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RADIATION PRESSURE IN THE RESONANCE LINES

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ABSTRACT

The effects of large scale gas motions on the radiation pressure in a resonance lines are investigated. We have assumed a medium with pure scattering together with emission in the continuum. A linear velocity law is employed with maximum velocity V=30 mean thermal units at $\tau=0$ and V=0 at $\tau=\tau_{max}$. The geometrical thicknesses of the atmosphere B/A, (where B and A are the outer and inner radii of the atmosphere) are taken to be 3, 10 and 20. Total optical depth is set equal to 10^3. It is found that there is a sharp fall in the radiation pressure from media with large optical depths to those with smaller optical depths. When β ($=K_C/K_L$ where K_C and K_L are absorption coefficients per unit frequency interval in the continuum and line respectively) changes as $1/\tau_{shell}$ the radiation pressure falls off rapidly somewhere in the middle of the atmosphere and then starts to rise again.

Key words: resonance lines—radiation pressure

1. Introduction

It is well known that radiation pressure in a resonance line is strong enough to change the kinematics of a gaseous medium. This has been studied very extensively (see Lucy and Solomon 1970, Castor 1974, Grinin 1978 and others) in a variety of circumstances. However, most of these investigations are either analytical or semi-analytical and these do not always give a clear picture as to how the line radiation drives the matter. In a real stellar atmosphere, one encounters the line centre optical depths of the order of 10^3 or 10^5 and calculations of transfer of radiation in such thick media is possible only numerically. In this paper, we calculated the radiation pressure in an extended medium with optical thickness of 10^3 moving with velocity gradients.

2. Discussion of the Results

The solution of the transfer equation has been obtained as described in Peraiah (1980). We have made use of this solution with the following data:

$$\begin{aligned} B/A &= 3,\ 10 \text{ and } 20 \\ \epsilon &= 0 \\ \beta &= 0 \text{ and } 10^{-6} \text{ and } 1/\tau_{shell} \\ V_B &= 0,\ 10 \text{ and } 30 \text{ mtu} \\ V_A &= 0 \\ T &= 10^5 \end{aligned} \tag{1}$$

Where B and A are the outer and inner radii of the medium, ϵ is the probability that a photon is thermalized by collisional de-excitation in a single scattering. τ_{shell} is the optical depth in the shell and T is the total optical depth in the medium. V_A and V_B are velocities in mean thermal units at radii A and B respectively. And the law of velocity we have used is given by

$$V_r = V_A + \frac{V_B - V_A}{B - A}(r - A) \tag{2}$$

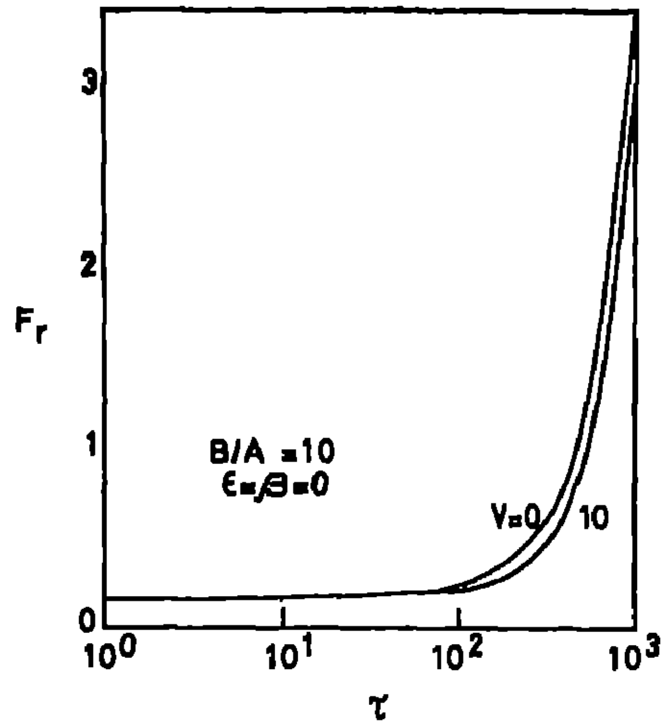

Fig. 1 Radiation force F_r plotted against for B/A=10, $\epsilon=\beta=0$ and V_s = 0 and 10.

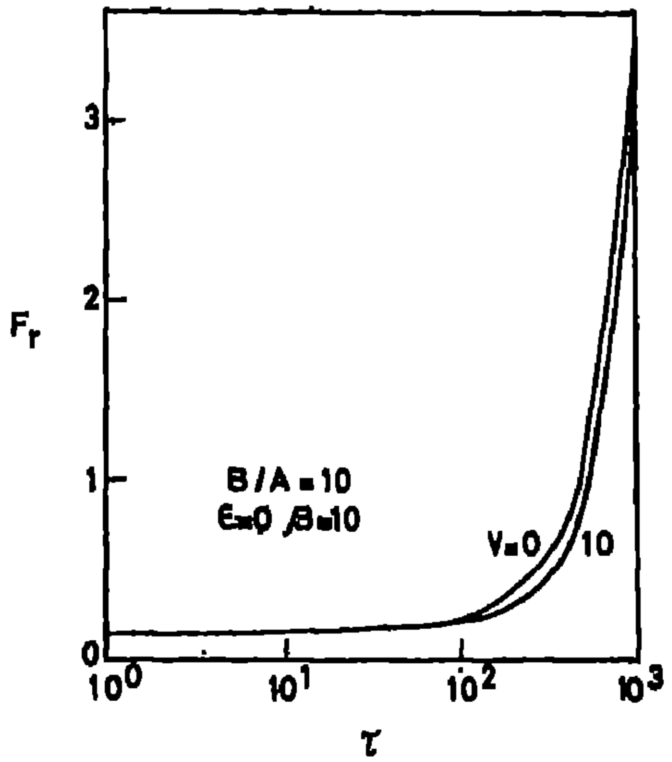

Fig.2 Radiation force F_r plotted against for B/A=10, $\epsilon=0$, $\beta=10^{-4}$ and V_s = 0 and 10.

We have calculated the solution of the transfer in comoving frame and this provides the radiation field and the radial distribution of fluxes. The radiation pressure term is calculated by using the expression

$$F_r = \int_{-\infty}^{+\infty} F_x(r)\, K_a(r)\, dx \qquad (3)$$

Where F_r is the radiation pressure, K_a (r) is the absorption coefficient and F_x (r) is the net outward flux at the radial point r.

In Figures (1 – 3), we plotted F_r with respect to the optical depth for various parameters listed in the data (1). Figure 1 gives F_r for B/A = 10, $\epsilon = \beta = 0$ and V = 0 and 10 mtu. There do not seem to be large differences in the effects due to varying velocities. Generally, F_r falls off quite rapidly as the optical depth decreases. This is true in the case of the media with small continuum emission also shown in Figure 2. However, when the absorption characteristics of the continuum change (i.e.) as in the case of the results shown in Figure 3 the radiation pressure falls off, but again at much smaller optical depths it starts increasing. In this case, we have shown results for B/A = 3, 10 and 20 and higher geometrical extensions show large radiation orces.

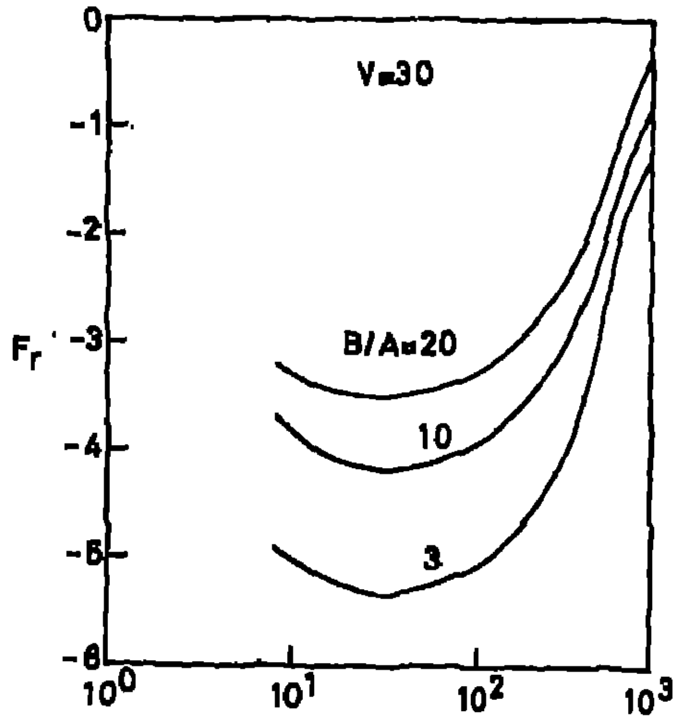

Fig. 3 Same as in Figure 2, but B/A = 20, 10 and 3 with $\epsilon = 0$ and $\beta = 1/\tau$, shell and $V_s = 30$

These calculations are only indicative of the effects of various parameters. However, one should consider the equation of hydrodynamic equilibrium and equation of continuity for calculating the velocity distribution consistent with the solution of the transfer equation.

References

Castor, J.I. 1974, *Mon. Not. R. astr. Soc.* 169, 279
Grinin, V.P. 1978, *Astrofizika*, 14, 537
Lucy, L.B. Solomon, P.M. 1970, *Astrophys. J.* 159, 879
Peraiah, A. 1980, *Acta Astronomica* (in press)