Some comments on evolution of magnetic fields of CP stars

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Theses

1. A comprehensive study of the magnetic fields of upper main sequence CP stars and their progenitors, emission Herbig stars, has shown that the magnetic fields and chemical anomalies in CP stars originate at the moment young Ae/Be stars arrive on the zero-age line, when the gaseous-dust envelopes surrounding them dissipate and accretion ceases. It is the ZAMS that is the place magnetic CP stars form at.

2. Near the ZAMS the atmospheres stabilize, the emerged magnetic field stabilizes in addition the upper parts of the stellar atmospheres, conditions for diffusion of chemical elements that brings about the observed chemical anomalies arise.

3. The study of the rate of CP stars amid main sequence stars has shown that the smaller *v sin i* the greater the proportion of CP stars. So, magnetic stars account for 30%, at an average level of 10-15%, amongst the stars with *vsin i* = 0-10 km/s. This relation is contrary to the one expected in the case the magnetic field is dynamo generated. The dynamo magnetic field must lead to a field magnitude proportional to the rotation velocity, and it must be null in stars with minimum velocities. The assumption that the observed relation is the result of subsequent magnetic braking with the magnetic field involved may lead to most improbable laws of braking.

4. The dependence of the average magnetic field on *vsin i* confirms the conclusion drawn in point 3. This dependence shows that practically all stars with strong magnetic fields fall within the range v sin i = 30 - 40km/s, while after vsini = 40km/s only stars with weak magnetic fields, most frequently with fields weaker than the normal detection threshold. This boundary is sufficiently clear-cut. Taking into account point 3 it is inferred that whether the relic magnetic field is preserved depends strongly on the star rotation velocity.

5. Magnetic field measurements in young emission Herbig stars, 15 % of which later become magnetic CP stars, have shown that typical strong dipolar magnetic fields are absent in them.

6. The results given in points 3 and 4 illustrate that the slow rotation velocities of magnetic CP stars result not from magnetic braking but rather from the fact that it is the slow rotators that conserve the relic magnetic field better.

7. The magnetic fields of CP stars are not generated in the convective core, neither then are they driven to the surface. This assumption is verified by the fact that along the whole main sequence, CP stars form exactly on the ZAMS, and the most massive of them on the ZAMS are two orders of magnitude younger than the most low-mass stars. Taking into account that it takes the field a long time to rise to the surface, one might expect the field in these stars to appear at later phases than in low-mass stars.

8. As a consequence of the present-day point of view that the protostars and emission Herbig stars with masses $M > 1.5 M_{\odot}$ do not undergo the convective phase of evolution throughout the whole lifetime, different authors assume that the magnetic fields are relic. This assumption is corroborated by inferences made in points 3,4 and 7. Despite the failure to reveal strong dipolar magnetic fields in them, one can claim that strong magnetic fields do exist in the subsurface layer. Having a relatively low speed of emergence and undergoing the distructive action of mass of accretion, a magnetic field cannot appear on the entire surface. After the end of accretion and stabilization of the surface layers, the magnetic field rises to the surface unimpeded (see p.2).

9. A comparison of the behaviour of *vsini* for normal and CP stars as they evolve from the ZAMS to the upper boundary of the main sequence has shown that the ratio of their *vsini* is preserved within the errors. This suggests that CP stars do not undergo additional braking. In so far as there is no magnetic braking at the phase of emission Herbig stars either (see p.5), there remains the only possibility for the magnetic field to be involved in the braking at the earliest stages of their formation, prior to the "birthline" of Herbig stars.

10. The properties of CP stars described in points 3 and 4 give rise to the assumption that one of the main conditions for retaining of the field is the low rotation velocity (the magnetic braking is likely to be of minor importance).

11. At low velocities, as one may suppose, no differential rotation occurs, which would have converted a poloidal initial field into a torroidal field and led to other instabilities. In tandem with the effect of am-

bipolar diffusion, the absence of differential rotation is possibly the second principal condition of conservation of the poloidal field in magnetic stars. It is impossible to detect a toroidal field by means of the classical Zeeman procedure. The immediate task is a search for signs of toroidal fields in stars.

12. Investigations of emission Herbig stars demonstrate that many properties, for instance, the local outflows, cannot be accounted for without assuming that local magnetic fields are involved. It is not improbable that in particular portions of the local magnetic fields conditions arise that favour the emergence of magnetic lines of force. The problem consists in searching and detecting such cases.

13. The fraction of stars with measured magnetic fields has been found to decrease monotonically with growing mass. So, the share of He-strong stars with a magnetic field is 40%, while that of magnetic SrCrEu stars is as large as 90 %. It implies that the magnetic field formation time in massive stars is rather long as compared to the lifetime of stars on the main sequence. This fact together with the results of modeling allows us to infer that the appearance of a magnetic field lags behind the generation of chemical anomalies, and the field has initially a complex configuration. As a result, the measured field may initially be weak.

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