CP STARS INTERACTION WITH INTERSTELLAR GAS.

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ABSTRACT. It is shown that the interstellar gas (ISG) accretion cannot occur onto magnetic stars as the gas should be effectively expelled by the magnetic field. The star rotation braking is highly ineffective. The conclusion is that these stars had acquired their sloe rotation before they came to the Main Sequence. The critical value of the magnetic field strength on the pole, below which ISG accretion is possible equals only to a few Gs. It is supposed that all the CP stars possess the magnetic fields higher that the critical ones. If ISG accretion starts onto a CP star, then for the observer in a relatively short time a CP star eay turn a normal star or a star with weak chemical anomalies in the atmosphere. It is predicted, that some normal not-rotating stars possess strong magnetic fields. CP stars distribution along the Z-coordinate of the Galaxy and the frequency of CP stars appearance in clusters is discussed. It is supposed, that Ap stars are faint extended X-ray sources.

1. INTRODUCTION.

Strong magnetic field is often observed in CP stars. There is no uniformly assumed formation mechanise of the peculiar chemical composition in stellar atmospheres (Borra, Landstreet, Mestel, 1980; Khokhlova, 1983). It was supposed for example that those anomalies might be caused by accreting interstellar gas, enriched with star evolution products, onto the stellar surface. When there are any convective surface zones in which gas mixing occurs in A stars, they should be very thin. Therefore even small accretion rate of interstellar gas ($\dot{M}_a \sim 10^{18} - 10^{12}$ g/s) may be sufficient for the chemical composition of interstellar gas to form in the atmospheres of A star.

We are testing the possibility of interstellar gas (IS6) accretion onto a magnetic star. It is shown that accretion is impossible in a wide region of star and ISG parameters values, as the magnetic field of a rotating star will effectively expel the falling gas ("propeller effect", see Shvartsman, 1970, 1971a; Davidson and Ostriker, 1973; Illarionov, Sunyaev, 1975).

To make everything definite we will admit such values for star and ISG parameters: mass of the star $M=3\, m_3 M_\odot$, rotation period $P = 2\, p_2$ days, magnetic field strength on the pole $H_0 = 10^4$ Gs, stellar radius $R_0 = 2.5\, r_{2.5} R_\odot$, the corresponding magnetic moment (the field is supposed dipole) $\mu = H_0 R_0^3/2 = 2.68 \cdot 10^{37} \mu_{37}$ Gs cm^3, the velocity of the star motion through ISG $V_0 = 20\, v_{20}$ km/s (Allen, 1973), ISG density accounting for average molecular weight (Kaplan, Pikel ner, 1979) $\hat{\rho} = 1.42\, m_H \hat{n} = 2.37 . 10^{-24} \hat{n}_1$ g/cm^3. We will admit also that the sound speed c in IS6 is less that the velocity of star motion relatively to ISG, ($c_s < V_0$) or that the parameter $\xi = (1 + c_s^2/V_0^2)^{1/2} \approx 1$. We will keep to these values of the parameters further with the exception of specially mentioned cases.

2. ACCRETION ONTO MAGNETIC STARS.

The star going through IS6, the quantity of the gas captured by it will be determined by the so-called capture radius:

$$R_G = \frac{2GM}{\xi^2 V_0^2} \approx 2.0 \cdot 10^{14} m_3 \xi^{-2} v_{20}^{-2} \text{ cm} . \qquad (1)$$

The stars accretion rate $\dot{M}_a$ in a common case depends on a number of parameters, in particular, on gas adiabatic index. We will assume the following definition (Bondi, 1952) for the future consideration:

$$\dot{M}_a = \frac{4\pi (GM)^2 \hat{\rho}}{\xi^3 V_0^3} \approx 5.9 \cdot 10^{11} m_3^2 . \hat{n}_1 \xi^{-3} v_{20}^{-3} \text{ g/s} . \qquad (2)$$

The gas, captured by the star, mainly comes to it from the side, opposite to star motion direction, a cone shock being formed behind the star (see, for ex. Shvartsman, 1971b). In the shock the captured gas loses a part of its kinetic energy. As mean path length of a particle (Lang, 1974) is $l_c \approx 3.7 \cdot 10^{13} \xi^4 v_{20}^4 \hat{n}_1^{-1}$ cm, and its Larmour radius (supposing of interstellar magnetic field $H \sim 3\, 10^{-6}$ Gs) is equal to $l_H \approx 10^7 v_{20}$ cm, the shock wave is collisionless. Besides, the shock behind the moving star must be unradiative because of IS6 low density. During further falling of the heated gas onto the star the accretion flow will become spherical (Hunt, 1971).

A well-known value is Alfven radius R_A , at which the magnetic field begins to influence the gas motion or, in other words, the density of magnetic energy is close to the dynamic pressure of the matter. The relative motion velocity of the matter and they field is $V = (V_{ff}^2 + V_s^2)^{1/2}$, where $V_{ff} = (2GM/R)^{1/2}$ is the free falling velocity, $V_s = \Omega R = 2\pi R/P$ is the rotation velocity of the magnetic field. At Alfven radius the following condition is realized: $H^2/8\pi = \rho V^2$. Assuming that in the case of a dipole field $H = 2\mu/R^3$, and $\rho = \dot{M}_a / 4\pi R^2 V_{ff}$, we have

$$R_A = 2^{2/7}\mu^{4/7}(2GM)^{-1/7}\dot{M}_a^{-2/7}\left[1+\left(\frac{V_s}{V_H}\right)^2\right]^{-2/7}. \qquad (3)$$

At the corotation radius

$$R_c = \left(\frac{GM}{\Omega^2}\right)^{1/3} \approx 6.71\cdot 10^{11} p_2^{2/3} m_3^{1/3} \quad \mathrm{cm} \qquad (4)$$

the magnetic feld rotation velocity is equal to Kepler velocity. We can write down that at Alfven radius $R_A/R_c=2^{1/3}(V_s/V_{ff})^{2/3}$

HOW does magnetic field interact with the matter? At present observation data of magnetic stars are best described with the model of an obliqued rotator, i.e. the magnetic dipole is inclined to the rotation axis by some angle β . As magnetosphere possesses no spherical symmetry the field strength around the star is periodically changing. If α is the angle between some direction and the rotation axis of the star, then depending on α and β there will be single or double wave of magnetic field change with rotation period. If $V_s > V_{ff}$ in the interaction region, then this interaction will cause effective gas outflow from the rotating magnetosphere (the propeller effect)•

If to account only for the perpendicular to the direction of magnetic field line velocity component (or to ignore V_s in (3)), then the expression for Alfven radius will take the form:

$$R_A = 2^{2/7}\mu^{4/7}\dot{M}_a^{-2/7}(2GM)^{-1/7} \approx 1.8\cdot 10^{14}\mu_{37}^{4/7} m_3^{-5/7}\hat{n}_1^{-2/7}\xi^{6/7}V_{20}^{6/7}\,\mathrm{cm}. \qquad (5)$$

Comparing (4) and (5) shows that for typical parameter values, Ap stars are hard propellers, i.e. $R_A \gg R_c$ or $V_s \gg V_{ff}$ (supersonic propeller (Davies et al., 1979)). As the magnetosphere possesses no spherical symmetry, it will spherize while gas is accreting onto it. Besides that, as calculations by Wang and Robertson (1985) show, magnetosphere is subjected to Kelvin - Helmholtz and interchange instabilities at the boundary. The magnetic field is sheared with approaching matter and carries it along. In this case the tangential velocity component should be accounted for. If $V_s \gg V_{ff}$ we obtain from (3):

$$R_A = 2^{2/13}\mu^{4/13}\dot{M}_a^{-2/13}(2GM)^{1/13}\,\Omega^{-4/13} \approx 1.5\cdot 10^{13}\mu_{37}^{4/13}\, m_3^{-3/13}\,\hat{n}_1^{-2/13}\xi^{6/13}V_{20}^{6/13}\, p_2^{4/13}\,\mathrm{cm}. \qquad (6)$$

The expressions (5) and (6) restrict up and down respectively the value of real radius of the magnetosphere R_m, though R_m may be close to the value (6).

What is the outflowing velocity of the gas? This question has been discussed in a number of papers (see Lipunov, 1982a, for example), but there is no unambiguous answer yet. It may be suggested that the matter outflowing velocity is V_s (Shakura, 1975; Wang, 1979; Halloway et al., 1978). It should be the upper limit as effectiveness of outflowing will decrease because of dissipation of energy of the gas motion and spherization of magnetosphere when $V_s \gg V_{ff}$. The lower limit for the outflowing velocity is V_{ff}, i.e. the matter heated by a propeller will flow out with the parabolic velocity (Illarionov, Sunyaev, 1975; Davies et al., 1979).

In the region $R_A < R < R_G$ sectorial structure of gas motion is formed, i.e. in some sectors gas will fall onto the star, in some - it will flow out. According to the results of Wang and Robertson (1985) calculations the star sucks the gas in along the direction of rotation axis and expels it out along the equator. Moreover, the general picture of gas motion may be non - stationary.

All the above described effects are reliable only in the case of ionized ISG, as the stellar Magnetic field does not influence neutral gas motion. But the gas around the rotating magnetic star should be ionized. Firstly, the size of H II zone in the vicinity of A stars is about 1 pc (Kaplan, Pikel'ner, 1979), that is much more than R_Q. Secondly, there are ionized particles present in the gas even in the case of very dense and cold medium ($N_e/N_H \sim 10^{-3}$), for example, owing to cosmic rays ionization. This priming ionization is quite sufficient. Charged particles while interacting with the magnetic field of the star and gaining velocity about some thousand kilometers per second ionize the environmental gas, that would cause avalanche ISG ionization around the star. Gas stop in the shock behind the star also leads to origin of priming ionization.Interstellar grains are destroyed at a distance $R \sim 0.5\ R_*(T_*/T_d)^2$ from the star, where R_* and T_* are the radius and the temperature of the star.In the vicinity of AO stars the grains with evaporation temperature $T_d \sim 10^3 K$ are destroyed at a distance $R \sim 10^{13}\,cm$ from the star.Besides that, the dust will be destroyed and ionized in the shock behind the star, as when the collisions occur at 20 km/s and more, destruction and ionization of the grains take place (Kaplan, Pikel'ner, 1979).

3. THE REGIMES OF INTERACTION WITH ISG AND EVOLUTION OF ROTATION PERIOD

Various regimes of magnetic stars interaction with interstellar medium are possible (Lipunov, 1987). If the star possesses its own stellar wind, the gas is accelerated by the magnetic field of the rotating star (magnetic stellar wind) and blows ISG out of its vicinity. But nowadays there are no still sufficient proofs yet of stellar wind presence in A stars. According to the observed Ap stars rotation periods distribution (North, 1984), only the upper limit may be placed on probable stellar wind rate (Lipunov, 1987). Undoubtedly at early stages of evolution magnetic stellar wind was playing the dominant part in Ap star rotation braking. The relativistic ejector regime is also possible, when ISG is swept out by magnet-dipole radiation of a magnetic star formed at light cylinder. But this effect may be sufficient only for fast rotating Ap stars (Lipunov, 1987) with $P < 1^d$ and in the low density ISG, $\hat{n} < 1\ cm^{-3}$. For the main quantity of magnetic stars (maybe, for CP stars in general, as we will see below) three regimes are **important:**

1. The propeller regime, when $R_G > R_A > R_c$.
2. The accretor regime, when $R_A < R_c$ and the accretion onto the star is possible.
3. The georotator regime (Illarionov, Sunyaev, 1975; Lipunov 1982a; 1987), when $R_A > R_G$-In the last case the magnetic field of star shovels umperturbated gas out of the capture radius. We will dwell upon these regimes in detail.

The critical values of the star rotation period P_a at the propeller———> accretor transition, when accretion on star becomes possible, can be estimated, equating $R_A = R_c$. As at such transition the star is in the soft propeller regime ($V_s \approx V_{ff}$), to estimate P_a value it is necessary to use (5):

$$P_a = 2^{27/14}\pi\mu^{6/7}\dot{M}_a^{-3/7}(2GM)^{-5/7} \approx 8.9\cdot10^{3}\mu_{37}^{6/7}\hat{n}_1^{-3/7}m_3^{-11/7}\xi^{9/7}v_{20}^{9/7} \text{ days,} \qquad (7)$$

ISG accretion is possible only when $P > P_a$. We'll estimate the rotation braking rate of the magnetic star because of propeller mechanism. Braking torque is $\mu^2/3R_m^3$ (Lipunov, 1987). For the size of the star magnetosphere (R_m) in the case of hard propeller ($V_s \gg V_{ff}$ or $P \ll P_a$) we will take the expression (6), and in the case of soft propeller ($V_s \gtrsim V_{ff}$ or $P \lesssim P_a$) - the expression (5). The motion equation will take the fore:

$$I\frac{d\Omega}{dt} = -\frac{1}{3}\cdot\frac{\mu^2}{R_m^3}. \qquad (8)$$

For the inertia moment of the star we will take polytrope intertia moment with the index 3 (Burke, 1967)

$$I = 1.4\cdot10^{55}\, m_3 r_{2.5}^{2} \text{ g cm}^2. \qquad (9)$$

Integrating the motion equation for the case of hard propeller we get

$$P = \frac{P_0}{(1 - t/t_a)^{13}} \quad \text{when } P \ll P_a, \qquad (10)$$

where $t_a \approx 3.3\cdot10^{9}\mu_{37}^{-14/13}m_3^{4/13}r_{2.5}^{2}P_2^{-1/13}\hat{n}_1^{-6/13}\xi^{18/13}v_{20}^{18/13}$ years - the characteristical braking time. We must stress very weak t_a dependence on the initial period P_0 and sharp increase of the period when $t \approx t_a$. In the case of soft propeller the period is changed as follows:

$$P = \frac{P_0}{(1 - t/t_a)} \quad \text{when } P \lesssim P_a, \qquad (11)$$

where $t_a \approx 4\cdot10^{11}\mu_{37}^{-2/7}m_3^{-8/7}r_{2.5}^{2}P_2^{-1}\hat{n}_1^{-6/7}\xi^{12/7}v_{20}^{12/7}$ years. It is seen that with "standard parameters" accepted by us (see Introduction) the braking time exceeds lifetime of A stars ((3-7)*10^8 years), i.e. "standard" star, fitting these parameters will have no time to slow down its rotation during its lifetime. The braking time of the star vastly depends on the ξ V_0 value. V_Q value may be "standartized" - $< V_0 > = 20$ km/s, but the density and the temperature of ISG $\hat{\rho}$, ξ , may change in a wide range. During its lifetime a star may repeatedly occur both in very rarefied medium $\hat{n} \sim 10^{-2} - 10^{-3}$ cm^{-5} , $\hat{T} \sim 10^{6}$ K_f and in a dense and cold ISG phase: $\hat{n} \sim 10^{5} - 10^{6}$ cm^{-3}, $T \sim 10^{2}$ K. The braking of the star because of propeller Mechanism is comparable to or less than the star lifetime only in the case of dense and cold medium. We will not try to average ISG characteristics during the lifetime of a star here and to explain the observed distribution of Ap stars rotation periods. Such procedure of course would make sense. We will only draw the conclusion that Ap stars at the Main Sequence do not slow down their rotation at expence of interaction with IS6. These stars had slown down, but apparently - before they came into the Main Sequence (North, 1984). However, he effect of slowing down by the propeller should be for separate stars.

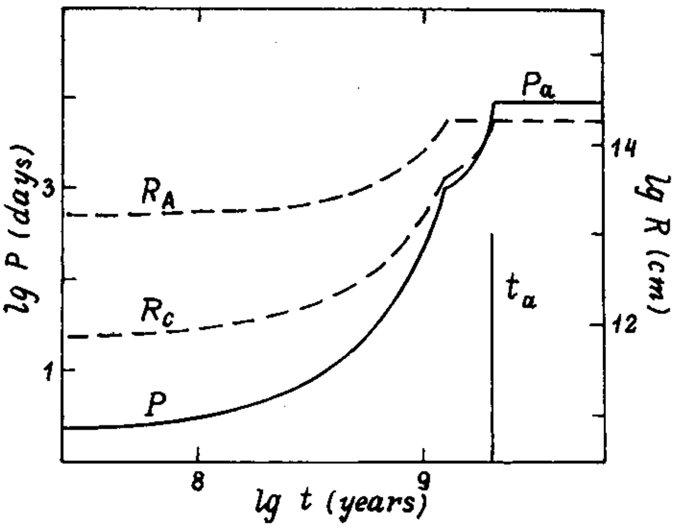

Fig.1. The time dependence of the rotation period (solid line) and Alfven and corotation radii (dotted line) at the standard star and ISG parameters. After t_a the rotation period is constant, accretion is possible.

The transitions propeller - accretor for magnetic stars are mainly determined by the parameters of the medium, through which the star passes. Really, from (7) it may be obtained that when ISG density is $\hat{n} = 10^{6}$ cm^{-3} the critical period for this transition is equal to $P_a \approx 24$ days, i.e. in dense interstellar cloud a star with rotation period $P > 24$ days (and with other standard parameters) will accrete ISG. During their lifetime stars may repeatedly change the regime of interaction with ISG. When reaching $R_A = R_c$ the gas is no more expelled by the magnetic field of the star, as it is rotating with Kepler velocity at this distance. At that time the envelope around the star may be formed, i.e. gas may be accumulated over the Magnetosphere. When accretion begins the magnetic field capturing gas transmits the angular momentum to the gas, as ISG has no momentum initially. The star is braked down at that time. But in the process of further falling of rotating gas, as Kepler velocity increases to the star $V_{ff} \propto R^{-1/2}$ and the solid one decreases as $V_s \propto R$, the gas in its turn, transmits to the field almost the whole angular momentum, i.e. accelerates the star. The effectiveness of braking in the considered case lowers by $\delta = \sin\beta\,(R_0/R_c)^2$ times. As $\delta < 1$, it may be believed, that at accretion stage the period of a star is not changed and is equal to P_a.

Figure 1 shows the time dependence of the rotation period (solid line) and Alfven and corotation radii (dotted line) at the standard star and ISG parameters. After t time the rotation period is constant, accretion is possible. The breakage of the curve is due to formula (10) made use at $P << P_a$ but (11) at $P \lesssim P_a$ (supposing $P_0 = 400$ days and $t_a = 2 \cdot 10^9$ years).

In the case of geo-like magnetosphere $R_A > R_G$, or gravitation plays no part in the star interaction with ISG. The case can be realized with the star entering the hot phase of ISG. Alfven radius may be estimated then equating $H^2/8\pi = \hat{\rho}\,(c_s^2 + V_0^2)$:

$$R_A = (2\pi)^{-1/6} \mu^{1/3} \hat{\rho}^{-1/6} (\xi V_0)^{-1/3} \approx 1.6 \cdot 10^{14} \mu_{37}^{1/3} \hat{n}_1^{-1/6} (\xi V_{20})^{-1/3}\ \mathrm{cm} \qquad (12)$$

From the inequality $R_A > R_G$ we can write down the condition, with which the magnetosphere of a star will be geo-like:

$$(c_s^2 + v_0^2)^{1/2} > 2.3 \cdot 10^6\ m_3^{3/5} \mu_{37}^{-1/6} \hat{n}_1^{1/10}\ \mathrm{cm/s} \qquad (13)$$

with standard parameters it means that ISG temperature $\hat{T} > 10^4 K$, i.e. magnetosphere is geo-like, when the star passes a hot ISG phase. In this case ISG accretion is also impossible, but braking is less effective than in the case of propeller. From (8) and (12) one may obtain that the dependence P(t) is the same, as (11), but the braking tine of the georotator is equal to $t_m \approx 3 \cdot 10^{11} \mu_{37}^{-1} m_3 r_{2.5}^2 \hat{n}_1^{-1/2} (\xi v_{20})^{-1} p_3^{-1}$ years. The effectiveness of braking is so low, that we will not make a serious mistake supposing that the rotation period of the star does not change. The same as in the propeller case (11), the georotator braking time is comparable to the lifetime of a star only for very long periods $P_0 \sim 10^3$ days, or the case of dense ISG (the latter is true only for propeller).

Thus, ISG accretion on Ap stars is practically impossible, it is hindered by the magnetic field or a rotatinq star, Rotation deceleration of star owing to propeller mechanism is not effective. The reasons of CP-stars slow rotation might be found in the mechanisms having worked before the star appearance on the Main Sequence, (North, 1984), when the star is actively exchanging gas with interstellar medium. Most perspective and effective braking mechanism at this stage is Magnetic stellar wind (the regime of non-relativistic ejector (Lipunov, 1987)). On the other hand, the star passing trough dense and cold ISG phase, the effectiveness of star rotation deceleration abruptly increases. Besides that, the star may begin to accrete gas. What regime is realized at the moment: propeller, accretor or georotator - is mainly determined by local interstellar medium parameters.

4. APPLICATIONS TO CHEMICAL ANOMALIES FORMATION.

It is well-know that chemical peculiarities (CP) are surface phenomena. This conclusion follows, for example, from CP stars location at GR diagram and CP stars rotation periods distribution (Borra, Landstreet,Mestel, 1982). At high temperatures (B stars) the mass loss owing to stellar wind sharply increases, which hinders CP formation. And helium anomalies may also change. At low temperatures (F stars) the depth of convective zone is increased, and the convection goes out to the surface, that also hinders CP formation. At fast rotation (VsinI > 100 km/s) another effect of mixing appears - meridional circulation. All this speaks in favour of chemical anomalies in the stars being located on the surface.

Most natural mechanism of CP-formation is the elements diffusion under the influence of light pressure and gravitation forces (Michaud, 1970). Quite attractive feature of this mechanism is its muitiparametrity. This means, that the resulting CP in the atmosphere depend (in a number of cases non-linearly) on many parameters (on temperature, mass, rotation velocity of the star, mass loss rate, accretion rate, magnitude and structure of the magnetic field, size and location of the convection zone, initial anomalies of chemical elements and so on): Many authors have investigated the influence of accretion, mass loss, meridional circulation on the diffusion (Vauclair , 1981; Havnes, Conti, 1971; Rajamohan, Pati, 1979; Gutrie et al., 1984; Michaud et al., 1987).

Here it is important for us that if there goes ISG accretion onto a star, then the chemical composition of its atmosphere may be renewing for a very short time. Really, in the A stars which helium convection zone does not go out to the surface the optical depth about 1 is reached at $N \sim 10^{23}$ cm^{-2}(Allen, 1977). The lines in stellar atmosphere are formed up to the optical, depth of $\tau \approx 0.2$ (Michalas, 1978). Using (2) we will find the time of stellar atmosphere renewing with interstellar gas:

$$t = \frac{4\pi R_*^2 N(\tau) m_H}{\dot{M}_a} \approx 700\ \tau_{0.2} r_{2.5}^2 m_3^{-2} \hat{n}_1^{-1} \xi^3 v_{20}^3 \text{ years} \qquad (14)$$

We will give only simple estimates here and will not find critical accretion rates, upper which accretion changes the chemical composition in the whole convection zone of the star (Vauclair, 1981).

We have found above an expression for critical rotation period of the star (7), such, when $P > P_a$ the star becomes accreting. Interesting opportunities are casing if from (7) to find an expression for critical magnetic field at the star s pole, such, when $H_Q < H_a$ the star accretes ISG, and when $H_Q > H_a$ the propeller forbids accretion:

$$H_a \approx 0.6\, m_3^{11/6}\, P_2^{7/6}\, r_{2.5}^{-3}\, \hat{n}_1^{1/2}\, \xi^{-3}\, v_{20}^{-3}\, . \mathrm{Gs.} \qquad (15)$$

Critical magnetic field strength is very low, the field about 1 Gs is far beyond the limits of modern equipment recording magnetic fields on stars.

We consider important the suggestion that <u>all CP stars have regular magnetic field greater than the critical one (15).</u> Then ISG accretion on them is impossible, and diffusion mechanises create in their atmospheres chemical composition anomalies. On the other hand, the stars which potentially could become CP stars (i.e. stars of spectral classes from late B to early F and possessing low rotation velocities VsinI < 100 km/s) but having the magnetic field less than the critical H_a are accreting ISG. Diffusion mechanism in this case cannot create CP in their atmospheres. The gas in accreting stars atmospheres will have the chemical composition of the local ISG. We consider extremely low probable that the dispersion of ISG chemical composition can be so large (see review Pagel, Edmund, 1987) that the atmospheric composition of accreting stars will strongly differ from the normal one. If to suggest even that CP in the atmospheres is formed because of IS6 accretion, it is not clear, why similar anomalies on stars (and namely such), as, for example, Sr-Cr-Eu or Hg-Mn ones occur in different places of the Galaxy. Apparently, all the CP stars satisfy the condition (15) and if the star begins to accrete IS6, the chemical composition of its atmosphere becomes "normal" and we classify it as a normal A star. Though it is possible, that the dispersion of chemical composition of accreting A stars will be somewhat different from the dispersion of chemical composition of normal ordinary A stars.

Thus, to the mechanisms controlling the diffusion operation and occurrence of chemical anomalies in the atmosphere the expression (15) should be added. Depending on the parameters of the star and of local interstellar medium the star may have CP ($H_0 > H_a$, no ISG accretion, diffusion is going) or not ($H_0 < H_a$ ISG accretion is going). In the frames of our discussion the appearance of "normal" A star with slow predicted rotation can be understood. They might be accreting A stars. A star may repeatedly change its atmosphere chemical composition during its lifetime depending on the parameters of local IS6 and star magnetic field magnitude H_0.

Let's consider the predictions that can be made on the basis of our discussion.

1. The problem of long periods in CP stars is well-known. Now 8 stars are known with $P > 100^d$ and two stars with $P > 1000^d$ (North, 1984; Catalano, Renson, 1988). The search for long periods is possible only with AP stars (with spot on the surface). Naturally, observational selection should lead to shortage' of such stars,as to find a large period durable and uniform observations are necessary. As long-period stars are Ap stars, it is necessary to draw a conclusion, that their periods are less than P_a (7) or $H > H_a$ (15), i.e. these stars are accreting ISG. *) If the rotation period increases further according to (11) or star enters a core dense ISG phase, the condition $P = P_a$ is satisfied, and the star does not retain its CP features. So, there may exist a class of accreting stars, possessing strong magnetic field and possessing very long rotation periods. These stars are to be searched for among the normal A stars with anomally small line widths (VsinI) by the criterion of large magnetic field presence. Special search in this direction is considered highly significant by us.

2. A number of other predictions based on regulation by a potential accretion rate $\dot{M}_a$ of transitions CP <—> "normal" for the stars with $P \approx P_a$ or $H_0 \approx H_a$. The more is the value $\dot{M}_a \propto \hat{\rho} (\xi' V_0)^{-3} M^2$, the higher is the probability of becoming accreting for such a star. As follows from (15), the critical value of the magnetic field on the pole depends on these parameters in the following $H_a \propto \dot{M}_a \hat{\rho}^{-1/4} M^{-1/6}$. From here it may be found, that CP stars distribution in the 6alaxy versus to Z - coordinate must be different from that of normal stars of apropriate spectral classes: Z - coordinate of CP stars should be higher. Really, with increase of distance from the galactic plane the average ISG density ($\hat{\rho}$) falls; its temperature (ξ) and velocities stars dispersion (V_0) increases. All this noticeably decreases the potential accretion rate onto the star, and the star with $H \approx H_a$ may stop accreting ISG, or become CP star. Now the data are available, that Z - coordinate of Ap and Am stars is higher than in normal stars of apropriate spectral classes (Bartaya, 1979; Bond, 1970).

3. In framework of our consideration the appearance of run away Ap star i.e. Ap stars with large value of V_0 (Jaschek, 1983) can be understood. Really, the accretion rate onto star depends on the velocity as V_0^{-3}. Of all A stars, which can potentially become Ap stars (i.e. not accrete ISG) due to the criteria (13) and (15); the stars with larger velocities possess all the opportunity to turn into them. Therefore the appearance of a high speed wing in Ap stars distribution along V_0 is possible. Naturally, this problem requires statistical investigation. In this connection the anomal location of Ap stars (Lebedev, 1987), with large spatial

*) Undoubtedly, the detailed spectra investigation of these stars aiming to find probable differences from normal Ap stars is of interest. For example, if the star period is close to the critical one, appearance of emission details in its spectrum because of the envelope beyond the magnetosphere formation is possible.

velocities at Δa - Be diagram is interesting. Fast moving stars are singled out with their faint dependence of the effective magnetic field Be on the λ5200 depression magnitude (Δa).

4. We will consider how the potential accretion rate M_a onto star in cluster is changed. As typical size of open cluster (about 2 - 3 pc) essentially exceeds the capture radius for the star (1), then belonging of the star to a cluster does not anyhow change the potential accretion rate onto a star. Velocity dispersion of the open clusters in the Galaxy (V_0) appears to be much lower then of field Ap stars (Allen, 1973). Some investigators show that Ap stars occurrence in the clusters is lower than in the field and even may depend on the cluster age (Abt, 1979; Maitzen, Wood, 1983). We will show some effects which may influence on the CP stars occurrence in the clusters. Firstly, by analogy with p.2 of this part with the increase of Z - coordinate of a cluster (this value is associated with the cluster velocity in the space and with the cluster age) possible accretion rate onto star decreases. Owing to that a dependence of CP stars occurrence in a cluster upon Z - coordinate of a cluster may appear. Other effects depend on the cluster age and on the position of the star in a cluster: accretion of gas remained after star formation is possible.

With time the cluster should loss the residual gas, that is particularly facilitated with IS6 blowing by hot 0 - B stars of the cluster. These effects are rather difficult to account for at present, additional data on CP stars occurence in clusters, on the dependence of this value on the age and position of stars in the clusters are needed.

5. As it was mentioned above, on the base of our consideration it may be suggested that the chemical composition dispersion of the accreting "normal" A stars will be different from chemical composition dispersion of ordinary A stars. This is true for relatively slow rotators, as in the case of fast rotating stars (Vauclair, 1980), the influence of meridional circulation mixing the gas is strong. So, it is possible that the gas in the atmospheres of slow rotating normal A stars has the chemical composition of local ISG. It is possible, that the raised chemical composition dispersion of normal A stars (Eggen, 1984) is associated namely with this effect.

Basing on these considerations it say be predicted that the chemical composition dispersion of the atmospheres of normal A stars of one cluster will be less, than in the stars of different clusters. Panchuk and Klochkova (1985) mentioned the similar effect using the example of stars of seven open clusters.

6. Interesting is the question on the propeller influence on IS6. Energy loss of the propeller is (Lipunov, 1987):

$$\dot{E} = \frac{1}{3} \cdot \frac{\mu^2}{R_m^3} \Omega, \qquad (16)$$

where the magnetosphere radius R_m, as it was already said, is determined not quite accurately (see (5) and (6)). Assuming for R_m value the expression (6), we will obtain:

$$\dot{E} \approx 2.5\cdot 10^{30} \mu_{37}^{16/13} P_2^{-25/13} m_3^{9/13} \hat{n}_1^{6/13} \xi^{-10/13} v_{20}^{-18/13} \,\mathrm{erg/s}. \qquad (17)$$

Such amount of energy is lost by the propeller in heating and acceleration of ISG. The magnetic star leaves a trace or a corridor of heated ISG behind it. The width of this corridor R_{cor} may be roughly estimated when equalling the pressure in it $\dot{E}/\pi\ R_{cor}\ V_Q$ to the pressure of non-perturbated ISG. Assuming the temperature of ISG $\hat{T}$ 10^4 K with all the standard parameters values from (17), we will obtain $R_{cor} \sim 5\cdot 10^{17}$ cm. More detailed considering of the question does not fall into the frames of this paper, but it should be mentioned that probably some magnetic stars due to this reason may be faint soft extended X-ray sources with thermal spectrum. It is interesting,that some Ap stars are found in X-ray band (Golub et al., 1983). X-ray luminosities of two single Ap stars ω Oph and β Scl are equal to lg $L_x \approx 29.0$ and 29.4 respectively, which seriously exceeds probable coronal luminosity. These authors make the conclusion, that Ap stars are stranger X-ray sources, that Am and normal A stars (in the latter ones in the average <lg L_x> ~ 27 + 28).

5. CONCLUSION.

Thus, ISG accretion cannot go onto rotating magnetic stars, the gas should be effectively expelled by the propeller mechanism. Star rotation braking is highly ineffective in this case. Therefore we approve the conclusion that Ap stars had acquired their **slow** rotation before they came to the Main Sequence, when the star actively exchanges the gas with the outer environment. The most perspective star rotation braking mechanism in this stage is magnetic stellar wind. Critical value of star rotation period, when accretion is possible, corresponds to dozens of years, and critical magnetic field strength is only a few Gs. If ISG accretion starts onto a CP star, then in a relatively short time (some hundreds years) ISG covers CP gas in star atmosphere. And CP star for the observer may turn a normal star or a star with weak chemical anomalies in the atmosphere. What regime is the star in - accretor or propeller - is defined both by the star (μ ,P ,V_Q) and ISG parameters ($\hat{n}$, $\hat{T}$). The appearance of stars with strong magnetic fields, completely braked their rotation, accreting ISG and possessing therefore normal chemical composition of the atmosphere, is possible. Basing on our consideration the conclusion of CP stars distribution along Z-coordinate of the Galaxy being probably anomalous, can be drawn; run away Ap stars appearance can be understood. We also suppose that the dispersion of chemical composition of normal A stars inside a cluster will be lower than between different clusters. It is probable, that Ap stars are faint extended X-ray sources, as the propeller perturbates and heats the interstellar gas.

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