A new molecular outflow in the Vulpecula Rift

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Context

We present the initial results of follow-up observations towards a molecular outflow identified in Exeter-FCRAO ^{12}CO (J=1-0) data[1]. The outflow is associated with strong sub-mm emission in BLAST and MIPSGAL observations, which Chapin *et al.*[2] used to derive a core mass of 390$M_{\odot}$. As can be seen in Figure 1, Hi-GAL[3] images show this emission to be spatially distinct from the Red MSX Source Survey[4] object G059.6403-00.1812 to the NW which dominates at mid-IR wavelengths and has a luminosity of ~$2\times10^3 L_{\odot}$[5] at a distance of 2.16kpc[6]. The outflow is probably part of the same complex, so we use this distance.

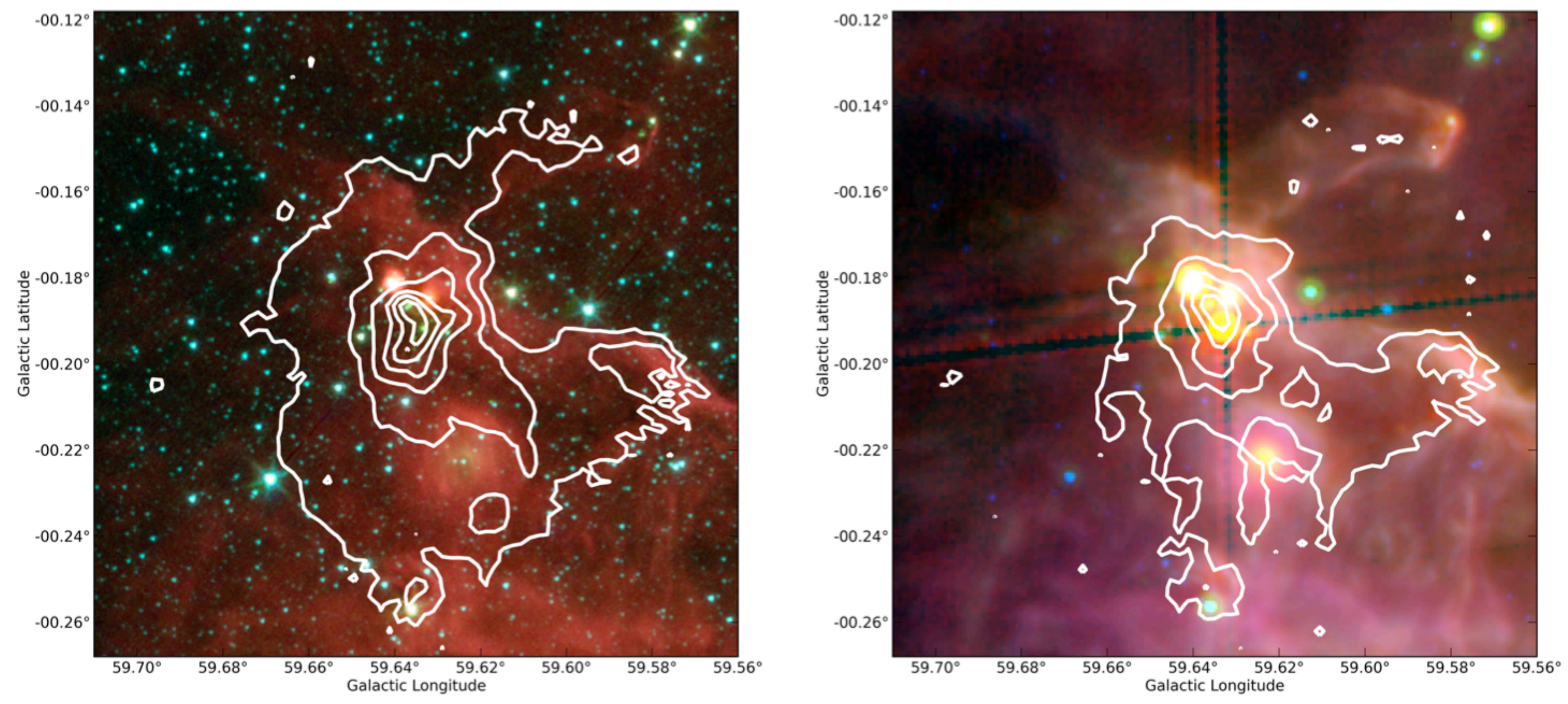

Figure 1: 3.6, 4.5 and 8.0 μm GLIMPSE (left) and 8.0μm GLIMPSE, 24μm MIPSGAL and 70μm Hi-GAL[3] (right) 3-colour images. The white contours are integrated ^{12}CO (left) and ^{13}CO (right) (J=3-2) observations.

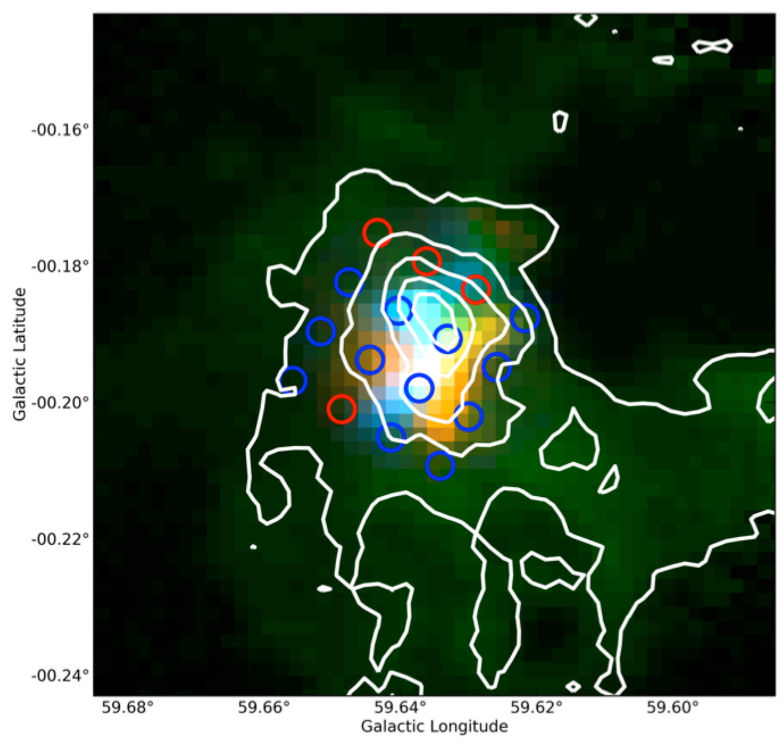

Figure 2: RGB image of integrated ^{12}CO (J=3-2) intensity where the red and blue outflow wings were identified by masking the peak ±2σ of gaussian fits to the ^{13}CO spectrum for each pixel. The white contour shows the integrated ^{13}CO. The blue and red circles show the locations of the active and dead detectors respectively for the stare observations.

Observations

Mapping observations were undertaken in ^{12}CO, ^{13}CO and $C^{18}O$ (J=3-2) were undertaken with HARP-B and the ACSIS autocorrelator at the JCMT of a 4' by 4' field centred on l=059.6331°, b=-00.1906°. In addition, single pointing stare observations were undertaken in HCO^+, $H^{13}CO^+$ (J=4-3) and SiO (J=8-7). The locations of the 16 detectors are show with red and blue circles in Figure 2.

Component	M ($M_{\odot}$)		dv_{max} (km s^{-1})		P ($M_{\odot}$ km s^{-1})		E (10^{45} ergs)	
	r	b	r	b	r	b	r	b
1	36.9	10.7	43.9	43.9	172.4	47.6	10.00	2.52
2	16.9	7.2	40.6	58.0	69.2	34.6	3.40	2.37
3	7.2	14.5	39.9	58.0	35.9	75.1	2.27	7.12
4	4.8	15.9	42.2	52.3	25.2	85.2	1.55	5.87

Table 1: Measured properties of the four observed outflow components shown in Figure 3 from the ^{12}CO (J=3-2) observations corrected for optical depth using the ^{13}CO data. The ^{12}CO/^{13}CO ratio was calculated as a function of velocity for each spectrum using the method of Bally *et al.*[7]

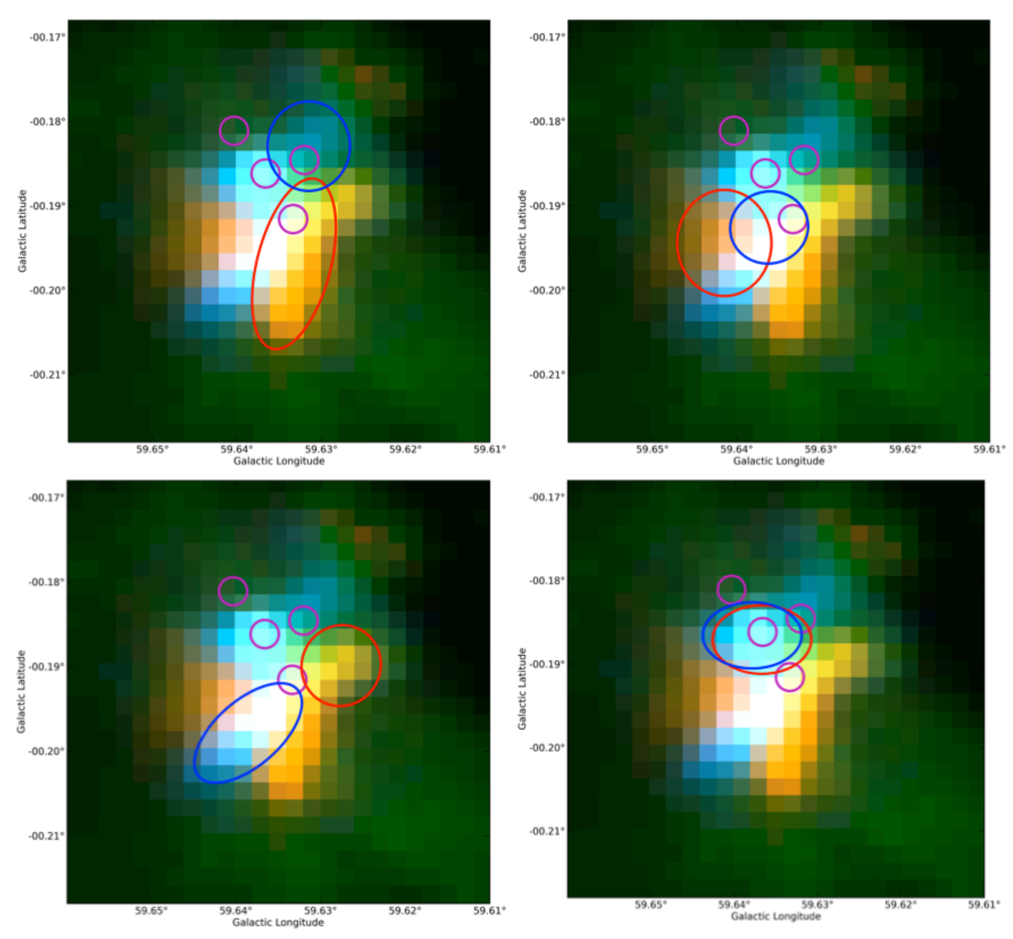

Figure 3: Zoomed versions of Figure 2 indicating (from left to right and top to bottom) the four observed outflow components found in our follow-up JCMT observations. The red and blue ellipses indicate the regions used for the measurements presented in Table 1. The magenta circles indicate the locations of the mid/far-IR bright sources visible in the region in Figure 1

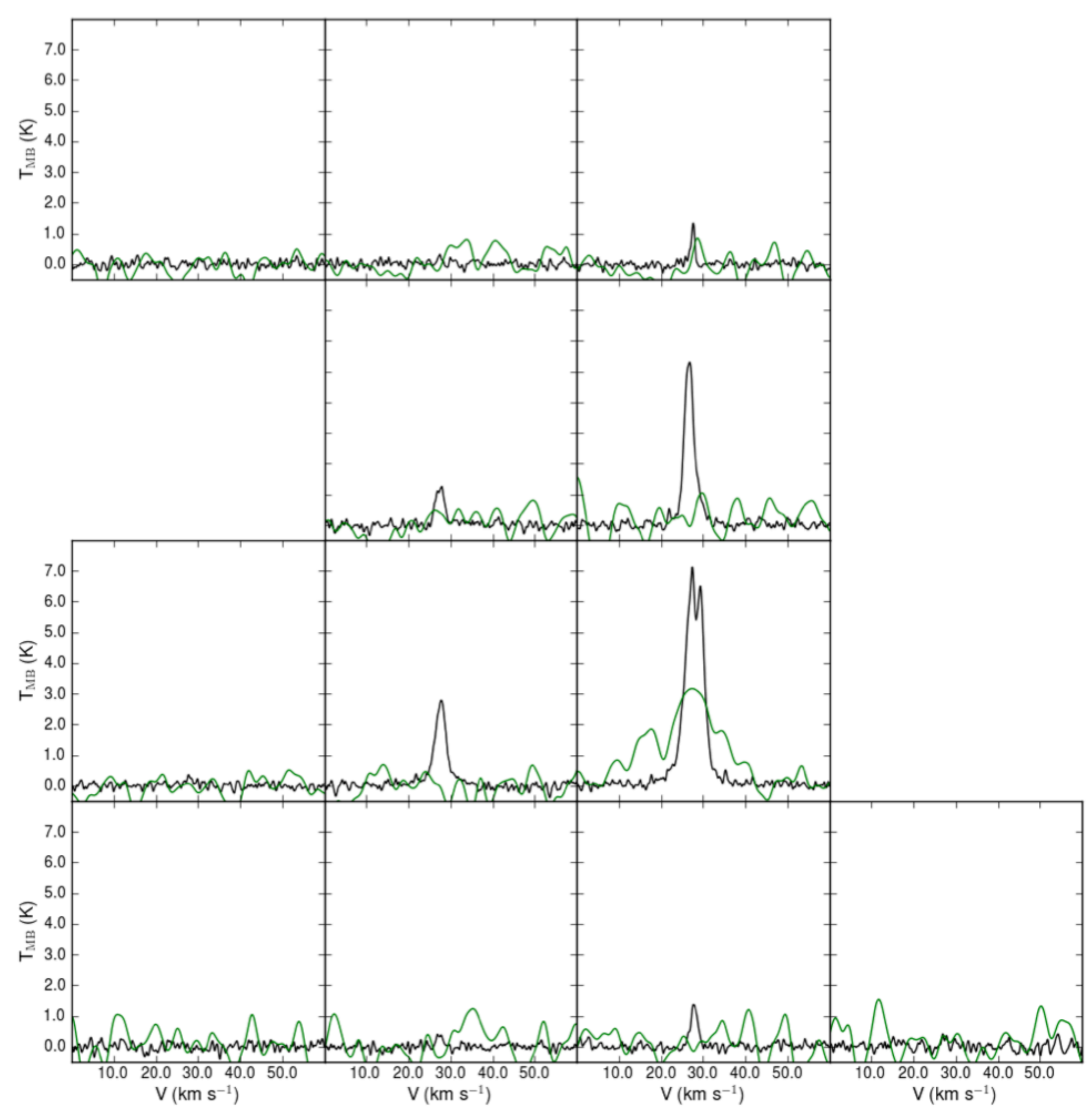

Figure 4: HCO^+ (black) and SiO (green) star spectra at the locations shown in Figure 2. The SiO has been multiplied by 15 in order to show both sets of spectra on the same scale. The detection of SiO indicates that at least one of the outflows is active rather than fossil. The HCO^+ emission traces the dense cores within the cloud.

Summary

Several of the young sources in the region around G059.6331-00.1906 are powering molecular outflows, injecting a significant amount of energy into the surrounding cloud. Given the variation in SEDs suggested by the mid and far-IR data, this region is ideal for high-resolution studies into the relationship between outflow activity and evolution of the central object.

References

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[7] Bally *et al.*, 1999, AJ, 117, 410.

Acknowledgements

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