A SPECTROSCOPIC STUDY OF THE Bp-STAR θ Aur

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ABSTRACT. The atmosphere parameters, spectral variability and the magnetic field geometry of the Bp-star θ Aur are evaluated from 30 coude-spectrograms. We adopt $T_e = 10\,800$ K and lg g = 3.40 (with lower reliability of lg g). The equivalent widths of the metalic lines show a relatively great scattering which troubles the period search. The best fit to our data gives the period $P = 3.620^d$, but the variability is clearly seen only for SiII lines. The uncertainties in the star parameters obtained bring to a great uncertainty in the magnetic dipole geometry : $i = 86^o \div 39^o$ and $\beta = 18^o \div 80^o$. We adopt the most plausible star parameters to be: $R = 3.8\,R_\odot$ $M = 3.5\,M_\odot$, $i = 80^o$, $\beta = 20^o$, Bp = 1 KGs .

1. STELLAR PARAMETERS

1.1. Observations

The spectrograms of θ Aur are obtained at the coude-focus of the 2-m telescope in BNAO mainly on IIaO plates with a dispersion 4 and 9 Å/mm. The aim of this work is to estimate the main stellar parameters and to study the spectral variations of θ Aur. We selected 30 "blue" plates of comparatively good quality and processed them by registrograms. We estimate (from sets of spectra obtained consecutively) the accuracy of W_λ to be about 10 ÷ 20% for lines with $W_\lambda \sim 300 \div 100$ mÅ. Theta Aurigae have a difficult for studying spectrum because of the broad lines - one can see the great scattering of W_λ noted in the very important papers by Adelman et al.(1984) and Van Rensbergen et al.(1984).

C. R. Cowley et al (eds.), Upper Main Sequence Stars with Anomalous Abundances, 295–298.

1.2. Hydrogen lines and stellar atmosphere parameters

We did not detect any significant variations of $H\gamma$ and $H\delta$ with the known periods of θ Aur. Therefore we averaged the profiles to improve the accuracy - $H\gamma$ coinsides exactly with the published ones by Gray and Evans(1973) and Van Rensbergen et al.(1984) from photoelectric scans.

The averaged profiles of $H\gamma$ and $H\delta$ were compared with the theoretical ones (Kurucz,1979). Our profiles fit the theoretical ones in the range: T_e=10 000 ÷ 12 000K and lg g = = 3.00 ÷ 4.00. The best agreement we have for the lowest T_e but then lg g must be embarrassly small. In addition $H\delta$ gives systematicaly lower (by 0.2 dex) lg g. Using the calibrations of $(B-V)_0$ vs. T_e given by Underhill(1982) we estimate T_e to be between 10 800 ÷ 11 000K. Finally we adopt T_e=10 800 K and lg g =3.40 (with a lower reliability). These values are close to the published ones by Van Rensbergen et al.(1984) and differ rather significant from our first estimations (11500K;3.85), based only on $H\gamma$.

1.3. Radius and mass

We obtain V sin i = 53 km/s and must note the relatively great differences in the published values of V sin i - from 45 km/s(Babcock,1958) until 55km/s(Khokhlova et.al.,1985). The oblique rotator formula gives for our P and Vsin i a radius $R \geqslant 3.8\,R_\odot$. The same value we obtain from the calibrations of Underhill(1982) and Straizys and Kuriliene(1981) for the temperature adopted. The mean absolute visual magnitude from both calibrations is $M_V = -0.62^m$ and with the bolometric correction from Straizys and Kuriliene(1981) we obtain $M_{bol} = -1.07^m$. This allows us to estimate the mass to be 3.3÷ 3.6 solar masses. The well known relation between R, T_e and M_{bol} gives the same value for the radius. Assuming a mass of 3÷ 4 solar, for lg g=3.40 we obtain a radius of 5.6 ÷ 6.6 $R_\odot$, while $R \simeq 4\,R_\odot$ needs lg g – 3.8. Because cf the low reliability of lg g values we can conclude, that the actual value of the radius of θ Aur may to be in a wide range: 3.8 ÷ 6.6 solar radii .

2. SPECTRAL VARIATIONS

We used the W_λ obtained for SiII(5 lines),CrII(5 lines), FeII(3 lines), CaIIK and MgII 4481 for a period search in a range 1 ÷ 5 days. The intervals: 1 ÷ 1.5 ; 1.8 ÷ 2.1 and 3.6 ÷ 3.8 days are suspected,which covers the intervals obtained by Borra and Landstreet(1980) from magnetic field measurements. The best fit to our data gives P= 3.620 ^{d}, which practicaly coincides with P = 3.618 ^{d} (Borra and

Landstreet, 1980) and $P = 3.6190^d$ (Adelman et al., 1984).

The averaged values $W_\lambda / \overline{W}_\lambda$ for the ions considered are plotted on the figure below. Nevertheless the great scattering at least for SiII it may be possible to suppose the presence of a "single wave" variations. The ephemeris are

$$JD(\text{Si max}) = 2\,444\,538.56 + 3.620\,E\ .$$

No attempt was made to map the plausible surface inhomogenities because of the low accuracy of our data.

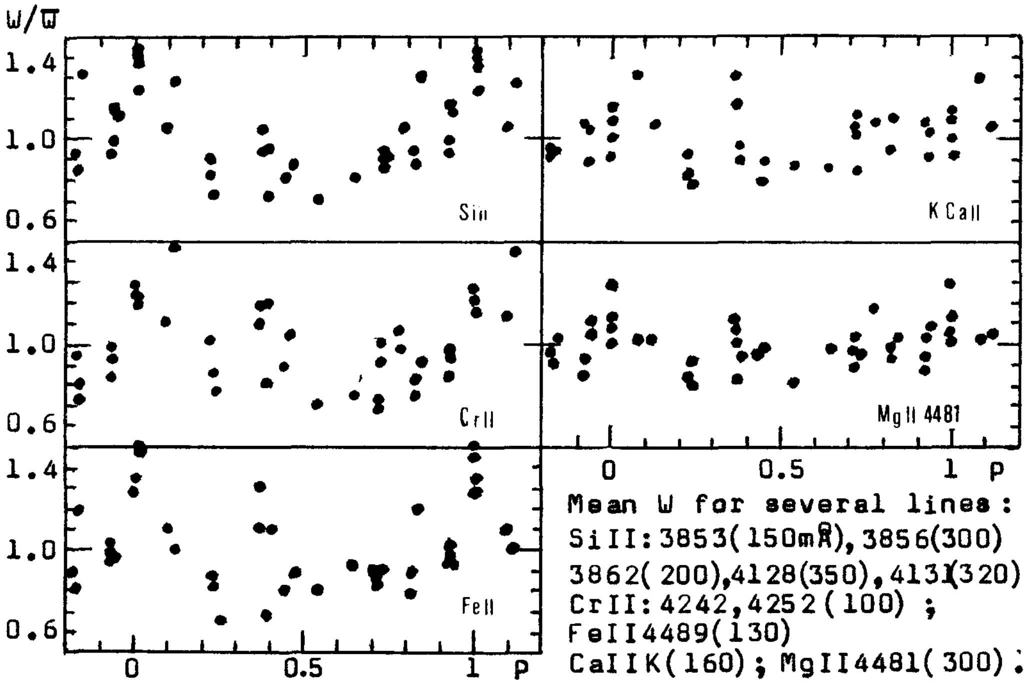

Fig.1. The spectral variations of θ Aur.

3. MAGNETIC FIELD GEOMETRY

Following Borra and Landstreet's (1980) conclusions about a dipole geometry of the magnetic field of θ Aur and using theirs measurements, we made an attempt to re-obtain the possible values of the dipole parameters. The inclination of the oblique rotator "i" have a possible value between 86° and 39° for R of 3.8 and 6.0 $R_\odot$ respectively. The dipole-geometry formulae give values for the angle between rotational and dipole axes "β" in the range : 18° ÷ 80°! The polar field Bp maybe vary much more less - from ~1 to 2 KGs. In addition the uncertainties of V sin i influence the accuracy of the field geometry derived too. So, taken into account a possible error of Vsin i about 10% for Aur we can estimate an additional uncertainty of "i" about 25° ± 10° for different radii !

4. CONCLUSIONS

Some of our results are in good agreement with the results in the papers ouoted. There is no doubt that the actual period of θ Aur is about 3.6^{d}. The star is most probable a B9 III Si-variable. At present, we suppose, the greatest uncertainties occur in the field geometry. Obviously we need more precise data and, perhaps, a more extensive statistics to be able to make more definite conclusions.

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