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ATMOSPHERIC PARAMETERS AND EVOLUTIONARY CP STARS. I.21 COM FROM THE OLD COMAE BERENICES CLUSTER

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On the basis of Hipparcos observations and complex observations carried out at the Shamakhy Astrophysical Observatory named after N. Tusi of the National Academy of Sciences of Azerbaijan, the main parameters of the atmosphere and the evolutionary status of the magnetic CP star 21 Com from the old Comae Berenices cluster have been determined.Almost all atmospheric parameters are determined taking into account the peculiarity effect - the presence of large chemical anomalies and a strong magnetic field (Be≈1000 G). By comparing the phase curves of the magnetic field (Be), brightness (V), and equivalent widths (Wλ) of the Sr, Cr, and Eu lines, which are the main peculiar elements of the star, we determined the phases (0.95) of the maximum peculiar (P) and normal (0.45) area (N) on the surface of the star.When constructing the phase curves, we used observational materials obtained at ShAO with the use of data taken from previously published works.

To determine the absolute magnitude (M_v = 0.565) and the evolutionary status of the 21 Com star, the parallax value (π) was taken from the Hipparcos observations. It was found that it is located closer to the upper boundary (TAMS) of the MS band, where old pro-evolved magnetic CP stars are located (17 Com A, HD144897, HD177765, HD 204411, etc.

The paper discusses the question of when (or at what stage of evolution) a magnetic star acquired its anomalous chemical composition and other peculiar features (a decrease in the rotation rate and balmer jumps, a strong magnetic field, etc.)

Keywords: magnetic stars– parameters of the atmosphere–evolutionary status.

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1. INTRODUCTION

Most of the published work to date has shown that magnetic chemically peculiar (MCP) stars belong to the Main Sequence (MS). In general, a number of works note that the main (fundamental) parameters of the atmosphere of these stars (with the exception of the rotation rate), on the whole, do not differ much from the atmospheric parameters of normal stars of the same spectral types.
In the 1980s, a large series of studies was carried out under the leadership of IM Kopylov (for example [1]), in which it was noted that during the life of MSR stars on the MS, they do not change either the degree of peculiarity or the rotation rate. In the subsequent series of these works [2], it was found that the magnetic field at the MS stage does not differ in stars - members of young and old star clusters.
However, in some works, these results were questioned. For example, in [3], the evolutionary status of a number of MCP stars was determined. It was found that stars over 3 (three) solar masses are evenly distributed across the entire MS band, while stars with less than 2 solar masses tend to concentrate towards the center of this band. Hubrick et al. [4] noted that MCP stars with masses less than 3 solar masses in the Hertzsprung – Russell diagram differ in detail from the distribution of normal stars of the same temperature.There is still no clear picture of the evolution of the magnetic field and the chemical anomaly during their stay at the MS.It should be noted that the question of the evolution of magnetic fields has not yet been supported by sufficiently reliable observational data. The question of what is the difference between magnetic and nonmagnetic chemically peculiar (CP) stars and their evolutionary features has not yet been finally resolved. Of particular interest is the question: Do the peculiar features - the intensity of the magnetic field and the lines of peculiar elements and, accordingly, the chemical anomaly of the MCP-star change during their stay at the MS. From the modern point of view, a more important question is what exactly what basic parameters of MCP stars undergo changes during their lifetime on the MS. Therefore, it is natural to consider the problem of studying the atmospheric parameters and evolution of MCP stars belonging to clusters of different ages.
Based on this, we decided to study the main (peculiar) characteristics of two magnetic CP - stars 17 Com A and 21 Com, belonging to the old ($\log t = 8.7$) Coma cluster (Veronica's Hair). In this paper, we present mainly the results of a study of the magnetically variable star 21 Com. The aim of this work is to determine the fundamental parameters of the atmosphere and the evolutionary status of the21 Com MCP star and to compare the data obtained with the results for MCP of stars of this type of peculiarity of different ages.
The star 21 Com HD = 108945 = HR 4766 = HIP is one of the brightest (mv

= 5.45) magnetic stars of the A3p spectral class with the Sr,Cr peculiarity type. Complex observations have shown that it is a photometric, spectrally and magnetically variable star with a period of P = $1^d.026$. [5]

2. OBSERVATION AND PROCESSING

In this work, we used the materials of spectral observations carried out on the 2-m telescope of the ShAO National Academy of Sciences of Azerbaijan. To date, a large number of high-quality spectra have been obtained in two versions:

1. With the help of traditional photographing of spectra (4 Å/ mm);
2. Using an echelle spectrometer (ShAFES) mounted at the Cassegrain focus. About 10 spectra were obtained with a resolution of R = 55000 and two spectra with a resolution of R = 27500. Detailed information about the equipment and processing technique is presented in [6].

Photometric observations of the 21 Com star were carried out by Wolff et al. [7] over 12 nights in 1970, February - March. Observations were made in the Y, B, V and U system which are close in the Kitt Peek system. The phases of the period ($P = 1^d.026$) were determined by the ephemeris JD = 2440630.03 + $1^d.026E$. The value of this period was obtained even earlier by Dautsh A. (1955) from the change in the intensity of the KCaII line.

In April - July 1971,23 photographic spectrograms of dispersions of 4 Å/mm in the wavelength range $\lambda\lambda$3700 - 4700 ÅÅ were obtained at the focus of the Kude 2-meter telescope of the National Academy of Sciences of Azerbaijan. All spectrograms are evenly spaced in the phase of the rotation period ($P = 1^d.026$). Hydrogen lines were processed, the equivalent widths of which show synchronous changes in phase [8].

3. DETERMINATION OF ATMOSPHERIC PARAMETERS TAKING INTO ACCOUNT THE PECULIARITY EFFECT

The parameters of the atmosphere, determined using observational data obtained from a star inhomogeneous over the disk, do not correspond to the real values of these parameters either in the peculiar (spotted) or normal (outside the spotted) regions. Consequently, when determining the parameters of the atmosphere of MCP stars, it is necessary to take into account the effect of the peculiarity (inhomogeneity over the surface) of these stars. For this necessary to determine the phases corresponding to the most peculiar (spotted) (P) and relatively normal (N) regions on the surface of the star. For this, the phase curves of the brightness variation (V) and equivalent widths (Wλ) of the Ca, Sr, Cr, and Eu lines, which are peculiar elements of the 21 Com star, were compared.

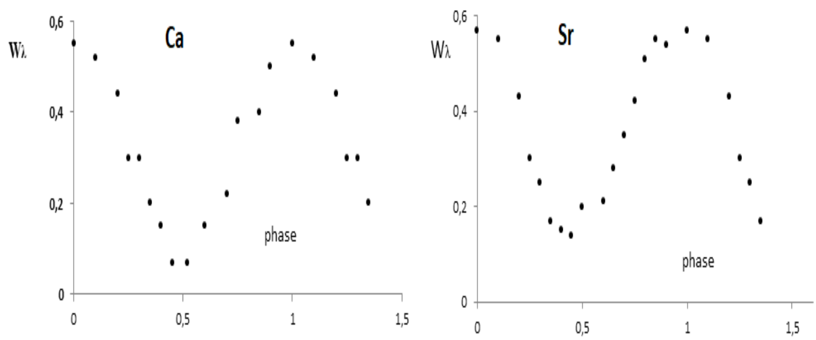

Fig. 1. Phase curves of the equivalent widths of the CaII and Sr II.

As an example the phase curves of the equivalent widths of the CaII (λ3933)Å, Sr II (λ4215 Å) lines (Fig.1) and phase curves of the light (UVBY) (fig.2) are presented. It can be seen from these figures that the phases of the extreme for all plotted dependencies almost coincide ($\Delta\phi \approx \pm$ 0.05).

By comparing the constructed phase curves, we were able to determine the phases of the extrema of the constructed dependences. According to the oblique rotator model, the phase of the maximum (ϕ = 0.0-0.01) of these values corresponds to the most peculiar (P) region, and the phase of the minimum (ϕ = 0.45 - 0.55) relative to the normal (N) region on the surface of the 21 Com star (see Table 1).

Almost all the parameters of the atmosphere, indicated in Table 1, were determined, taking into account the peculiarity effect, on the basis of observational materials obtained at the of the National Academy of Sciences of Azerbaijan with the use of literature data [7]. The effective temperature T_{eff} and the acceleration of gravity g were determined from the hydrogen line profiles (α, δ) and photometric indices in the Johnson and Stromgren systems (UVBY). The found values for the T_{eff} and (lg g) values are presented in Table 1.

The radius of the star were calculated from the found effective temperatures (for T (P) and T (N)) according to the formula $logR = 8.46 - logT_{eff}0.2M_{bol}$ where M_{bol} is the bolometric magnitude M_{bol} = V + ΔM_{bol}. Bolometric correction ΔM_{bol} was determined by extrapolation using Straizys data [9].It is known that the average rotation speed vsini of MCP stars is 2-4 times lower than vsin i of normal stars of the same spectral types. It is still unclear for what reason and at

Table 1. The main parameters for the peculiar and normal atmospheric region of the magnetic star 21 Com.

Parameters	P	N
Phases corresponding to the peculiar (P) and normal regions of the atmosphere.	0.05-0.15	0.5-0.6
Fundamental parameters atmosphere T_{eff} and log g found from hydrogen line profiles	9200 4,91	8400 4,77
Fundamental parameters atmosphere found by photometric indices.	9000 4.04	8200 3.88
Radius found by Tef(P) and Tef(N)	2.23	2,67
Projection rotation speed onto the line of sight-V_eSin i. (km/s)	78	60
Effectiv magnetic field (Be) obtained with the help of the Zeeman analyzer(G)	-400	+537
Spectral Peculiarity indexes P(E) for peculiar elements Cr, Sr, Eu.	2.70, 4.80, 2.85	2.20, 4.45 2.50
Luminosity Log L*/ L_0	1.73	

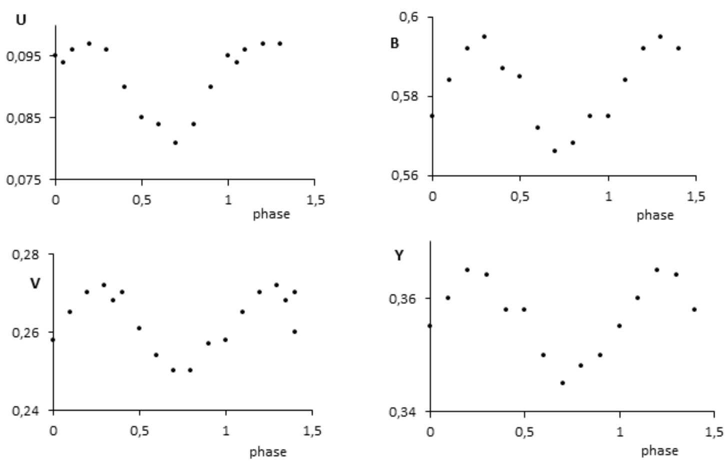

Fig. 2. Phase curves of the light (UVBY) for the 21Com.

what stage of the evolution of MCP - stars lose most of their angular momentum. Therefore, we considered it expedient to determine the projection of the rotation velocity on the line of sight (vsini) for the 21 Com A, star, taking into account the peculiarity effect.The rotation rates for this star were determined (see table1) from the half-widths of the MgII λ4481 Å and FeI λ4476 Å lines for which the Lande factor is less than unity (g ≤1.05).

The longitudinal component of the magnetic field for 21 Com varies from -350G to + 440G [10]. The work [11] also presents the extreme values of the effective magnetic field Be = -400/+ 537G.

To quantitatively characterize the anomalous chemical composition of the 21 Com star's atmosphere, we used the spectral peculiarity indices P(E) [12]. The index P(E) =W(P)/W(N) characterizes the quantitative measures of the enhancement of the line of a peculiar element in the MCP spectrum of the star. In the atmosphere of the star under study, the main peculiar elements are Sr, Cr and Eu. Therefore, the P(E) values were determined for these elements and the found values are shown in Table 1.

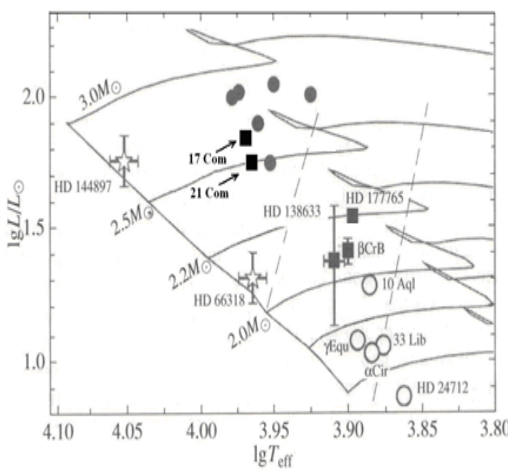

Fig. 3. Establishing and Evolutionary status of 17 Com and 21 Com stars on the Hertzsprung-Russell diagram.

To determine the evolutionary status of the 21 Com A star, its luminosity was calculated using standard relationships. $Lg(L^*/L_0) = 0.4(M\text{-} M^*)$, where M is the absolute stellar magnitude of the Sun equal to $4^m.8$ and Δ bol =-$0^m.1$. The absolute stellar magnitude is v = 0.82, and its luminosity is log $L/L_0 = 1.725 \pm 0.15$.

Using the found values of luminosity and effective temperature, the location of the 21 Com star on the Hertzsprung-Russell diagram was established and this its evolutionary status was determined. It was found that it is located closer to the upper boundary (TAMS) of the MS band (Fig.3). In this diagram, the black square with an arrow marks the position of the 17 ComA and 21Com stars, where the evolved MCPs are located - the stars marked with black circles. This group also includes a number of old stars, such as HD8441, HD5797, HD40711, HD103498, HD204411, etc.

This group of stars is characterized by strong and numerous lines of the iron peak elements in the spectra. However, the lines of rare earth elements are somewhat weakened in comparison with others. In the diagram, asterisks indicate stars with strong magnetic fields (HD66318 and HD144897).These young stars have a strong magnetic field, in the spectra of which there is a high abundance of both the elements of the iron peak and rare earth elements. They were selected by the authors of [13] for comparison with the evolved MCP stars. Open circles indicate classical pulsating magnetic stars. The position of these stars on the MS near the zero age line indicates that they are young MCP stars. The results of determining the spectral index of the peculiarity of these stars show a strong excess of the abundance of silicon, iron, and especially rare earth elements (Eu, Nd, etc.). When constructing the diagram, the data from work [13] were used.

4. CONCLUSION

According to the above facts, the following conclusion can be made.

1. It has been found that 21 Com magnetic stars are evolved stars that are approaching the end of their life on the MS2.

2. In the spectra of this star, the intensity of the magnetic field ($\Delta Be \approx 1000G$) and the lines of rare-earth elements are approximately two times weakened in comparison with young magnetic CP-stars.

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ECLIPSING EVENT IN BINARY CTTS TYPE STAR AS 205N

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The results of new photometric observations of the classic T Tauri type star AS 205N, carried out in the 60 cm ShAO telescope, are presented. It was shown that the existence of a period of 24 days is confirmed for individual observation seasons, but this period has stochastic components. We have constructed the spectral energy distribution of the star in the range 0.36-100 μm. Significant infrared radiation is detected in the near and far infrared spectral regions. The excess is also observed in the UV range of the spectrum. The results of the analysis show that, apparently, AS 205N has a cooler component - a star with spectral type M or a low mass brown dwarf, with a temperature of about 2000±500 K.

Keywords: dwarf stars – infared regions – instrumentation system

1. INTRODUCTION

AS 205A = AS205N (V866 Sco) is a young late K5 type dwarf star with an average brightness V = 12.4 mag belongs to a hierarchical triple system. At an angular distance of 1.3" (≈180 AU at 140 ps) from AS 205N, there is a low-mass K7/M0 spectroscopic binary star [1–3]. According to [4], there are two stable periods ($P_1 = 6.78$ and $P_2 = 24.78$ days) on the master light curve of AS205N. The P_1 period is a typical CTTS rotation period that can occur due to the presence of cold spots on the star's surface. In this case, U-B color variability in anticorrelation may be a sign of chromospheric emission and a cold spot. The phase diagram of the P_2 period shows the modulation of brightness and red colors, which is an indication of the presence of a cold source. Since AS 205N is about

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2 magnitudes brighter than AS 205S [5] in the V band, the observed brightness modulation (V = 0.25 mag) belongs to the primary star, or its envelope. The mass of the star AS205N, obtained from the relation between temperature and bolometric luminosity [6], and from the evolutionary tracks of Baraffe et al. [7] expected to be 0.9 M. According to Artemenko et al. [4] Period P_2 must belong to the unknown close component AS205N, which is disturbing the accretion disk with dense waves. According to IR interferometry data [3], [6], the semi-axis of the orbit was predicted to be about 0.18 AU, which is close to the inner radius Rin = 0.14 AU. Artemenko et al. [4] explained the brightness variability with the period P_2 due to the effect of scattering or extinction of the disturbing disk at the radius of dust sublimation.

In this paper, we present the results of an analysis of photometric observations of the star obtained in the data archive and partly at the ShAO.

2. OBSERVATIONS

Photometric BVRcIc observations of the star were carried out with the Zeiss-600 telescope of the Shamakhy Astrophysical Observatory named after N. Tusi of the Azerbaijan National Academy of Sciences. A detailed description of the telescope together with the photometer was presented in [8,9]. After that, the equipment of radiation was changed. The photometer is now equipped with a CCD FLI 4000×4000 camera. The aperture of the telescope is 1: 12.5, the Cassegrain focus is F = 7500 mm. In this case, the scale on the focal plane of the camera was 27.5"/mm. Taking into account the size of one pixel 9 μm = 0.009 mm, for the per pixel resolution we have get 0.247". During observation, depending on the image quality, we used the binarity of the pixels 2×2 and 4×4, which for the resolution, respectively, allow to get 0.49" and 0.99". The total field covered by the camera was about 30', and the effective linear area in the focal plane was 17'×17'. The whole process of observation and processing of the material was carried out using the MaxDel program. Typical average measurement errors for individual bands were ± 0.008 mag for V and Rc, ± 0.03 mag for B, ± 0.04 mag for Ic bands.

For reference to the Johnson international system, star fields of a group of standards from the Landolt list were observed in 2019 [10]. Figure1 shows transforming plots from instrumental system to the standard the system. The formulas for transformation of our instrumental system to the international BVRcIc system are as follows: