RECENT ACTIVITY OF THE SYMBIOTIC STAR AX Per

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ABSTRACT. Echelle medium high dispersion spectroscopy and UBV photoelectric photometry of the symbiotic star AX Per, carried out in the period November 1989 to March 1990, are presented. Maximum of the star's brightness (V=9.28, B-V=0.58, U-B=-0.40) was observed in December 1989. Deep minimum (0.4 to 0.5 mag) was observed in all filters during January 7 to March 1990. It was interpreted as the eclipse of the cool component by the hot one. The radius of the red giant (160 $R_\odot$) and the radius of the hot object (105 $R_\odot$), contributing in U and B colours, were determined.

No high excitation lines were observed. Absorption shell spectrum of once ionized metals (Ti II, V II, Sc II, Cr II) and neutral metals (Fe I, Ti I, Cr I) were present. Emission line spectrum was characterized by the Fe II, [Fe II], and H I lines. Secondary emission component in the red emission wings of the Fe II and H I lines was observed.

1. INTRODUCTION

AX Per is the eclipsing binary symbiotic star consisting of a rather masive (~3 $M_\odot$) M type giant and a Main-Sequence star (~0.6 $M_\odot$) (Iijima, 1988). Kenyon and Fernandez-Castro (1987) classified the cool component as M (5.2 ± 0.4) II or III giant. Kenyon (1982) analysed photographic light-curve obtained by Mjalkovskij (1977) and found a strong periodicity of 681.6 days with the ephemeris: JD_{min} = 2 436 679.4 (±8) + 681.^{d}6 (±7.2) x E. This minimum was interpreted as the

eclipse of the hot component by red giant.

AX Per has been intensivelly monitoring photographically from 1887 and its light-curve was discussed by many authors (Lindsay 1932, Wenzel 1956, Seidel 1956, Mjalkovskij 1977). The historical range of the light's variations was 9.4 to 13.4 mag. Owing to the lack of the photoelectric UBV observations, the symbiotic star AX Per was included among the suggested objects in the Campaign of long-term photometry of symbiotic stars (Hric and Skopal, 1989).

Optical spectra of the AX Per are characterized by deep absorption bands of TiO and emission lines of H I, He I, He II, Fe II, [O III], [Fe VII] (e.g. Boyarchuck,1966; Iijima, 1968). But when the star's brightness increase, the high excitation lines fade (Kenyon, 1983).

In November 1989 the brightness of AX Per increased (Vittone, 1989). New UBV photoelectric photometry and middle-dispersion spectroscopy were carried out. The changes in the light curves and the line spectrum are discussed.

2. OBSERVATIONS

Photometric observations of AX Per were made in the standard UBV system using a one-channel photoelectric photometer installed in the Cassegrain focus of the 0.6/7.5 m reflector of the Skalnaté Pleso Observatory, operating on the principles of the method of pulse counting. HD 10063 (SAO 22481), V=7.39, B-V=0.25, U-B=-0.33 was used as the comparison star and SAO 22444, m_v=7.8, m_{pg}=8.3, as the check star. The measurements were reduced to the international system and are shown in Fig. 1. Each value represents the average of the observations made during one night.

Optical spectroscopy were made in the coudé focus of the 2-m telescope of the Astronomical Institute at the Ondřejov Observatory. 3 spectrograms of medium high-dispersion (1.7 nm/mm) covering the optical spectrum region from 355 nm to 490 nm were obtained.

3.RESULTS AND DISCUSSION

Our UBV photometry is shown in the Fig. 1. In December 1989, the star's brightness reached its maximum: V=9.28, B-V=0.58, U-B=-0.40.At the period January 8 to February 22 1990, the gradual decrease of the brightness in all filters by about 0.4 to 0.5 mag was observed. Thereafter the flat minimum, V=9.63, B-V=0.73, U-B=-0.50 for 24 days was indicated. Such behaviour of the light curves can be interpreted as an eclipse of the cool component by the hot component. A small difference between the orbital phase 0.5 (Kenyon's ephemeris) and the observed minimum may be caused by the inaccuracy of the Kenyon's ephemeris or by the eccentricity of the orbit, which was assumed to be zero (Iijima, 1988) or by the additional radiation source displayed on the red giant hemisphere, but not to be faced to the hot component accurate.

We derived the contact times t_1= JD 2447895, t_2= JD 2447945, t_3= JD 2447969

and from the symmetry of the minimum we assumed t_4= JD 2448019. According to Iijima (1988) the distance between the components is 487 $R_\odot$ (i=90°) and M_{cool}=2.83 $M_\odot$, M_{hot}=0.51 $M_\odot$. It yields the radius of the red giant of 160 $R_\odot$ and the radius of the hot object contributing in U and B colours, of 105 $R_\odot$.

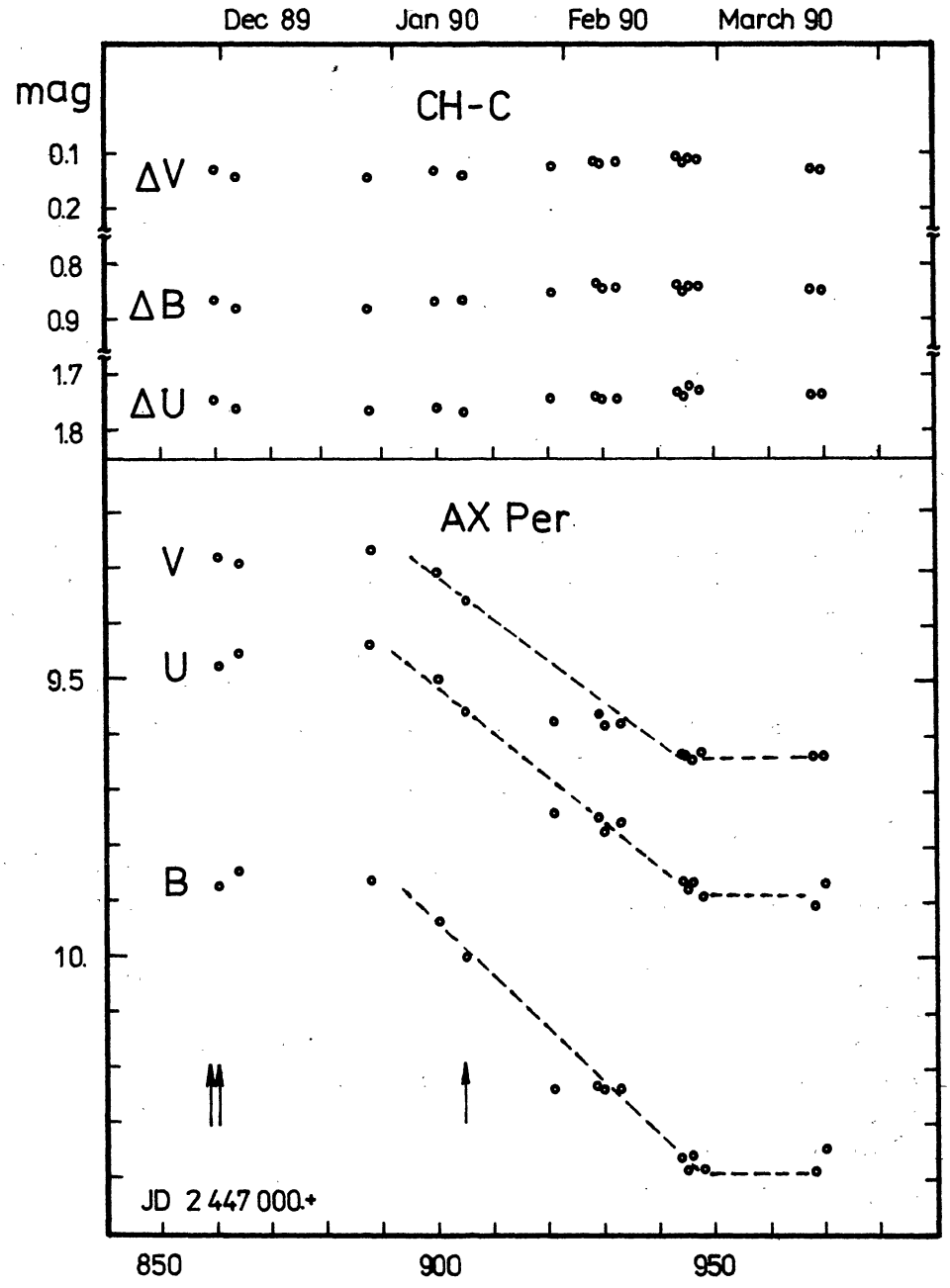

Fig. 1. UBV photometry of the symbiotic star AX Per. The star's brightness difference of the check (CH) and comparison (C) stars are shown at the top of figure. Time of the spectroscopic observations is denoted by arrows.

The facts that the minima in U and B light curves are deeper than in the V light curve and the eclipsed star is the M5III giant, implicates the existence of an additional radiation source in these spectral bands placed between the binary components. The shape of these minima, determining its geometry, seems to be a result of the eclipse of the cool component by the hot component. So, this additional source of the U and B radiation is probably displayed on the whole cool giant hemisphere. This phenomenon can be explained by the reflection effect in symbiotic stars, where the hot component heats up the facing hemisphere of the cool giant. The nature of such heating may be caused either by the irradiation or by the mass flowing from the hot to the cool component. The existence of that flow is confirmed by spectroscopic observations of AX Per.

The main characteristics of the optical spectrum in this active phase of AX Per were: 1. The M-type absorption spectrum was filled up by the blue continuum - no TiO bands and a typical triangular profile of the Ca I 422.7 nm line were observed. 2. The line spectrum was characterized by the absorption shell spectrum and emission Fe II, [Fe II] and H I lines. Absorption lines of the once ionized metals Ti II, V II, Sc II, Ca II (M II) and neutral metals Fe I, Ti I, Cr I (M I) were presented. Their radial velocities were practically the same: RV_{MII}= -112.4 ± 1.0 km/s (56 lines), RV_{MI}= -111.8 ± 1.0 km/s (42). 3. The lower members of the Balmers series H_β, H_γ and H_δ were double peaked with the central absorption core and with second component in their ($H_{\delta,\gamma}$) red wings (Fig. 2). The ratio of the H_γ and H_δ emission wings was V/R>1, but for the H_β was V/R<1. 4. The second emission component, RV=-98.5 ± 4.9 km/s (6), in the Fe II red wings and the weak absorption shell component, RV= +19.7 ± 5.5 (7), were observed. Radial velocity of the main emission Fe II peak was -139.0 ± 0.9 km/s (27). 5. The most complicated profile showed the Ca II K and H lines. Three absorption components, -192.4 km/s, -125.2 and -5.7 km/s and two emission components, -155.0 km/s and -86.5 km/s were present in Ca II K line profile. 6. No high excitation lines as the He I, He II, [O III] and [Fe VII], typical for AX Per, were observed.

The second emission components, observed in this binary position ($\varphi \lesssim 0.5$), reflect the emission mass flowing from the hot to the cool component with the radial velocity about of 26.5 km/s (gamma velocity is ~ -125 km/s). Then it collides with the red giant and a "hot spot" on its surface can be created.

The optical spectrum of AX Per in this phase of activity resembles the spectrum of the symbiotic star CH Cygni in its maximum activity 1982 - 1984 (Fig. 3). The spectral lines and the structure of their profiles are similar. This fact might reflect the similar nature of the creation and behaviour of the accretion material in these symbiotic stars, although their orbit's geometry (P_{orb}(CH Cyg)= 5700 days, P_{orb}(AX Per) = 681.6 days) is strongly different.

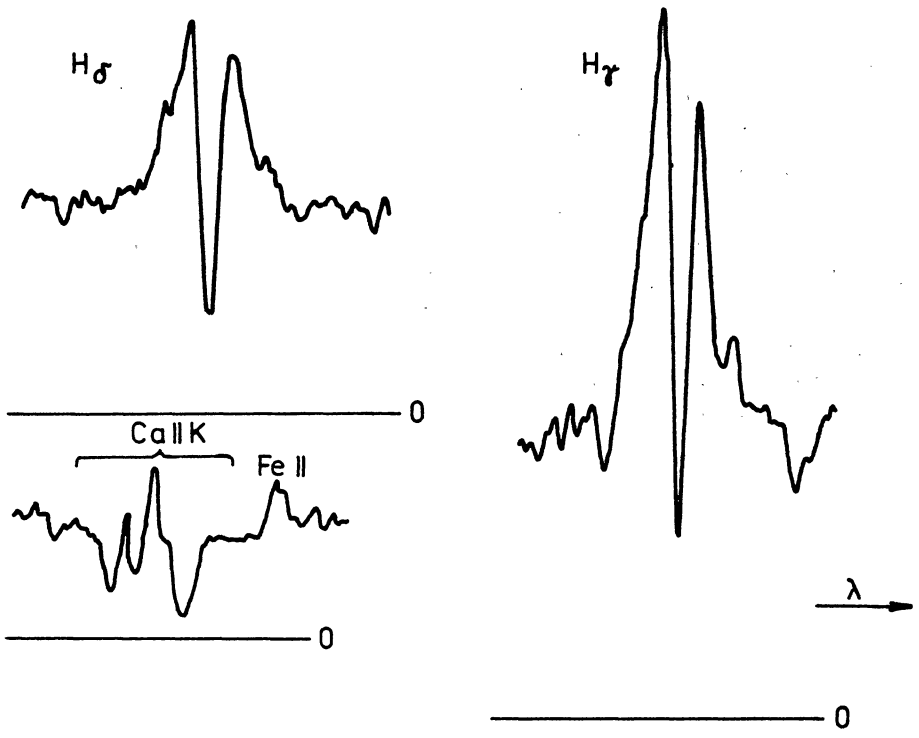

Fig. 2. An example of the H_σ, H_γ and Ca II K line profiles of AX Per observed on November 30, 1989. Second emission component in the red wings of the H_σ and H_γ line is distinct. The Ca II K line profile reflects the complicated structure of the circumstellar matter in the system.

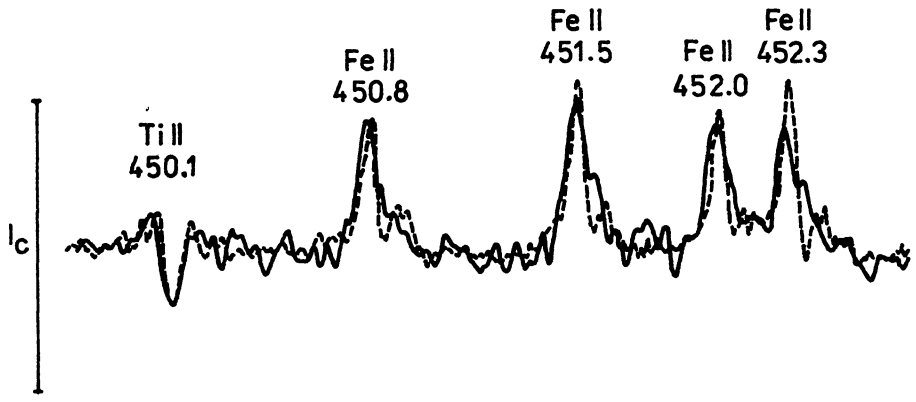

Fig. 3. A comparison of the optical spectrum of AX Per (30.11.1989, full line) and of the symbiotic star CH Cyg (25.6.1982, broken line).

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