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LINE FORMATION IN STOCHASTIC WINDS OF T TAURI STARS

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ABSTRACT

We discuss in this poster the problem of the formation of Hα lines in the stochastic winds of T Tauri stars.

INTRODUCTION

The Hα profiles in T Tauri stars show a remarkable variety of line shapes. Nevertheless, it is possible to identify some typical features, which characterize them:

i) Hα has a double-peak shape, with a broad, symmetric emission and a narrow, slightly blue-shifted absorption component.

ii) The red emission peak occurs very near zero velocity, and it is in general two to five times stronger than the blue peak.

iii) Often the transition from the absorption to the red peak is very sharp.

Models which assume that the wind is continuous and spherically symmetric cannot reproduce these features. Recent attempts to reproduce the Hα profiles in conical winds (Calvet, Hartmann and Hewett 1991), as well as in accreting columns of gas (Calvet and Hartmann 1992) do account for some aspects of the line profiles only.

A new approach was suggested by Grinin and Mitskevich 1991, who assumed that T Tauri stellar winds are not continuous, but rather consist of clumps of gas (*stochastic winds*). We present here a new discussion of the formation of Hα profiles in stochastic winds.

WIND MODEL

We assume in our models that the wind is made of clumps moving in an empty space. The clump velocity increases to a maximum value of ~250 km s^{-1} near the stellar surface and then decreases to a terminal velocity v_∞. The wind is on average stationary, i.e., the mass loss rate at each radius is constant. The clump properties (velocity, line source function, optical depth, etc.) are only function of the distance from the star. Each clump keeps its individuality while

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moving outward. At each distance r from the star, the clumpy structure of the wind is characterized by the typical clump size l and the filling factor q.

The radiation transfer is solved following the approach developed by Lindsey and Jefferies 1990 for inhomogeneous, static stellar atmospheres, applied here to moving media.

Two classes of models have been computed, and the results are shown in Figure 1. In the first (*Case A* models) the filling factor is constant with r; in the second (*Case B* models), the clumps expand at sound speed and merge in the wind periphery. In this case, the filling factor is a function of r.

In all cases, we describe the line source function and opacity by simple parametric laws, which, nevertheless, agree well with the results of non-LTE calculations.

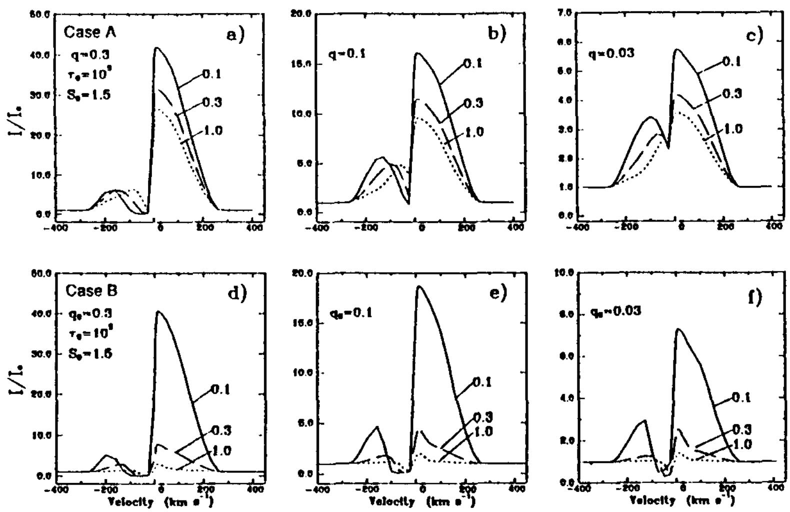

Fig. 1. Computed profiles for lines of high optical depth ($\tau_0 = 10^3$). Panels a, b and c are for *Case A* models, Panels d, e and f for *Case B* models. Each curve is labelled with the value of l_0 in units of the stellar radius.

RESULTS

The results indicate that most of the features characterizing the observed Hα profiles are indeed well accounted for by the models of stochastic, decelerating winds.

More specifically:

i) For a large range of the parameters q_0 and l_0, the computed lines have double peaked profiles, with an intensity of the blue peak two to five times smaller than that of the red peak.

ii) The position of the maximum of the red peak is very near zero velocity. The absorption peak is slightly blue-shifted; the width of the absorption depends on the model parameters, but is always much smaller than the width of the emission.

iii) The transition between the absorption and the red emission peak is very sharp. This is a typical feature of decelerating winds and is very difficult to obtain in any other type of models. The position of the transition depends mainly on the terminal wind velocity v_∞. Finite values of v_∞ may account for the fact that, in some stars, the transition from absorption to emission appears somewhat blue-shifted.

Few results have been obtained for lines of intermediate optical depth ($\tau_0=10$) and are shown in Figure 2. In this case, the line profiles are symmetric, without any absorption feature. These results seem to provide an interesting solution to the puzzling properties of the Ca II infrared triplet lines at ~8600 Å. In many T Tauri stars, these three lines have broad and very symmetric, nearly gaussian, emission profiles, with no absorption (Grinin and Mitskevich 1991; Hamann and Persson 1992). At the same time, the fact that the three lines have comparable intensity requires them to be optically thick. Unless high turbulent velocity gas exists near the star, clumpy winds seem the only way to produce pure emission profiles in optically thick lines (cfr. Figure 2b).

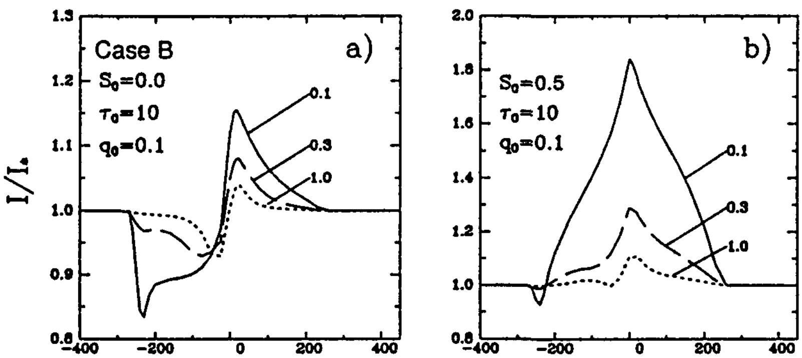

Fig. 2. Computed profiles for lines of intermediate optical depth. All curves refer to *Case B* models. The curves are labelled by the values of l_0 in units of the stellar radius.

From the results presented here, we think that stochastic winds can explain the main features of the various different line profiles observed in T Tauri stars. A detailed discussion of the method and the results will be published elsewhere.

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