THE DISTRIBUTION OF GAS AND DUST AROUND THE PROTOSTELLAR BINARY IRAS 16293–2422

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The deeply embedded, low-mass, proto-binary star IRAS 16293–2422 has attained considerable interest over the last decade, in particular, driven by the detection of millimetre line emission from a large number of complex organic molecules and the possibility of this source harbouring a 'hot core', similar to those found in regions of high-mass star formation (e.g. van Dishoeck et al. 1995; Ceccarelli et al. 2000; Schöier et al. 2002; Cazaux et al. 2003).

High angular resolution observations of the central core region of IRAS 16293–2422 have been carried out for a number of molecules using the BIMA and OVRO millimetre arrays (Schöier et al. 2005, in prep.; see Figure 1 for examples). Most molecules show a separation of red (4–7 km s^{-1}) and blue (0–4 km s^{-1}) emission peaks roughly perpendicular to the large-scale outflow, thought to be driven by one of the protostars (MM1), indicative of rotation in the envelope. Some species, e.g. HNC and N_2H^+, also seem to trace the interaction of the outflow with the circumstellar material. The observed chemical differentiation of $C^{18}O$, HNC, and N_2H^+ is consistent with the recent chemical model of IRAS 16293–2422 by Doty et al. (2004). Moreover, SiO and CH_3OH appear to be partly associated with outflow activity where the ices are liberated by grain-grain collisions.

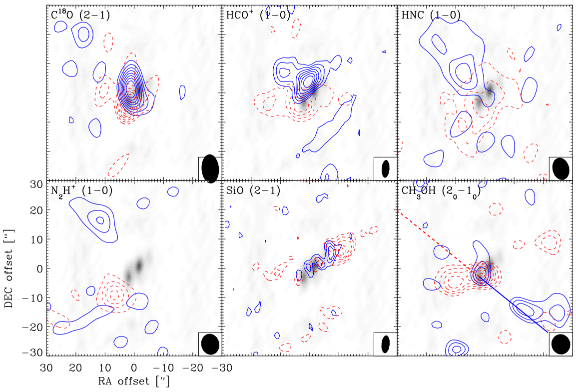

Figure 1: Maps of the integrated emission detected towards IRAS 16293–2422 for a selection of molecules, overlayed on the continuum emission (greyscale). The emission has been separated into a blue (1–4 km s^{-1}; solid contours) and red (4–7 km s^{-1}; dashed contours) part. The direction of the large scale CO outflow is indicated in the CH_3OH panel. The beamsizes are shown in the lower right in each panel.

We also report the detection of mid-infrared (23–35 μm) emission from IRAS 16293–2422 by the Spitzer Space Telescope infrared spectrograph, IRS (Jørgensen et al. 2005). The detection of mid-infrared emission suggests that the envelope is optically thin at these wavelengths. A detailed, spherically symmetric, radiative transfer model reproducing the full SED from 23 μm to 1.3 mm requires a large, approximately 1000 AU, inner cavity of the envelope in order to avoid quenching the emission from the central source (Figure 2). This corroborates a previous suggestion based on high angular resolution millimetre interferometric data (Schöier et al. 2004). An alternative interpretation with a 2D model of the envelope with an outflow cavity can also reproduce the SED but is not consistent with the interferometer data. With a large cavity the central source never heats the envelope to temperatures above 60–80 K, why a hot core chemistry in the inner envelope appears unlikely within the context of spherically symmetric modelling. An alternative explanation for complex organic molecules probing high temperatures around IRAS 16293–2422 is that these reside in the circumstellar disks surrounding each binary component.

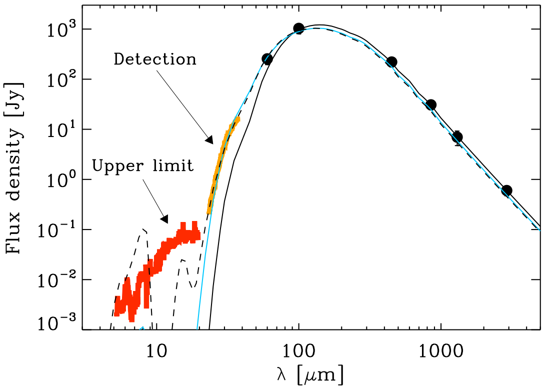

Figure 2: Spitzer/IRS observations of IRAS 16293–2422 and models for its SED. The black solid line is the best fit model by Schöier et al. (2002), the grey solid line is the Schöier et al. model with a 600 AU (radius) cavity, and the dashed line is the cavity model with a central 500 K black body.

References: [1] Cazaux S., Tielens A.G.G.M., Ceccarelli C., Castets A., Wakelam V., Caux E., Parise B., Teyssier D., 2003, ApJ, L51. [2] Ceccarelli C., Loinard L., Castets A., Tielens A.G.G.M., Caux E., 2000 A&A 357, L9. [3] Doty S.D., Schöier F.L., van Dishoeck E.F., 2004, A&A 418, 1021. Jørgensen J.K., Lahuis F., Schöier F.L., & the c2d/IRS team, 2005 ApJL, accepted. [4] Schöier, F. L., Jørgensen J.K., van Dishoeck E.F., Blake G.A., 2002, A&A 390, 1001. [5] Schöier, F. L., Jørgensen J.K., van Dishoeck E.F., Blake G.A., 2004, A&A 418, 185. [6] van Dishoeck E.F., Blake G.A., Jansen D.J., Groesbeck T.D., 1995, ApJ 447, 760.