The age of ε UMa

S. Hubrig
Zentralinstitut für Astrophysik der AdW der DDR
Potsdam, DDR

Abstract

A critical rediscussion of the luminosity confirms that ε UMa is brighter than expected for a star on the main sequence, in our determination by $0\overset{m}{.}6$.

ε UMa is a well known typical Ap star. The peculiarity refers mainly to Fe, Cr, Ti, Ca (Engin, 1975, Rice et al., 1981). Luminosity and spectrum vary with P = $5\overset{d}{.}0887$ (Guthnick,1931, Provin, 1953). But the effective magnetic field strength is small: $H_{eff} < 110$ Gauss (Borra, Landstreet, 1980), -300 ÷ +800 Gauss (Glagolevski et al., 1981). What is the reason for this? Are the metallic lines to much broadened by other effects, so that a magnetic field cannot be measured precisely? Are the surface inhomogenities taken into accont in the correct manner? If so, why does the more homogeneously distributed hydrogen give nearly the same result, that means very small effective magnetic field strength? Because no clear answer could be given, another question arose, the question whether ε UMa is in a somewhat other state of evolution than most magnetic Ap stars. Therefore a critical rediscussion of the position of ε UMa in the HR diagram was made.
The visual absolute magnitude M_v of ε UMa is based on parallaxe determinations, predominantly those derived under the assumption that ε UMa belongs to the nucleus of the UMa moving cluster.
The following values are given:

$\pi = 0\overset{''}{.}042 \pm 0\overset{''}{.}005$ (Rasmunson, N., 1921 Lund Medd. Ser.II No 26)
$\pi = 0\overset{''}{.}043 \pm 0\overset{''}{.}004$ (Roman, N.G., 1949 Astrophys, Journ. 110, 205)
$\pi = 0\overset{''}{.}040 \pm 0\overset{''}{.}001$ (Wielen, R., 1977, Astron.Rechen-Inst. Heidelberg, No 116)

C. R. Cowley et al (eds.), Upper Main Sequence Stars with Anomalous Abundances, 347–350.

$\pi = 0\overset{''}{.}041 \pm 0\overset{''}{.}001$ (nucleus stars, in Eggen, O.J., 1984, Astron. J. 89, No 9, 1350)

The trigonometric parallaxe of ε UMa is beyond the limit of large significance, the following values are published:

$\pi_{trig.} = 0\overset{''}{.}008 \pm 0\overset{''}{.}010$ (Jenkins, L.F., Gen.Cat. of trig. stars paral. 1952)

$\pi_{trig.} = 0\overset{''}{.}044 \pm 0\overset{''}{.}027$ (Flint, A.S., 1919, Publ.Washburn Obs. XIII, p. I)

To the nucleus of the UMa moving cluster belong six stars from the FK 4 - ε UMa included - with very precisely known absolute proper motions. For these stars a space velocity V = 17.99 ± 0.10 km/sec turns out with the components in the directions of opposite to the galactic center u = -14.4 ± 0.06 km/sec, galactic rotation v = +1.3 ± 0.08 km/sec and the North Galactic Pole w = -10.7 ± 0.08 km/sec using Eggens determination of the convergent point (A= 308°.43; D=-38°8'.2) derived from 31 stars. Another determination of the space velocity of the nucleus of the UMa moving cluster was made by Wielen (1977) with the result V = 16.0 ± 0.1 km/sec using the determination of A = 301°.92, D = -31°.22 from 20 stars. Wielen noticed that this cluster has the smallest velocity dispersion (0.1 km/sec) measured in a stellar system, indicating the strong gravitational binding. - Thus, the difference in V between the two sets of approximately 2 km/sec is much larger than the internal error.

The radial velocity V_r, which has to be expected for ε UMa as a member of the UMa moving clusters is V_r = -12.6 ± 0.07 km/sec in case using the data given by Eggen or V_r = -9.3 ± 0.06 km/sec using the data given by Wielen. The measured mean radial velocities show a large scattering. The following values in km/sec are given using metallic lines:

- 9	± 1	(Vogel, H.C., 1903, Astron. Nach. 163, 145)
- 7.1	± 0.46	(Baker, R.H., 1908, Publ.Allegheny Obs.1, 23)
- 8		(Lick) {Moor's Catalogue of Radial Velocities, 1932}
- 5.4		(Mc Donald) {Moor's Catalogue of Radial Velocities, 1932}
- 7.6	± 0.8	(Harper, W.G., 1937, Publ.Dom.Astrophys. Obs. 7, 1)
- 10		(Swensson, J.W., 1944, Astrophys. Journ. 99, 258)
- 7.1	± 1	(Woszczyk, A., Jasinski, M., 1980, Acta Astron. 30, No. 3, 331)
- 9.8	± 1	(Tektunali, H.G., 1981, Astrophys. Space Sci. 77, 41)
- 9	± 1	(Rice, J. et al., 1981, 23 Liege Coll. 265)

- 8.5 ± 1.3 (Hubrig, S., 1977, 1978)
- 9.4 ± 0.4 (Hubrig, S., 1978 - 1984)

The mean of all these determinations is V_r = -8.3 ± 0.4 km/sec. For the hydrogen lines Abt and Snowden (1973) give V_r = -11.1 ± 1.43 km/sec and Tektunali (1981), V_r = -10.0 ± 0.9 km/sec.

Our values have been obtained by two different methods of measurements:

V_r = -8.5 km/sec is derived from 38 spectra with dispersion 8 A/mm in such a way that for those lines which are split probably by inhomogeneities the radial velocity of each component was measured and the average afterwards computed. Contrary V_r = -9.4 km/sec was obtained using the wings of the whole line, in this case measuring 21 spectra with a dispersion of 4 A/mm.

If the radial velocity of ε UMa is -12.6 ± 0.07 km/sec as postulated by Eggens investigations then the systematic deviation from the mean measured radial velocity of -8.3 ± 0.4 km/sec need an explanation. One possibility would be the existence of a companion to ε UMa. The search for a period in the variation of the mean radial velocity had no success: the rotation period was recovered only. Even the values of proper motion do not exhibit any variation. Another possibility for the explanation of the deviation of the observed radial velocity value from the expected would be a contraction of the stars atmosphere; a possibility which is not discussed further. Finally such a difference could be produced by a special geometry of inhomogeneities of the elements. If all explanations for the discrepancy between observed and predicted radial velocity must be rejected, either a small correction to Eggens values of A, D or V is necessary or the membership of ε UMa to the nucleus of the UMa cluster must be inquired. We exclude the last mentioned possibility regarding that using Wielens values the predicted V_r agrees very well with the observed. Thus - as generally assumed - we conclude that ε UMa belongs to the nucleus of the UMa moving cluster and find from its parallaxe the visual absolute magnitude $M_V = -0\overset{m}{.}3 \pm 0\overset{m}{.}05$. On the main sequence such a luminosity corresponds to a B8 star with T_{eff} = 11900°K using the values given in Landolt-Bornstein, 1982.

From spectroscopic investigations and model calculations the following values T_{eff} are published:

T_{eff} = 9400° K (Schild, R. et al. 1971, ApJ 166, 95)
9600° K (Cucchiaro, A. et al. 1978, Astron. Astrophys. Suppl 33, 15)
10000° K (log g = 3.5)(Durrant, C.J., 1970, MNRAS 147, 75)
10200° K (Wolf, S.C. et al. 1968, ApJ 152, 871)
9900° K (Glagolevski, Ju. W., 1966, Astron. J. russ. 43, 73)
9500° K (log g = 3.5)(Glagolevski, Ju.W. et al. 1982, Astrophys. Issled russ. 15, 14)
9300° K (log g = 3.2)(Engin, S., 1975, IAU Coll. No 32, 623)
9985° K (log g = 3.5)(Tektunali, H.G., 1981, Astrophys. Space Sci. 77, 41)

Thus after rediscussion we come to the same conclusion given by Glagolevski et al. that the star is brighter than would be expected if it would be on the main sequence. The measured gravitational acceleration log g = 3.5 is in accordance with this assumption. The fact that ε UMa is the brightest member of the nucleus of the UMa moving cluster fits to a such a position in the HR diagram.
Whether ε UMa is in a somewhat other state of evolution than most magnetic Ap stars needs further investigations.

References:

Abt, H.A., Snowden, M.S., 1973, ApJ. Suppl. 25, No 215, 137.
Borra, E.F., Landstreet, J.D., 1980, ApJ. Suppl. 42, No 3, 421.
Guthnick, D., 1931, Sitz. preuss. Akad. Wiss. Berlin No 27, 618.
Provin, S., 1953, ApJ. 118, 489.