INFLUENCE OF THE MAGNETIC FIELD ON THE POLARIZATION OF RADIATION SCATTERED BY ELECTRONS IN STELLAR ATMOSPHERES AND ENVELOPES

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The radiation scattering by electrons play an important role for stars with the surface temperature $\geq 2.10^4$ ^oK. Many among these stars have magnetic fields of the order 1 - 100 G. We shall consider the role of the field for the radiative transfer in continuum spectra.

Electrons in the field form an axisymmetric medium similar to the single axis crystal. Hence, the medium will have dichroism and birefringency. If the gyrofrequency ω_B is much less than the radiation frequency ω then the dichroism can be neglected. The circular birefringency can be characterized by the angle of the Faraday rotation

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$$\chi = 1/2\ \delta\ \tau_{Th} \cos\theta\ ,$$

$$\delta = (3/4\pi)(\omega_B/\omega)(\lambda/r_e) \simeq 0.8\lambda^2(\mu) B(G),$$

$$r_e = e^2/m_e C^2,\ \tau_{Th} = N_e\ \sigma_{Th} \ell,$$

σ_{Th} is the Thomson cross-section, N_e is the electron number density, ℓ is the path of the light, θ is the angle between the field B and the direction n of the light propagation. One can see that for the wavelength $\lambda \simeq 1\mu$ in the field B $\sim$ 1 G the Faraday rotation is large enough. For the field $< 10^6$G and $\lambda < 1$ mm the Stokes parameters satisfy the equations $\mu dI/d\tau = I - B_I$, $\mu dQ/d\tau = Q + U\ \delta \cos\theta - B_Q$.

$$\mu dU/d\tau = U - Q\ \delta \cos\theta - B_u,\ \mu dV/d\tau = V - B_V.$$

Here $B_m(\tau, n)$ are well known scattering terms (Chandrasekhar, 1950).

If $\chi \geq 1$ then the linear polarization is decreased for all directions except the one perpendicular to the field. Photons travel different geometrical paths and possess because of the Faraday rotation different directions of the polarization plane. In this case we can separate the equation for the intensity only:

$$\mu dI/d\tau = I - (3/16\pi) \int dn'(1 + (n.n')^2) I(n', \tau).$$

For the parameters Q and U we have:

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$$-Q + iU = -\frac{F}{2\pi H_1}\cdot\frac{1-\mu^2}{1 + i\delta\cos\theta}\left[H\left(\frac{\mu}{1 + i\delta\cos\theta}\right) - \frac{3}{2}H_2 - \frac{3H_1\mu}{2(1 + i\delta\cos\theta)}\right]\left[3 - \frac{\mu^2}{(1+i\delta\cos\theta)^2}\right]^{-1}, \quad H_n=\int_0^1 d\mu\mu^n H(\mu).$$

Here $H(\mu)$ is the well known Chandrasekhar's H -function. From this equation we can see that the maximum polarization for $\cos\theta = 0$ is 9.14% instead of the value 11.7% obtained in papers of Chandrasekhar (1950) and V. V. Sobolev (1956).

The large-scale magnetic field destroys the optical symmetry of the stellar atmosphere (and envelope) and leads to a non-zero integral linear polarization of the radiation from the spherical star. In the paper of Dolginov and Silant'ev (1979) this polarization has been calculated for the case of the dipole magnetic field. Its maximum value was about 0.2% for $\delta_e \gtrsim 2 \div 4$ for the stellar magnetic equator. The qualitative spectral dependence of polarization is presented in Figure 1.

The influence of the Faraday rotation is much more effective for the optically thin atmospheres and envelopes as was shown by Gnedin and Silant'ev (1980, 1984).

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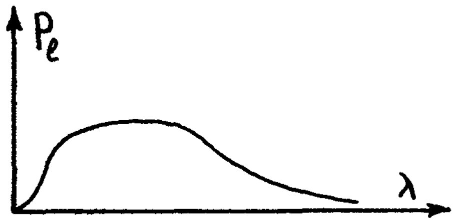

Fig. 1. Qualitative picture of the integral polarization spectrum of radiation emerging from spherical star with magnetic field.

The maximum of polarization may reach 10% if $\tau_{envelope} \sim 1$ for the case of a dipole field and with N_e = Const in the envelope. For small δ_e values the polarization degree P_ℓ increases as $\sim \lambda^4$ for any dependence of N_e the distance. For large Faraday rotation ($\delta_e \gg 1$) the law of the polarization decrease depends strongly on the function $N_e(r)$. For a spherical envelope with N_e = Const one has $P_\ell \sim \lambda^{-2}$ and for the case $N_e \sim r^{-2}$ the polarization degree $P_\ell \sim 1/\sqrt{\lambda}$. If the magnetic dipole axis is precessing then the polarization varies with the period of the precession.

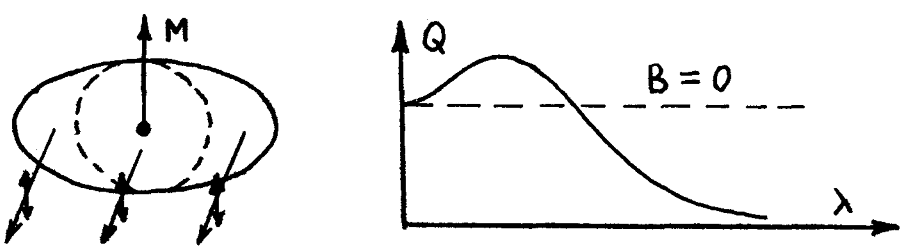

Figure 2. Polarization spectrum of radiation from ellipsoidal electron envelope when the axis of star's

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magnetic dipole is perpendicular to the sight of telescope and coincides with the envelope rotation axis. The short arrows denote the direction of the electric vector oscillation of the light.

For a nonspherical envelope without a magnetic field the integral polarization exists and it is independent of the wavelength. If the magnetic field is present in this case then the Faraday rotation may as well enhance as diminish the polarization degree (see Fig. 2 an 3).

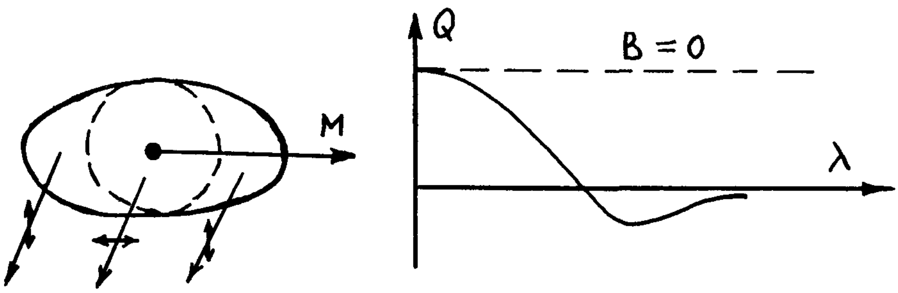

Figure 3. Polarization spectrum of radiation from an ellipsoidal electron envelope when the axis of star magnetic dipole is perpendicular to the sight of telescope and to the rotation axis.

The linear polarization spectra of hot stars can give information on the stellar magnetic field as well as on the electron number density distribution law in the envelope. This method may be useful also in those cases when the usual Zeeman-method is inefficient.

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