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FORMATION OF SPECTRAL LINES WITH THE REDISTRIBUTION FUNCTION R_I ALONG THE LINE OF SIGHT

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ABSTRACT

We studied the formation of spectral lines at infinity with the redistribution function R_I. The radial optical depths considered are .5, 5, 10, 50 and 100. A linear law of velocity is assumed in these calculations. Profiles clearly show the P cygni nature of asymmetry.

1. Introduction

In earlier papers, we have shown how the profiles of spectral lines will change in a radially moving medium. (See Peraiah, Raghunath, Nagendra 1980, Peraiah 1980). Here we have assumed various approximations to the source functions, the law of velocity distribution along the radius etc. However, in all these calculations, the assumed nature of the profile is Doppler or we have assumed a complete redistribution of photons in the line. This assumption is true when the line photons are not redistributed too far away from the centre of the line. When we deal with medium with large scale motions, the line continuously shifts across the continuum background. The photons absorbed at any radial point in the line centre, may be replenished at a further radial point as the centre of the line crosses the continuum. In a similar way, photons in the wings may be absorbed to replenish the photons absorbed in the line centre. If the gases are moving with large velocities, one must take into account of photons absorbed and emitted within a large band width of the line encompassing the large velocities of the gas. For this purpose, the partial redistribution has been employed so that we can estimate the fluxes in the line properly.

2 Discussion of the Results

The optical depth is calculated by using the formula

$$\tau (x, r) = E (r) f (x) \tag{1}$$

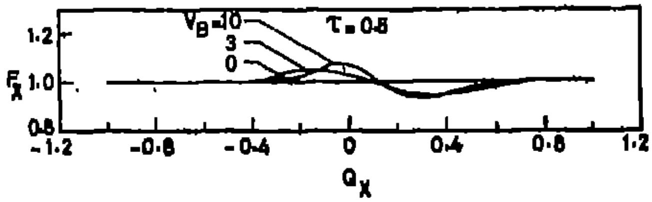

Fig. 1. Line profiles for τ = .5. Fx is given in arbitrary units. $Q = x/x_{max}$. V_B = 0, 3, 5 and 10 mtu.

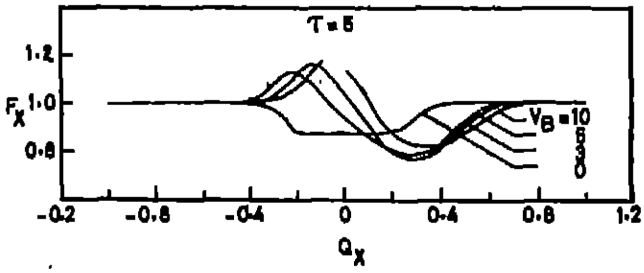

Fig. 2 Line profiles for τ = 5 and V_B = 0, 3 and 10 mtu

where

$$f (x) = \int_{-\infty}^{+\infty} R_{I-A} (x, x') \; dx' \tag{2}$$

and

$$R_{I-A} (x, x') = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{+\infty} e^{-t^2} \, dt \tag{3}$$

where

$$|\bar{x}| = \text{Max} \{ |x|, |x'| \}$$

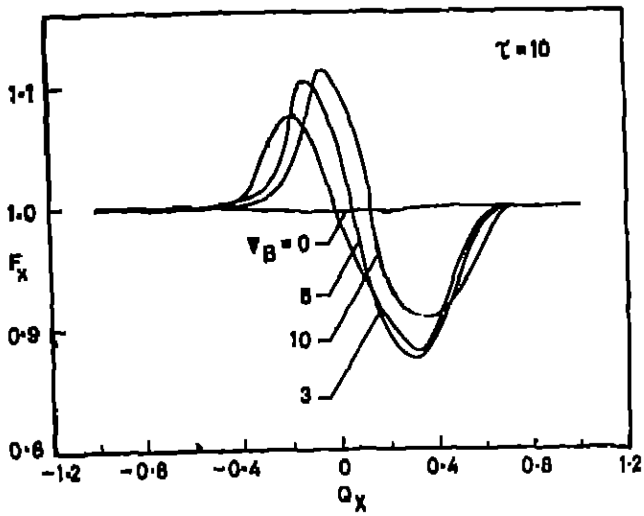

Fig. 3 Line profiles for $\tau = 10$, $V_B = 0, 3, 5$ and 10 mtu

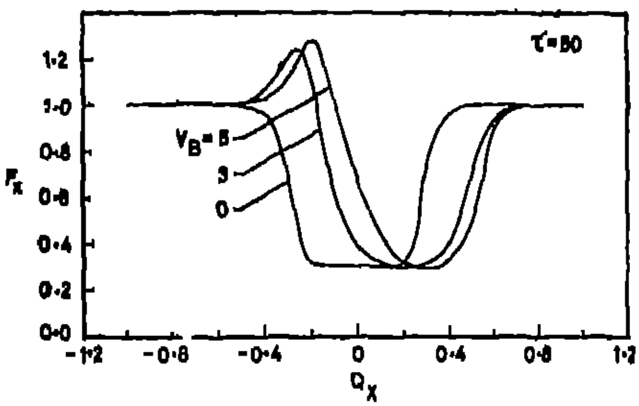

Fig. 4 Line profiles for $\tau = 50$, $V_B = 0, 3$ and 5 mtu

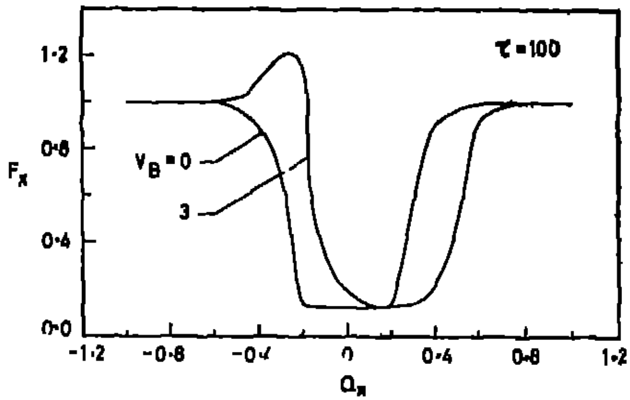

Fig. 5 Line profiles for $\tau = 100$, $V_B = 0$ and 3 mtu

The method of calculating the optical depth along the line of sight is described in the papers cited above and we need not repeat here.

We have considered a spherical medium with inner radius $= 10^{11}$ cm and an outer radius $= 1.5 \, 10^{11}$ cm. The initial density is taken to be $E(10^{11}) = 10^5$ neutral atoms/cm^3, we assume that E is decreasing as

$$E(r) \sim \frac{1}{r^3} \tag{4}$$

so that the velocity can increase uniformly

$$v \sim r \tag{5}$$

The computations take huge amount of time because of the fact that we have to calculate f (x) several times along the line of sight. We have investigated two types of variations (1) regarding the velocity and (2) the amount of absorption in terms of the optical depth. In all cases, we have set $V(10^{11}) = 0$ and $V_B (1.5 \times 10^{11}) = 0$, 3, 5 and 10 mean thermal units (mtu). The radial optical depths considered are .5, 5, 10, 50 and 100.

The results are presented in figures (1) to (5), for optical depths .5, 5, 10, 50 and 100 respectively. One can clearly see the effects of high optical depths. In figure 1, we see that there is hardly any line asymmetry. When τ is increased to 5, an absorption line for $V_B = 0$ becomes P cygni line profile at $V_B = 3$, 5 and 10 mtu with increasing asymmetries as shown in Fig. 2. A further increase in the amount of absorption (as shown in fig. 3) will enhance the asymmetry. Similarly the profiles in figures 4 and 5 show the same characteristics.

References

Peraiah A., Raghunath G., Nagendra K. N. 1980, *Kodaikanal Obs. Bull. Ser. A* 3, 30

Peraiah A., 1980, *J. Astrophys. Astr.* 1, 17