ABUNDANCES IN Ap STARS; RESULT OF MAGNETIC BINARY EVOLUTION

(Abstract)

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There is an old theory of Fowler *et al.* (1965) that the peculiar A stars are in the post-giant phase of stellar evolution. This theory tried to explain the anomalous abundances observed in Ap stars but data available today do not confirm it.

Another theory concerns the binary nature of Ap stars. It was suggested by Renson and elaborated by van den Heuvel (1968). The latter believed all the peculiar and metallic-line A stars to be evolved binaries.

The statistical analysis of mass functions for known spectroscopic binaries amongst Am stars developed by myself (Drobyshevski, 1973) shows indeed that about two thirds are evolved binaries.

As for peculiar A stars, the situation is complicated as few are known to have companions. These are the stars having strong magnetic fields and it is natural to suppose that the magnetic field must play a role in the evolution of the binary system.

Resnikov and myself have made approximate calculations of close binary evolution taking into account the influence of the magnetic field on exchange and loss of mass and angular momentum. The main emphasis was on the realization that the field became turbulent through convective motions in the envelope of the primary component – the red giant. The coherent field has a small influence on the process under consideration because of the small value of its flux through any cross-section of the star as compared with the turbulent field flux

$$\phi_{\text{coher}} = \int_s H_{\text{coher}}\, \mathrm{d}S \ll \phi_{\text{turb}} = \int_s |H_{\text{turb}}|\, \mathrm{d}S\,.$$

It follows from the calculations that the magnetic field influences mass and angular momentum exchange in systems with original orbital period $P_0 \gtrsim 100^{\text{d}}$. Then the magnetic field becomes so strong that its pressure in the stream of matter flowing from the primary on to the secondary exceeds the gas pressure

$$\frac{H_{\text{turb}}^2}{8\pi} \gtrsim P_{\text{str}} \quad \text{at} \quad P_0 \gtrsim 100^{\text{d}}\,. \tag{*}$$

The stream parameters were calculated by using the method of Paczyński and Sienkiewicz (1972).

The effect of having a large magnetic field will only be found in wide pairs as the magnetic flux ϕ_{turb} grows when one goes to increasingly wide separations. At the

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same time the relative cross-section of the stream becomes smaller in wide pairs. The details are discussed in an article submitted to *Acta Astronomica.*

When condition (*) is satisfied in the stream, solar-type flares must occur, but their intensity and scale should be much greater. The solar flares are known to be accompanied by the acceleration of heavy nuclei. Brancazio and Cameron (1967) have already shown that the observed abundances of peculiar A stars can be produced by the bombardment of matter with normal abundances by energetic α-particles.

The small observed duplicity of Ap stars is explained because their periods must be long and velocities small. A more detailed analysis, taking account of data concerning cluster membership, kinematics, geometry and magnetic field strength etc., shows that it is the Cr–Eu peculiar A stars which are the result of evolution of wide originally non-evolved binaries with Am components in the manner discussed.

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