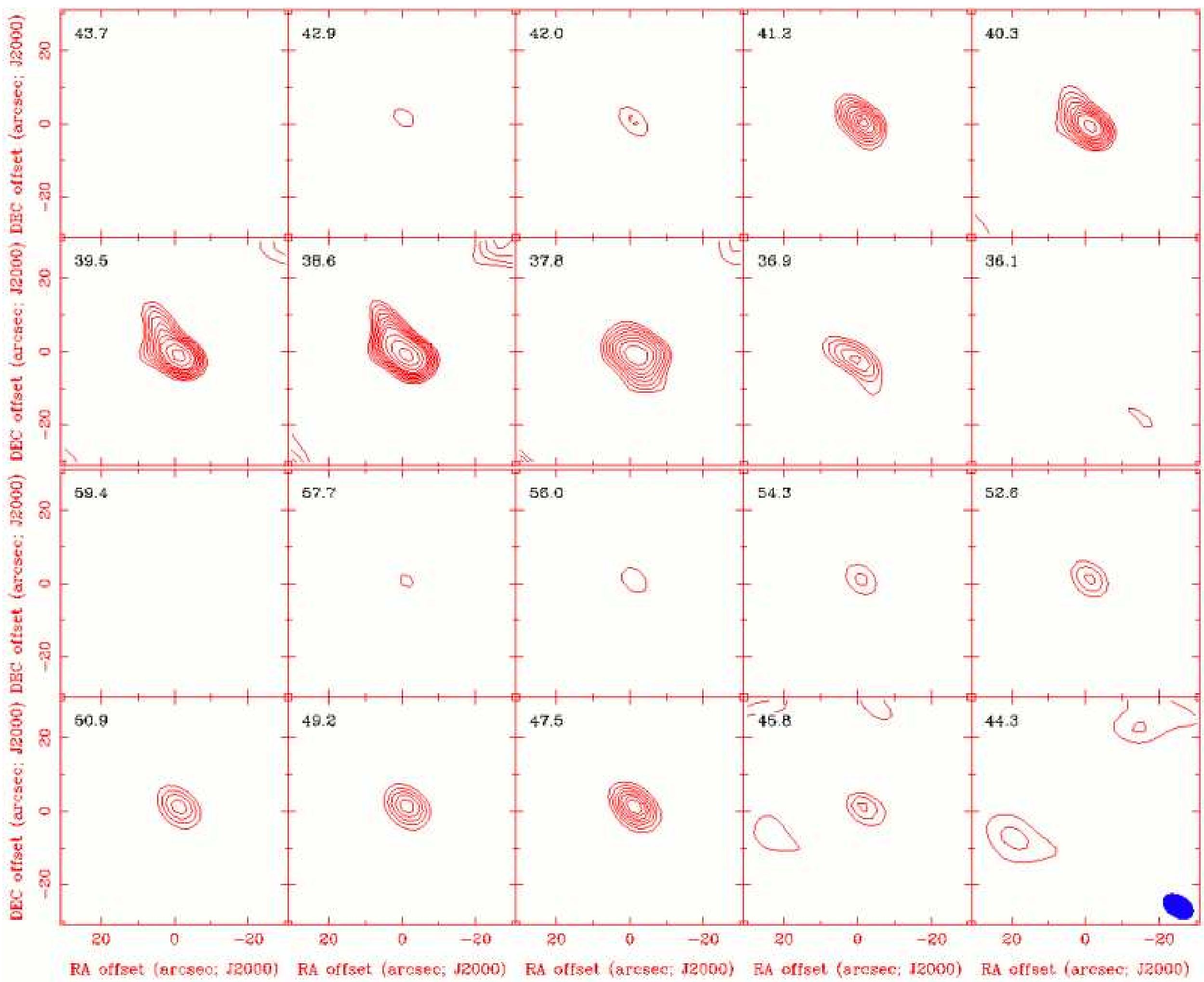

Fig. 2.— This figure shows channel maps for the CO line. The upper half (upper 8 frames) are channels where narrow emission line dominates, while the lower half are channels in which only broad emission is present. The numbers in the upper left of each frame display the mean velocity of the channel (refer to Fig. 1 for the line profile). The blue ellipse in the lower right matches the synthesized beam of the CARMA E-array. Note that the broad emission is consistent with a point source, while the narrow emission appears to be extended.

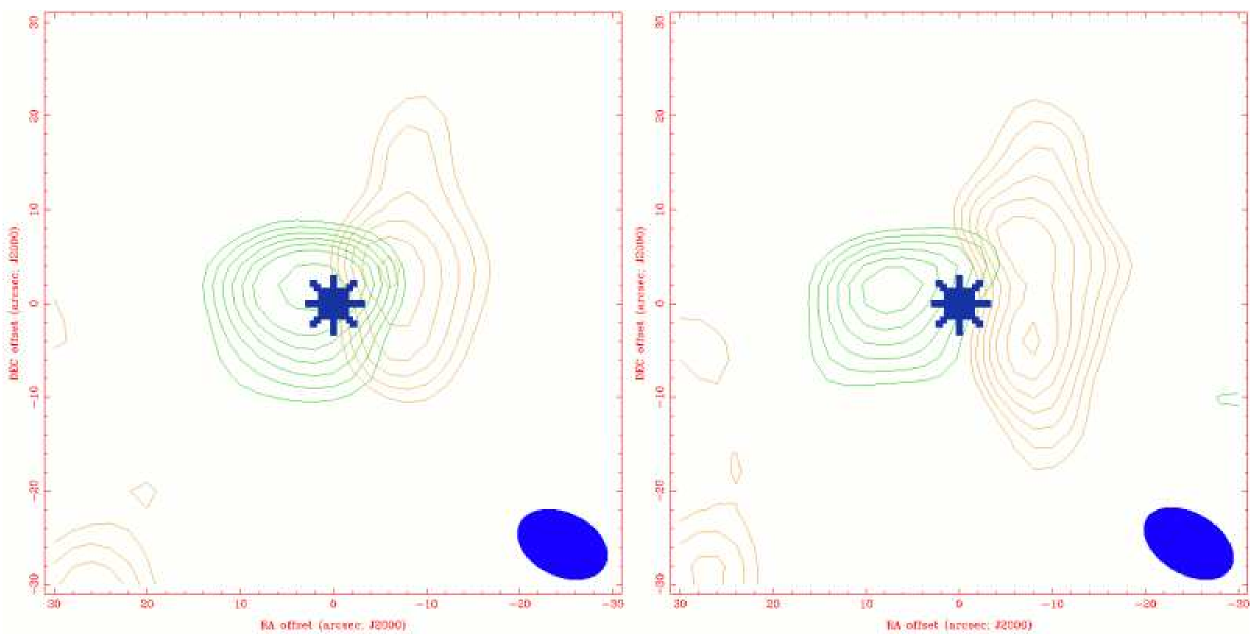

Fig. 3.— Both panels of this figure show velocity-separated emission seen in the ^{13}CO (left panel) and C^{18}O (right panel) lines. The orange contours correspond to emission integrated over the blue half of the lines, while the green contours mark the red half. The blue star marks the position of IRAS 19312+1950 and the ellipse shows the synthesized beam. Although there is a hint of a bipolar outflow from these plots, the spatial resolution of the observations is too low for investigation in greater detail.