RECOVERING THE PULSATION VELOCITY DISTRIBUTION ON STELLAR SURFACE

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1. Introduction

The analytical expression between the line profile and its corresponding pulsation velocity field is derived by the assumption of Doppler Imaging (DI). Based on this approach, numerical experiments of the recovery of the one dimensional nonradial pulsation velocity distribution from the residual line profiles are presented.

2. Motivation

Since the present methods of line profile analysis of nonradial stellar pulsation based on the DI principle employ the residual line profile series as the input data instead of the velocity field itself, they are more or less empirical and lack of firm mathematical foundation. Here we find that there exists the analytical relation between the line profiles and their corresponding velocity field in the case where the DI assumption is satisfied. Based on this relation, we give a method of reconstructing the one dimensional velocity distribution from the residual line profiles. We hope this effort can lead the way to approach more accurate mode identification of nonradial pulsation.

3. Basic relations

The mathematic form of a line profile can be expressed as

$$p(v) = \int\int_S b(x,y) f(v - v_{\rm rot}(x,y) - v_{\rm pul}(x,y)) dS,$$

where $b(x,y) = 1 - u_\lambda + u_\lambda\sqrt{1-(x^2+y^2)}$, is the limb dark law, and $f(v)$ is the intrinsic profile. The Fourier transform is expressed as: $P(\omega) = \int_{-\infty}^{\infty} p(v)e^{-i\omega v} dv$. When $\omega V_{\rm pul} \ll 1$, the DI assumption is satisfied and we can obtain $P(\omega) = F(\omega)(R(\omega) - i\omega V(\omega))$, where $F(\omega)$, $R(\omega)$ and $V(\omega)$ are the Fourier transforms of $f(v), r(x) = 2(1-u_\lambda)\sqrt{1-x^2} + \frac{\pi u_\lambda}{2}(1-x^2)$, and $\overline{v_{\rm pul}(x)} \equiv \int_{-\sqrt{1-x^2}}^{\sqrt{1-x^2}} b(x,y) v_{\rm pul}(x,y) dy$, respec-

F.-L. Deubner et al. (eds.), New Eyes to See Inside the Sun and Stars, 383–384.

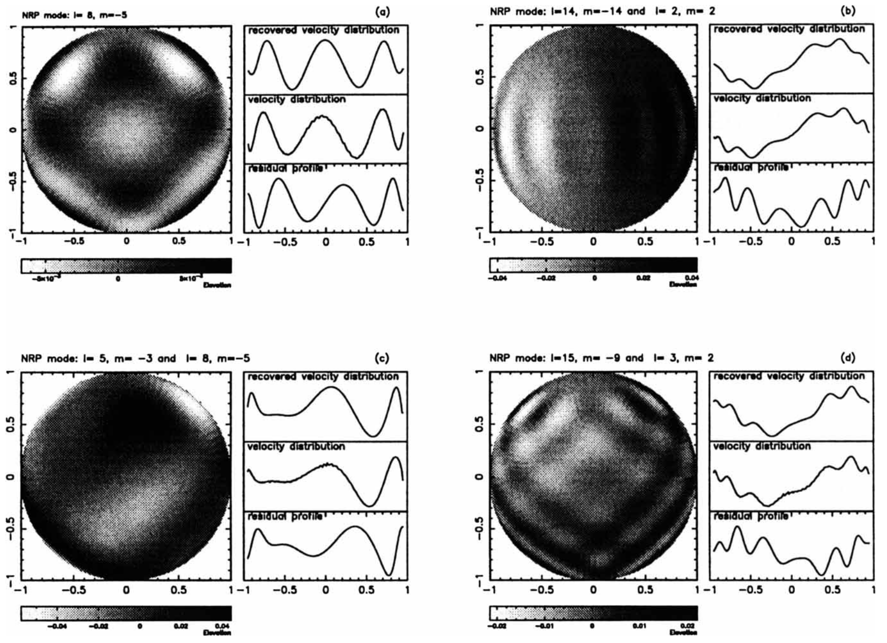

Figure 1. The results of numerical experiments for some modes. The parameters used in the calculation are as follows: (a) $l = 8$, $m = -5$ with amplitude of 0.01 $v \sin i$, $k = 0.25$, $i = 75°$, $v \sin i$ is 17 times the width of the intrinsic profile. (b) $l = 14$, $m = -14$ and $l = 2$, $m = 2$ with amplitudes of 0.01 and 0.1 $v \sin i$, respectively, $k = 0.25$, $i = 85°$, $v \sin i$ is 20 times the the width of intrinsic profile. (c) $l = 5$, $m = -3$ and $l = 8$, $m = -5$ with amplitudes of 0.09 and 0.03 $v \sin i$, respectively, $k = 0.25$, $i = 75°$, $v \sin i$ is 17 times the the width of intrinsic profile. (d) $l = 15$, $m = -9$ and $l = 3$, $m = 2$ with amplitudes of 0.01 and 0.03 $v \sin i$, respectively, $k = 0.25$, $i = 75°$, $v \sin i$ is 17 times the width of the intrinsic profile.

tively. Considering $F(\omega)R(\omega)$ is the Fourier transform of non-pulsation profile, $p^*(v)$, we obtain the relation:

$$\mathcal{F}[p(v) - p^*(v)] = -i\omega F(\omega)V(\omega), \quad \text{or} \quad p(v) - p^*(v) = -i\mathcal{F}^{-1}[\omega] * f(x) * \overline{v_{\rm pul}(x)},$$

where $\mathcal{F}$ and $\mathcal{F}^{-1}$ denote the Fourier transform and the reverse transform, respectively.

4. How to apply the technique

We use the observed residual profiles, $p(v) - p^*(v)$, and perform the deconvolution to them with $\mathcal{F}^{-1}(\omega)$, then the intrinsic profile, $f(x)$. Finally, the surface velocity distribution, $\overline{v_{\rm pul}(x)}$, can be recovered. The numerical experiments are made and the results are shown in Fig.1.