TRANSONIC DECRETION DISCS AROUND BE STARS

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1. Introduction

A Be star has a two-component extended atmosphere, a polar region and a cool disc-like region. The polar region consists of a low-density, fast outflow emitting UV radiation. In contrast to the polar region, the disc region consists of a high-density plasma with low outflow velocity. The optical emission lines and the IR excess arise from this region. The nature of this region is not well understood, depsite that large observational efforts have been devoted to the study of Be stars. The purpose of this paper is to study the disc structure of Be stars, based on the viscous decretion disc scenario, in which the matter ejected from the star drifts outward because of the effects of viscosity and forms a disc (Lee et al. 1991).

2. Transonic Decretion around Be Stars

We assume that the circumstellar disc of a Be star is geometrically thin and isothermal. We adopt the Shakura-Sunyaev's α-viscosity prescription. We take account of the radiative force in a parametric form proposed by Chen and Marlborough (1994).

Figure 1(a) shows the structure of the viscous transonic decretion disc around a B0 main-sequence star. Note that the outflow is highly subsonic for $r \ll 10^2 R_*$, where R_* is the stellar radius. Note also that $V_r \sim r$, $\Sigma \sim r^{-2}$, and $V_\phi \sim r^{-1/2}$ in the inner subsonic part, while $V_\phi \sim r^{-1}$ in the outer subsonic part and the supersonic part, where V_r and V_ϕ are the radial and azimuthal components of the vertically averaged velocity, respectively, and Σ is the surface density. The low outward velocity shown in Fig. 1(a), together with the observed range of the base density for Be-star discs (Hanuschik 1987; Dougherty 1994), suggests that the mass loss rate in the disc region is of the order of 10^{-12} to $10^{-11}\, M_\odot\, \mathrm{yr}^{-1}$ even for $\alpha \sim 1$.

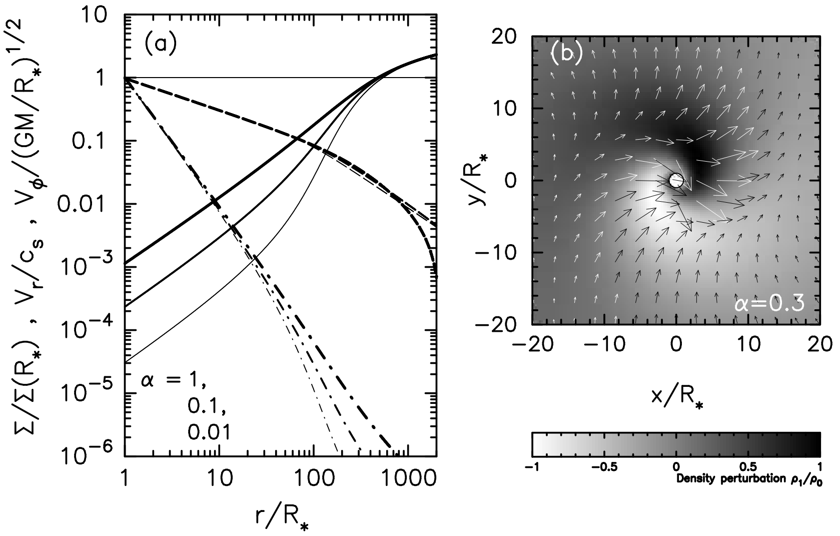

Figure 1. (a) Structure of the viscous transonic decretion disc. Solid, dashed, and dash-dotted lines denote V_r/c_s, $V_\phi/(GM/R_*)^{1/2}$, and $\Sigma/\Sigma(R_*)$, respectively, where M is the mass of the star and c_s is the isothermal sound speed. Thick lines, lines with intermediate thickness, and thin lines are for $\alpha = 1$, 0.1, and 0.01, respectively. The disc temperature is 2/3 of the effective temperature of the star. The radiative parameters, η and ϵ, are 0.05 and 0.1, respectively. (b) One-armed fundamental mode confined to the inner part of the transonic decretion disc for $\alpha = 0.3$. The other parameters are the same as those in panel (a). A grey-scale representation denotes the density perturbation, while arrows denote the perturbed velocity vectors. The period and the growth time of the mode are 7.2 yr and 7.5 yr, respectively

It is important to note that these are the basic features of viscous transonic decretion discs. Probing the circumstellar discs around Be stars with ISO is therefore highly desirable to test the viscous decretion disc scenario.

3. One-Armed Spiral Waves in Decretion Discs

In general, the viscous decretion discs are overstable for $m = 1$ perturbations. Figure 1(b) shows an example of the $m = 1$ fundamental mode confined to the inner part of a transonic decretion disc. Notice that the perturbation pattern is leading, one-armed spiral. The leading-spiral pattern is more remarkable in discs with larger α.

References

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