ANALYSIS OF THE PLASMA LASER STAR MODEL
OF QSOs

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Abstract. The investigations on the Plasma Laser Star Model of QSOs reported in our previous paper are continued. Here we assume that QSOs are early type stars with temperatures in the range $10^4-10^5$ K. It is pointed out that the spectral lines of such stars may have asymmetric shapes and large broadening leading to errors in measurement up to 20 Å. The conventional red-shift theory, however, allows fitting errors much more than this amount for many QSO emission lines. By taking the abundances of elements in QSO atmospheres identical with the average cosmic abundance we analyze and compare the interpretations of the emission lines of 330 QSOs (263 QSOs are from Burbidge et al.'s list and the rest are more recently discovered QSOs) according to the new and the conventional theories.

1. Introduction

In the Plasma Laser Star (PLS) model the QSO emission lines are explained simply as being due to laser action in the QSO atmosphere. The widely accepted view is that their spectral lines are highly red-shifted and the red-shift is believed to be cosmological in nature. But this view has been criticised on many grounds in our previous paper (Banerji and Bhar, 1978). In the PLS model we treat QSOs as local objects. We further assume that they have very small red-shifts ($Z < 10^{-3}$) if there is any. Taking the value for the Hubble constant as 50 Km s$^{-1}$ Mpc$^{-1}$ (Sandage and Tammann, 1976) an object at a distance of 6 Mpc will have a red-shift $10^{-3}$. The proper motion data suggest that for at least some of the objects the minimum distance is of the order of 1 Mpc, i.e., they must be outside our galaxy. The brightest QSO 3C 273 has a visual magnitude 12.86 and proper motion data suggest that it is at least at a distance of 200 Kpc (Robinson et al., 1965).

In this context it might be interesting to check whether the brightest normal stars have similar visual magnitudes when taken to such large distances. From the theory of stellar structure it is known that normal stars with mass greater than 60 $M_\odot$ become unstable (Allen, 1973). Assuming a mass-luminosity relation

$$\log \left( \frac{L}{L_\odot} \right) = 3.45 \log \left( \frac{M}{M_\odot} \right)$$

we get for the most massive stable star ($M = 60 \ M_\odot$)

$$\log \left( \frac{L}{L_\odot} \right) = 6.13.$$ 

The visual magnitude of the Sun is 4.71 while that of the most massive star would be $-10.62$. If the brightest star, assuming $M = 60 \ M_\odot$ is taken to a distance of 200 Kpc
then its apparent magnitude will be 10.88, that is, it will be brighter than 3C 273. However, the Sun taken to a distance of 200 Kpc will not be visible even with the largest telescope so far available. The minimum and maximum apparent visual magnitude of QSOs, discovered until September, 1977 (Burbidge et al., 1977; Osmer, 1977; Browne and Savage, 1977) are, respectively, 12.86 and 20.6. Thus from the above discussion it is seen that the data on apparent visual magnitudes of QSOs are not inconsistent with the hypothesis that the QSOs are normal stars.

In the following sections we analyze the properties of QSO emission lines with particular reference to intensity and broadening assuming relative abundances of elements identical with that prevailing in the cosmic material. Finally we discuss the emission spectra of 330 QSOs (some of them in detail) and compare their interpretations according to the new PLS and conventional red-shift (RS) theories.

2. Analysis of Line Intensity

We assume the QSOs to be stars with temperatures in the range $10^4$–$10^5$ K which means they are comparatively young stars. At these high temperatures the constituents are in the plasma state giving a high concentration ($10^{14}$–$10^{16}$ cm$^{-3}$) of electrons and ions. It has been found that a magnetized plasma jet expanding into vacuum can give rise to population inversion (Campbell et al., 1977). A jet like structure is visible in some QSOs (Greenstein and Schmidt, 1964). The laser action occurs in the form of amplified spontaneous emission (ASE) in the large volume of the active medium and hence the conventional laser properties are not observable. Because of the absence of a well-defined optical cavity that determines the modes of oscillation of the laser beam, the light generated by ASE is not expected to possess a good degree of coherence and its directional property is also worsened considerably. Varshni and Lam (1976) studied laser action in stellar envelopes which cool owing to rapid expansion and found that this is possible at temperatures $10^4$–$10^5$ K and electron densities $10^{14}$–$10^{15}$ cm$^{-3}$.

An approximate expression for the number of photons emitted per second in the frequency interval $f$ and $f + df$ from such a laser is given (Yariv, 1968; Siegman, 1971) by

$$N_0 l \, \alpha \,(N_2 - N_1),$$

where the quantity $\alpha/(N_2 - N_1)$ gives the gain coefficient per inversion density $(N_2 - N_1)$, which is related to the line strength of the transition, $l$ is the length of the active medium, and $N_2$ the population density of the upper level.

Let us take for $l$ the solar radius $7 \times 10^{10}$ cm, and the frequency $f$ corresponding to the visible wavelength of He 4686 Å, having a width of 50 Å. Varshni and Lam (1976)