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SPATIAL DISTRIBUTION OF H_2 FLUORESCENCE IN THE INNER $2'' \times 2''$ AROUND T TAU

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New subarcsecond observations of T Tau with STIS show spatially resolved structures around the star. The structures show multi-line emission of fluorescent H_2 pumped by Lyman α. One structure follows the cavity walls of the envelope observed in scattered light in the optical, which is probably the clearest evidence of a wide-angle outflow opening cavities into the molecular medium.

Using new STIS observations of T Tau, we detected extended emission around T Tau N. From the spectrum of the emission, and previous studies in the region (Valenti, Johns-Krull, & Linsky 2000), we identify it with H_2 fluorescence pumped by Lyman α, especially lines originating in the de-excitation of the level $(v', J' = 1, 4)$ populated by the 1–2 $P(5)$ transition. To identify the lines it was necessary to assume a wavelength shift, which, if interpreted as due to motions, were much bigger than reported values (Böhm & Solf 1994). Therefore, we interpreted the wavelength shifts as due to spatial shifts of the emitting region, given the large aperture slit used ($2''$).

We were able to identify two distinct regions, one surrounding the star, and the other separated from it (Figure 1). The first one (N) is fairly consistent, both in location and relative brightness, with the scattered light nebula in the optical reported by Stapelfeldt et al. (1998). The second (S) shows a double arc morphology similar to the system of H_2 2.12 μm and forbidden line emission outflows (Herbst, Robberto, & Beckwith 1997). The spectra from both structures are consistent with that of a low-excitation HH object.

Following Jordan et al. (1978), assuming optically thin emission and stellar Lyα irradiation (for the structure closer to the star), we find an upper limit for the latter of $L_{\mathrm{Ly}\alpha} \leq 0.4\, L_{\odot}$, so it can be accounted for by accretion energy ($1.7\, L_{\odot}$; Gullbring et al. 2000). Assuming local Lyα emission for the other structure yields a limit $L_{\mathrm{Ly}\alpha} \leq 0.02\, L_{\odot}$.

Using the estimated density in the level $(v'', J'' = 2, 5)$, combined with previous observations in the region (Kasper et al. 2002), which impose a limit to the 2.12 μm H_2 flux, and thus to the population of the level $(v'', J'' = 1, 3)$, and assuming statistical equilibrium, we estimated $T \geq 800$ K. Predicted values of T in the envelope at the position of the emission are ≈ 100 K (Calvet et al. 1994). Impact of outflows on the molecular medium can naturally explain the exciting temperatures, spectral features and morphology of the H_2 emission. The observed H_2 fluorescent emission at the cavity walls may be the clearest (although indirect) evidence of wide-angle outflows driving cavities in the molecular medium.

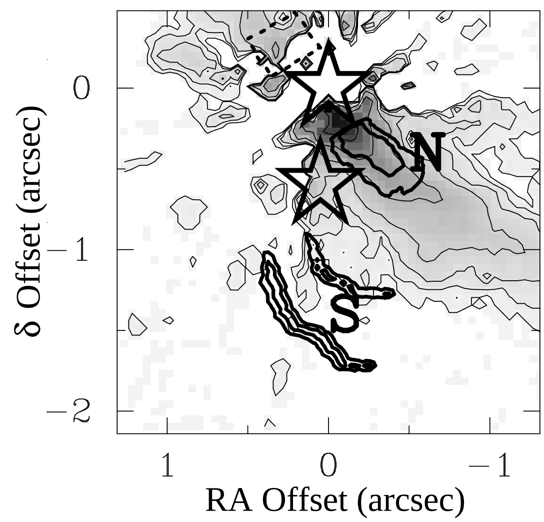

Fig. 1. Spatial distribution of H_2 (thick lines) compared to the optical emission from Stapelfeldt et al. (1998; grayscale/thin lines). T Tau N and S are indicated by stars.

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