ON THE ORIGIN OF H_2 IN T TAU STARS

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Narrow-band spectrophotometric observations (Cohen, 1975) showed that the extremely young star HL Tau has an absorption feature at 3.1 μm well matched by extinction from pure ice solid grains (radius $a \approx 0.3 \mu m$, $m_{ice} \approx 10^{-4}$ gr cm^{-2}). This feature, not present in others (more evolved) T Tau stars, suggests that ice may be only found around the very youngest T Tau stars and progressively disappears as stars become increasingly visible through their circumstellar shells (Cohen, 1975).

Here we suggest that the mechanism responsable for ice grains destruction in these stars is erosion by energetic protons ($\approx$1 MeV) copiously produced by stellar flare activity. During erosion the production of a large quantity of H_2 molecules occurs. The proposed mechanism is based on the huge experimentally measured erosion yields of frozen gas bombarded by energetic particles (Brown et al. 1978, Pirronello et al. 1981 and references therein) and on the molecular character (mainly H_2, O_2 and H_2O) of the products eroded from frozen H_2O and observed by mass spectrometry (Ciavola et al. 1982, Brown et al. 1982, Pirronello et al. 1983).

Worden et al. (1981) on the basis of Johnson U band observations derived $L_{Tau\ Flares}/L_{T\ Tau}$ and assumed a similar flare spectrum to UV Ceti flares. They also assumed that the L_{proton}/L_{Flare} ratios for the Sun and T Tau star were the same and found a flux of protons J ($\gtrsim$ 10 MeV)$\approx 10^8$ cm^{-2} sec^{-1} at 1 AU. Assuming a law of type $dJ/dE \sim E^{-\gamma}$ with mean $\gamma = 3$ we find J ($\gtrsim$ 1 MeV)$\approx 10^{10}$ cm^{-2} sec^{-1} at 1 AU. The lifetime against erosion by protons of a typical grain ranges then from $t_g \approx 2 \times 10^4$ yr at a distance from the star $R \approx 2 \times 10^{15}$ cm, to $t_g \approx 3 \times 10^6$ yr, at $R \approx 2 \times 10^{16}$ cm that according to Scwartz (1974) is the radius of the T Tau nebula. Thus lifetime always result shorter than 3×10^6 yr, the typical age of a T Tau star. For $T_g \lesssim 100$ K ($R \gtrsim 4 \times 10^{15}$ cm) these lifetimes are orders of magnitude lower than those expected against sublimation that

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can not explain the observed lack of ice grains in evolved T Tauri stars.

A consequence of ice erosion is the restore of molecules in the gas phase. In particular as experimentally shown (Ciavola et al. 1982, Brown et al.1982), the H_2 production increases with the temperature (i.e.decreases with the distance from the star) of the ice. Thus we find an integral H_2 production ranging between $n(H_2)\simeq 10$ ($T_g \lesssim 100$ K) and $n(H_2)\approx 100$ ($T_g \gtrsim 100$ K). This should be only a marginal contribution to the total in the region where $T_g \lesssim T_{cr}$ (100 K or 40 or 30 or?) is the maximum temperature for which H-H recombination on grains effectively works to produce H_2 molecules (Hollenbach and Mc Kee 1979, Lequeux 1981). In the regions with $T_g > T_{cr}$ (if grains do not sublime too quickly) the present mechanism should be the only one that produces a noticeable amount of H_2.

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