SOBOLEV TYPE LINE PROFILE IN CASE OF NON RADIAL WIND DENSITY PERTURBATIONS

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ABSTRACT. We have investigated the modifications induced on the P Cygni line profiles of an outwards accelerating wind by density fluctuations modulated by non radial pulsations. The results obtained in a first approach of the problem compare favourably with some observed time dependent profiles of ultraviolet lines.

1. INTRODUCTION

In a recent paper (Vreux, 1985), one of us has suggested that the variability observed in some Wolf-Rayet stars might be due to non radial pulsations. In this context, we have decided to investigate the signature on line profiles of perturbations of the wind density modulated by non radial pulsations. We have tackled this problem in the frame of a linear theory.

2. COMPUTATION OF THE PERTURBED PROFILE

We start with a classical Sobolev type profile produced by a spherically symmetric wind accelerating outwards. We have chosen, as our stationary model, a model described by Castor and Lamers (1979) with parameters corresponding to the case $\mathcal{T}$ = 1 of their figure 8B. As a working hypothesis we assume that the stellar oscillation affects the wind only through a modulation of the density at the base of the wind and has no effect on the velocity law. The density perturbation at the base of the wind is assumed to be given by the theory of non radial pulsations of stars, i.e.

$$\delta\rho/\rho = \varepsilon \sqrt{4\pi}\, Y_{\ell m} (\theta,\phi)\, e^{-i\sigma t}$$

where ε is a small parameter, $Y_{\ell m}(\theta,\phi)$ a spherical harmonics and σ the angular frequency of the pulsation. This perturbation of density moves through the envelope at the velocity of the wind. This affects the resulting line profile through the perturbation of the optical depth.

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One obtains the perturbation of the flux, relative to the continuum in the following form

$$\delta F(\lambda)/F_c = A(F_1(\lambda)\cos\sigma t + F_2(\lambda)\sin\sigma t)$$

where A depends on ℓ, m and θ_0, the angle between the axis of rotation of the star and the line of sight. F_1 and F_2 depends on λ, σ and ℓ only. The details of the computations and the exact form of A, F_1 and F_2 are given elsewhere (Scuflaire, Vreux, 1986).

3. RESULTS AND DISCUSSION

It is convenient to introduce the dimensionless parameter $\omega = R\,\sigma/v_\infty$ which measures the frequency of the stellar pulsation in a natural unit associated with the wind. Figures 1 and 2 give perturbed line profiles at different phases Φ of the pulsation for $\ell = 2$ and $\omega = 0.5$ and 2.

As presently our computations are made with only one velocity law and one opacity law, we have not tried to reproduce a given observed profile. Nevertheless a comparison between the perturbed profiles of figure 1 at phases 0.25 and 0.75, for example, leads to the description of a profile variation which is surprisingly similar to the one observed by Willis et al. (1986) in the P Cygni profile of N IV λ 1718 in the spectrum of WR6.

At higher values of ω, as displayed in figure 2, the perturbations sometimes give the impression of moving absorption features superimposed to a more or less normal P Cygni profile. This is reminiscent of the signature of the "puffs" described by Gry et al. (1984) and of the narrow components described by Henrichs (1984).

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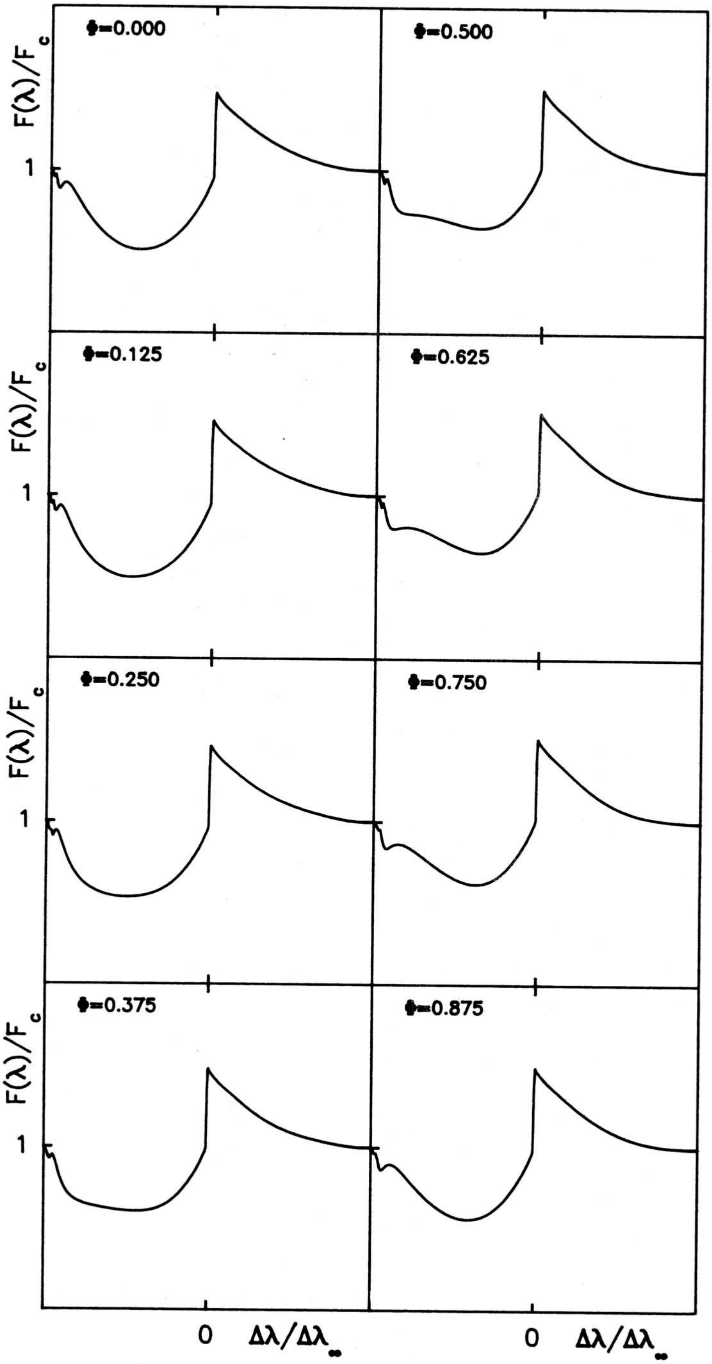

Figure 1. The line profile $F(\lambda)/F_c$ for $\ell = 2$ and $\omega = 0.5$

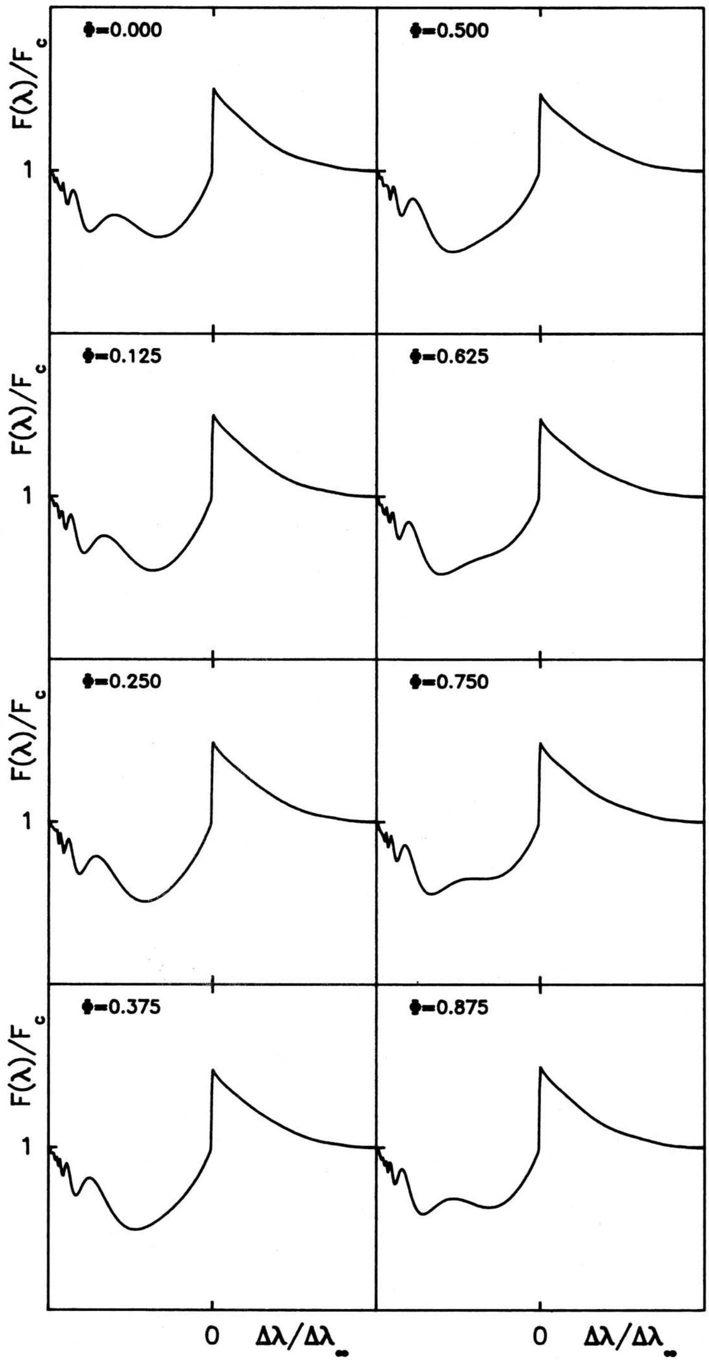

Figure 2. The line profile $F(\lambda)/F_c$ for $\ell = 2$ and $\omega = 2$