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EXTREME LONG PERIOD ECLIPSING BINARY EPSILON AURIGAE*

— Spectroscopic Study —

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Abstract

From the study of a spectroscopic plate of ϵ Auriage, we can measure the radial velocity and the relative abundance for this eclipsing binary. Calculated radial velocity is −37 Km/s and the abundance of [Fe] is estimated as -1.5.

1. Introduction

The long period eclipsing binary ϵ Aurigae reveals complexities both in photometric and spectroscopic observations. The photometric light curve only shows the primary minimum with the period of 27.1 years. The primary star which is classified FOIa has also light variation just like cepheid pulsations. However amplitudes of these light variations are irregular. It is known that the depth of the eclipse increases for decreasing wavelength from the IUE data(Hack and Selvelli 1979).

Comparison of the depth of eclipse indicates the long term variations in *UBV* systems and the *duration of totality is variable too(Gyldenkerne 1970). During* the eclipse (B-V) and (U-B) colors show gradual increases after the mid-eclipse, and this behavior is interpreted as the result of the increasing activity to the later contact.

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The spectroscopic data also show anomalous features. During the eclipse of ϵ Aurigae, line profiles of Hα and NaD have systematic changes in width and radial velocity values. Emission features are also presented in these absorption lines. Barsony *et al.*(1986) concluded these spectroscopic features as the losing materials from the disk.

High resolution spectra during 1982-1984 eclipse were taken by Thompson *et al.*(1987), and they found equivalent width variations of Hα, Hβ, KI and NaD lines. They assumed the gaseous component of the secondary contains these species. Lockwood *et al.*(1983) also reported changes in the equivalent widths of Hα, NaD and OI as large as a factor of 2.

It is generally believed that the primary star of ϵ Aurigae is F supergiant with non-radial pulsations, possible retrograde rotation and the extented atmosphere. However the secondary is still unknown object except shell lines in the partial phase after end of totality(Hack 1958). This feature indicates the gaseous envelope.

In this paper we studied ϵ Aurigae with a spectroscopic observation. The observation and reduction are described in section 2. In section 3 measurement of the radial velocity was calculated from some FeI lines. In section 4 abundance was determined from the equivalent width and curve of growth.

2. Observation and Reduction

The spectrum of ϵ Aurigae was taken at the Asiago observatory in Italy during August, 1989. The Cassegrain A spectroscope was used at the f/16 focus of the 122cm telescope. The used camera has 2 prism with the focal length of 287mm. The ratio of collimator to camera is 3.48 and the linear dispersion at Hr is 42 Å/mm. 9cm × 12cm 103a-0 plate was used and aperture size was 0.10 × 1.5. The comparison light source was the iron arc. with 20 seconds exposure and the spectrum of ϵ Aurigae was exposed for 10 minutes.

Measurement was made using a microdensitometer(Perkin Elmer PDS 1010A) at the Padova observatory. The actual scanning size was 12.5 × 50 microns and the scan speed was 10 mm/sec.

Reduction was done using IHAP FITS format which was made by ESO. Fig. 1 shows the PDS scanning of the ϵ Aurigae spectrum and 2 arc. spectra of iron.

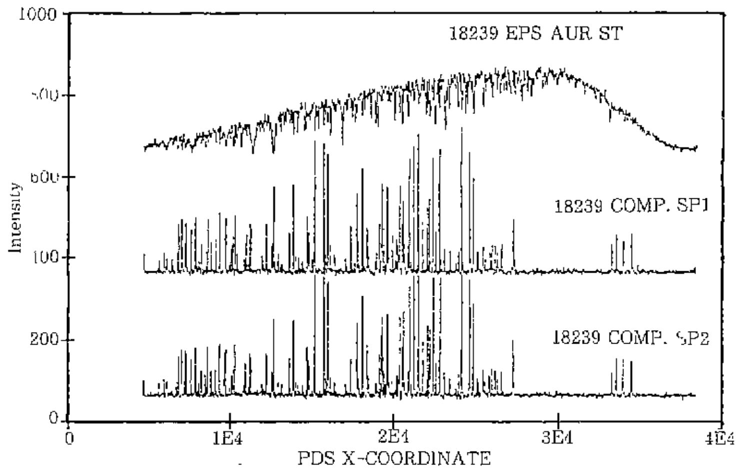

Fig. 1. PDS scanning of the ϵ Aurigae and Fe arc. spectra.

3. Measurement of the Radial Velocity

Calibration of pixels to wavelengths was made using the 5^{th} order transformation. The residual to wavelength is plotted in Fig. 2 and RMS error of the wavelength is less than 0.2 A. The spectrum of ϵ Aurigae was displayed for each wavelength region in Fig. 3.

The radial velocity was determined using the non-linear least square fitting method. Fitted lines were FeI lines and these listed in Table 1 with the measured radial velocities. In Fig.4 the fitting was made for FeI lines.

The calculated mean velocity was -62.3 ± 4.2 km/sec. From this value we estimated radial velocity of ϵ Aurigae as -38.3 ± 4.2 km/sec. This value is similar to that of the 3^{rd} contact during 1982-1984 eclipse and to that of the collapse phase of the outside eclipse(Saito *et al.* 1986, Saito and Kitamura 1986). As the systemic velocity is -1.4 km/sec, this radial velocity will be the radial motion of the photospheric gas. If we assume the pulsation of the photospheric gas of the primary star with the period of 83 days, then the observed time is in the stage of expansion.

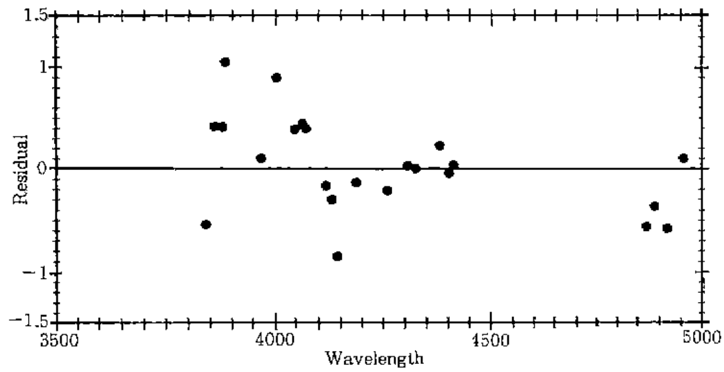

Fig. 2. The residual to wavelength calibration.

Table 1. Radial velocity calibration from some FeI lines

Observation	Comp	Velocity	Remark
3877.45	3878.02	-44.1	FeI
4004.17	4005.25	-80.8	FeI
4044.87	4045.82	-4711	FeI
4070.94	4071.75	-49.7	FeI
4062.57	4063.60	-76.0	FeI
4325.02	4325.77	-52.0	FeI

4. Abundance Determination

To get the curve of growth, we measured the equivalent width of same lines. Table 2 listed the measured equivalent widths with those of solar lines.

Abundance of ϵ Aurigae was made from the plotting of the curve of growth to laboratory f-values. We estimated [Fe] value as -1.5 from the fitting of empirical curve of growth for the sun.

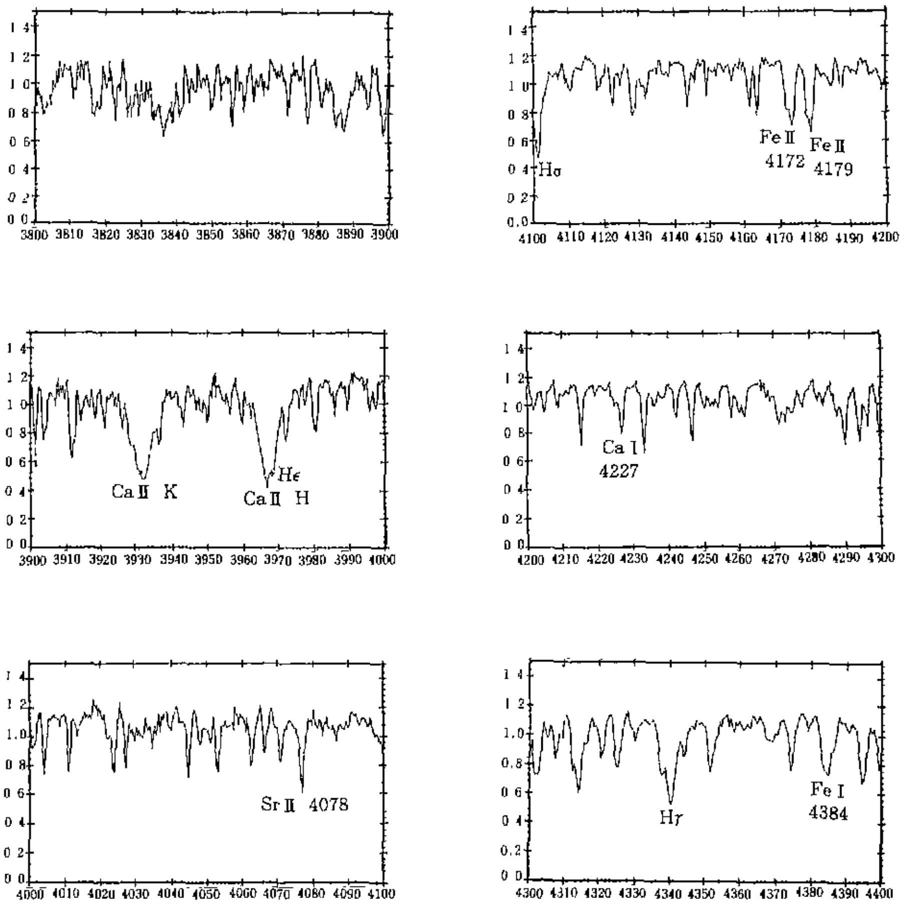

Fig. 3. The spectrum of ϵ Aurigae in the wavelength region from 3800 Å 4400 Å

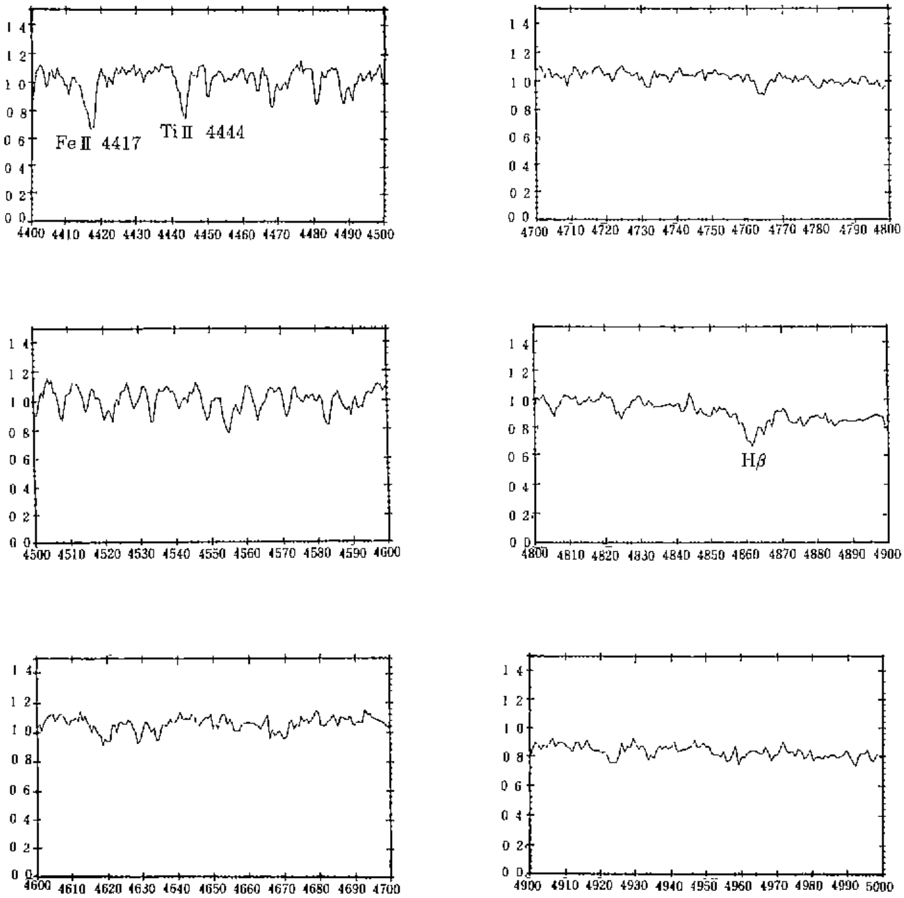

Fig 3. The spectrum of ϵ Aurigae in the wavelength region from 4400 Å 5000 Å

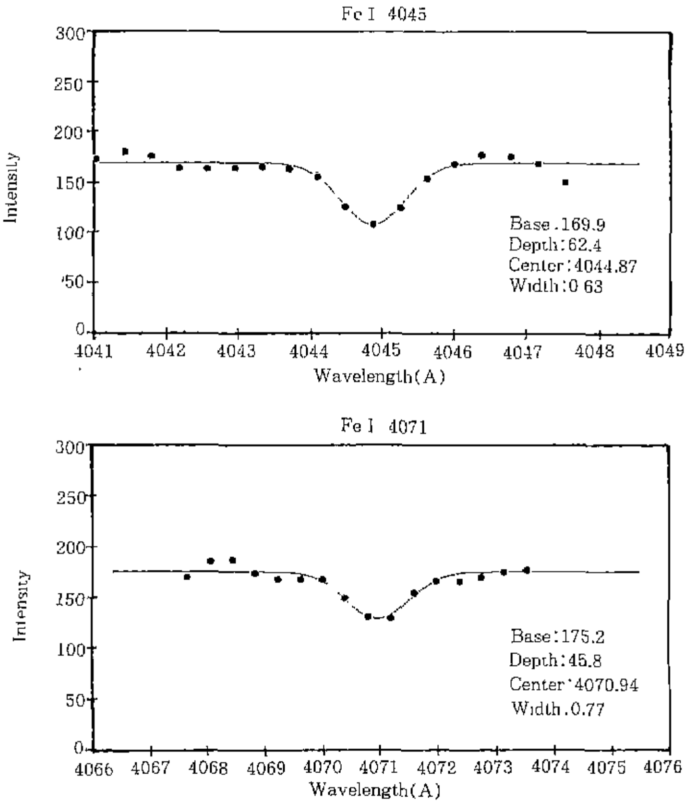

Fig. 4. Measurement of radial velocity from the least square fitting of FeI lines

5. Discussions

Measured radial velocity of ϵ Aurigae was estimated as -38 km/sec during the outside eclipse. This value is similar to that of the 3[rd] contact during the eclipse and the collapse phase of the outside eclipse. From the photoelectric data we can assume the period of light variation as 83 days during the outside eclipse.

If this light curve variation comes from the pulsation of the cepheid star, we assume the primary star as a cepheid variable, then the observed radial velocity reveals the expanding phase of the primary star.

Table. Measured equivalent widths

	$-\log(w/\lambda)_o$	$-\log(w/\lambda)_o$
Hβ	3.45	3.06
Hγ	3.30	3.09
Hδ	3.43	3.08
CaII H	3.02	2.44
CaII K	2.96	2.31
TiII 4444	3.69	4.95
CaI 4226	3.98	3.46
SrII 4078	3.84	3.98
FeII 4416	3.56	4.76
4179	3.59	4.72
4172	3.57	.
FeI 3817	4.16	4.47
3878	4.00	3.84
3899	3.73	3.95
3902	4.02	3.87
4005	4.01	3.98
4024	3.81	4.59
4045	3.99	3.54
4063	4.01	3.71
4071	4.05	3.75
4325	3.88	3.74
4383	3.55	3.64

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