Probing supernova remnant VRO 42.05.01's progenitor properties with IRAM 30m observations

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Following the results of Arias et al. (2019b), we observed mixed-morphology (MM) SNR VRO 42.05.01 with the IRAM 30m telescope in three carbon monoxide (CO) transitions. We found direct evidence of interaction of the SNR with its molecular environment, in the form of broadened ^{12}CO line profiles, high ^{12}CO (J = 2–1) to ^{12}CO (J = 1–0) line ratios, and arc features in position-velocity space. In particular, regions A, B, and K highlighted below show inverted high-to-low excitation level ratios due to the SNR shock encountering and shock-heating the molecular cloud (Seta et al, 1998). In this way, VRO 42.05.01 joins the long list of MM SNRs interacting with their dense environments (Jiang et al., 2010).

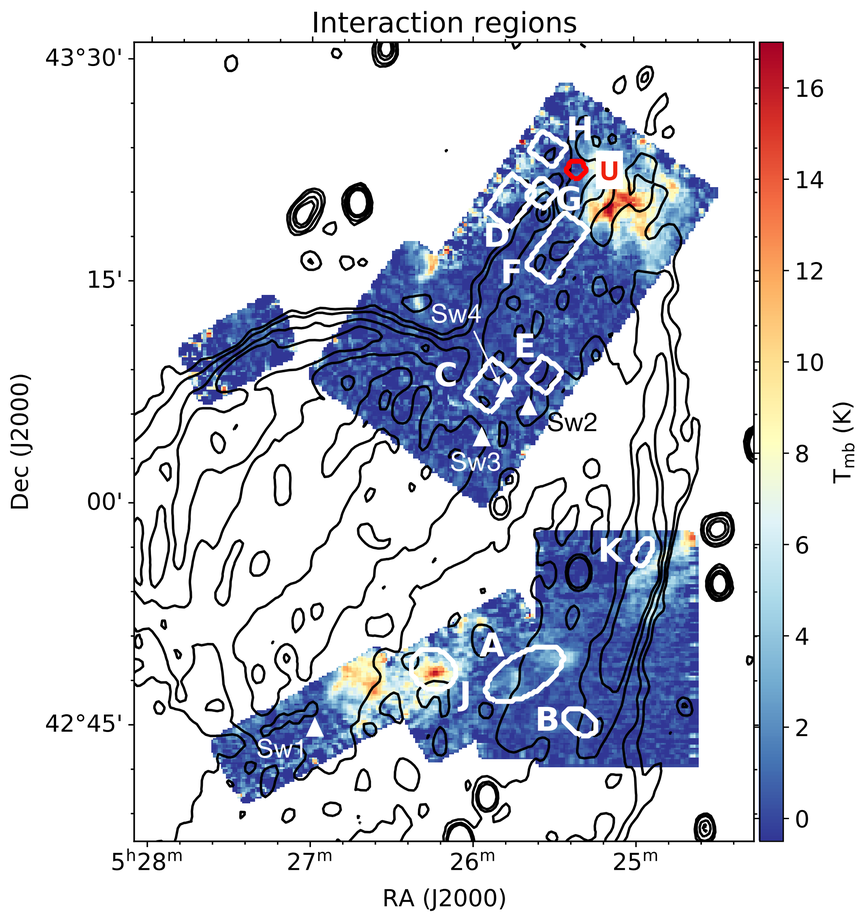

Figure 1: Regions of the disturbed molecular material around VRO 42.05.01. The regions are overlaid on the footprint of the IRAM observations, and the contours are at 1420 MHz.

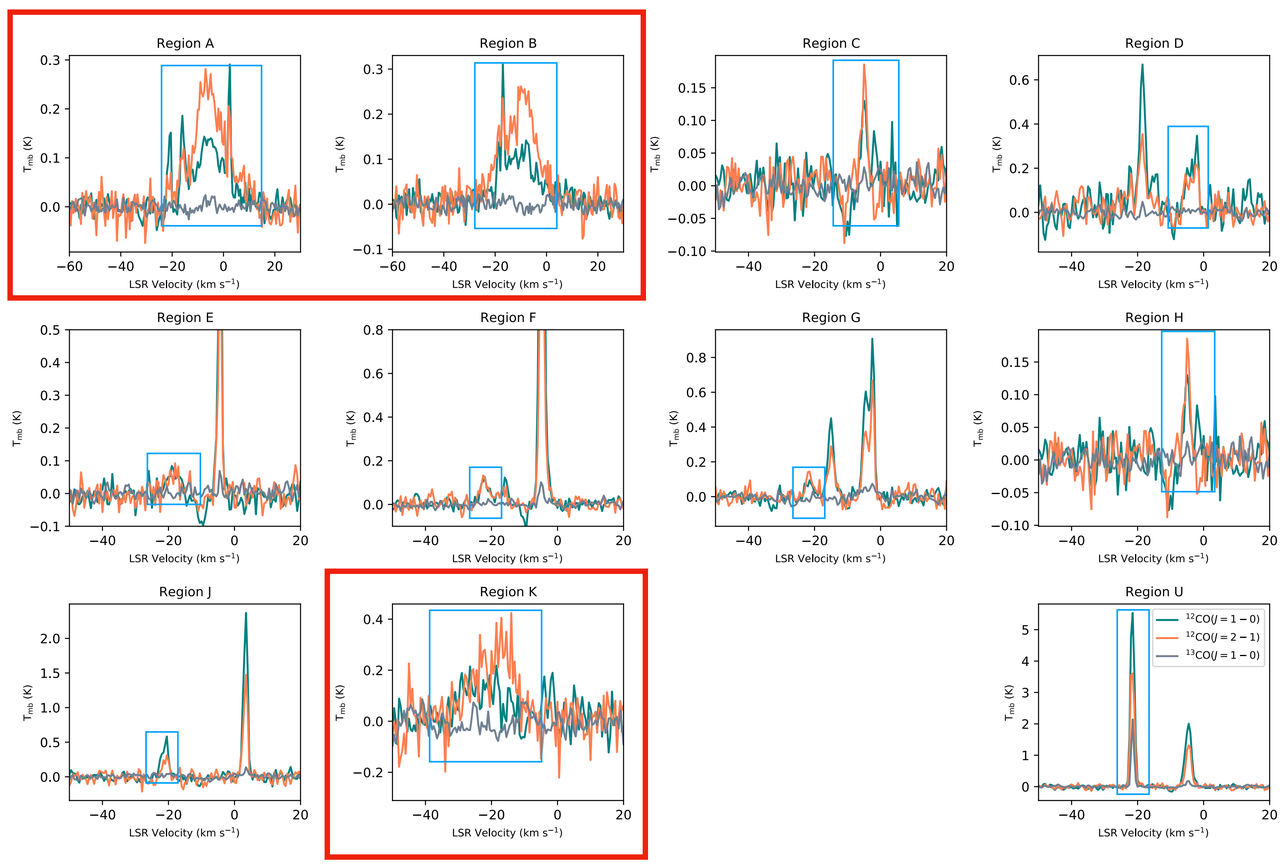

Figure 2: Integrated spectra for each of the regions shown in Figure 1. Region U is shown here for comparison, as an example of undisturbed emission.

In addition to the broadened line profiles, we found several regions that show sweeps in position-velocity space. Excepting the sweep coincident with region A, whatever is pushing the gas and causing Sweeps 1—4 is not affecting its velocity dispersion. We propose that the molecular gas is not swept up by the SNR shock, but rather by a stellar wind of the progenitor star. We further propose that a stellar wind could be responsible for the line profiles of regions C to J, which show weaker evidence for compressing and heating than regions A, B, and K. If true, the regions associated with a stellar wind (in cyan in Figure 4) are consistent with an equatorially enhanced wind, as proposed by Chiotellis et al. (2019).

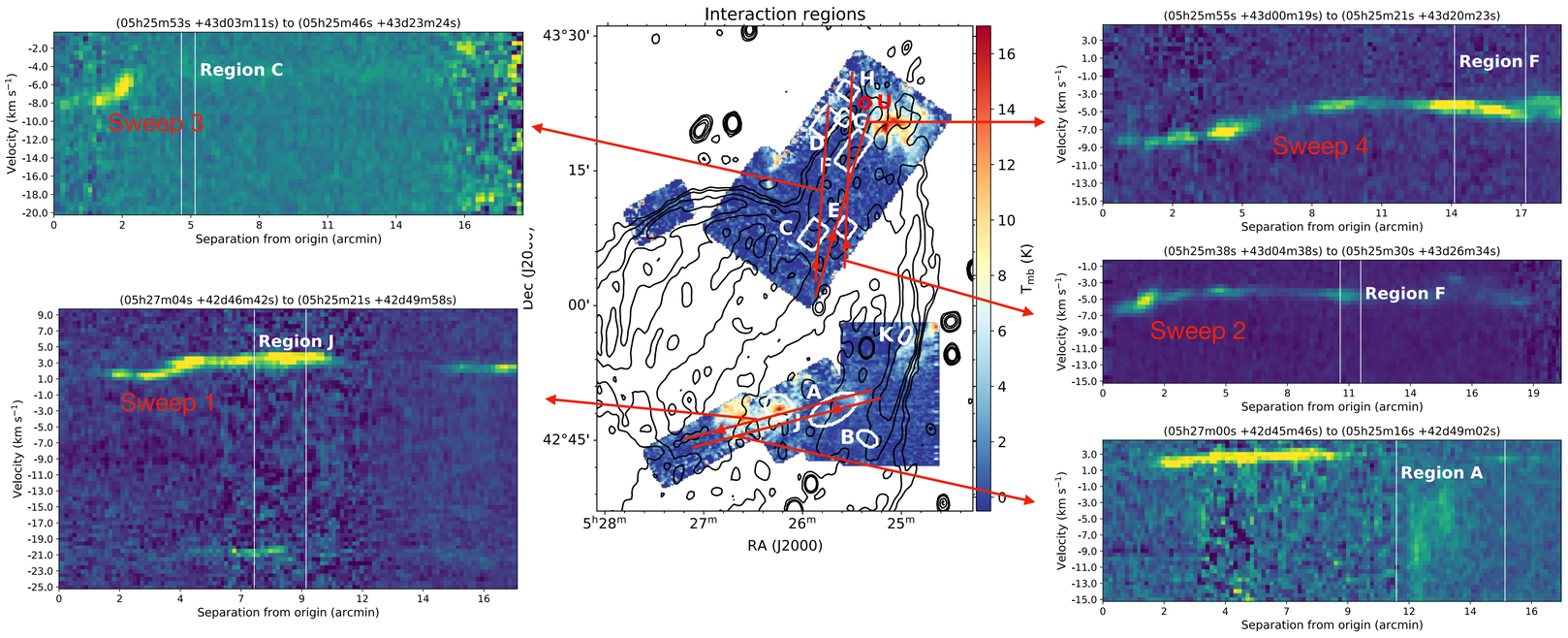

Figure 3: Position–velocity diagrams for three cuts along the VRO 42.05.01 ^{12}CO (J = 1–0) data cube. Each of the cuts is shown as a red line over the integrated molecular emission map, and the locations of the sweeps, where the bright molecular emission smoothly changes velocity channels, are shown as red triangles both in the map and in the position-velocity diagrams

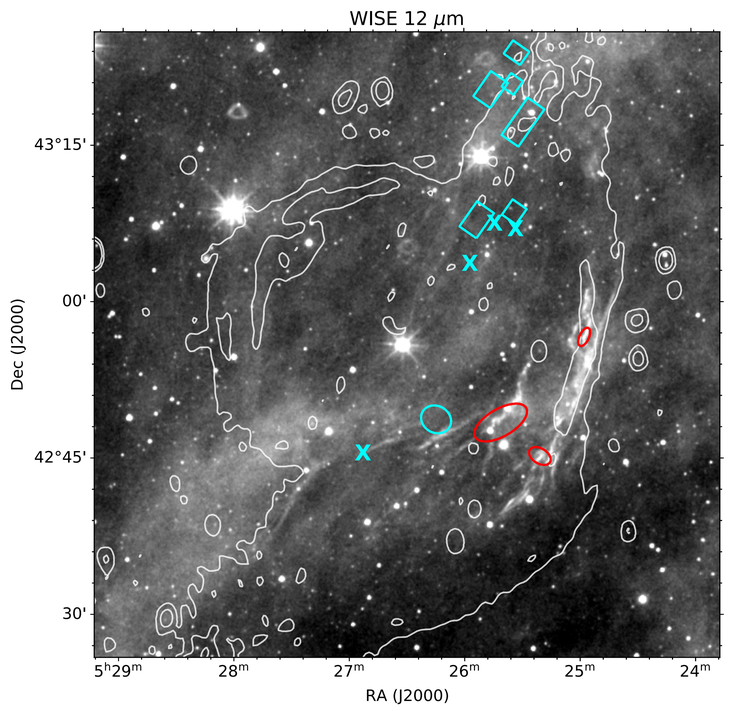

Figure 4: Infrared emission from VRO 42.05.01 at 12 μm, with the regions of interaction overlaid. The sweeps in position-velocity space are indicated with an ×. The features in red are those we believe are due to the SNR shock, and (some or all of) those in cyan could be due to a pre-SN stellar wind.

References

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