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A Spectroscopic Investigation of the Eclipsing Binary Epsilon Aurigae

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16. Abstract

The principal objectives of this investigation were to examine in detail specrtra of the eclipsing binary epsilon aurigae taken with the IUE satellite telescope during the 1982-84 eclipse. All of the low resolution spectra have been analysed and UV light curves are presented. The primary findings are a) A constant eclipse depth from 1600A to longer wavelengths and a sharp drop in the eclipse depth from 1600A to 1200A. b) the absence of large amplitude fluctuations in the UV as expected from a Cepheid primary c) equal ingress and egress times in contradiction to that interpreted from visible light curves. The effects of these findings on the eclipse geometry are being investigated.

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FINAL REPORT

A Spectroscopic Investigation of the Eclipsing Binary Epsilon Aurigae

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NASA Grant NAS5-30760

1. OBJECTIVES

The principal objectives of this investigation were to examine in detail spectra of Epsilon Aurigae taken with the IUE satellite telescope during the 1982-1984 eclipse. Only a small fraction of these data had been analysed and presented in the literature and it was felt that a more detailed investigation was warranted because the UV data holds clues to the presence of the suspected hot companion. The major task of this investigation, the examinination of all IUE archival spectra of Epsilon Aurigae, is explained in some detail in Section 2. The results are presented in Section 3 and the final conclusions summarised in Section 4.

2. ANALYSIS

Over 150 short and long wavelength low-resolution spectra of Epsilon Aurigae were obtained with the IUE telescope during the 1982-1984 eclipse by a number of observers. We had these spectra written on magnetic tape and transported to the Regional Data Analysis Facility at Boulder from where they were accessed remotely using the computers at the Institute for Astronomy at Hawaii. The major task of this project was to examine each spectrum carefully. Blemishes and overexposed portions edited out and the average fluxes in 50Å bins were measured to produce light curves. The first bin was centered at 1215Å and the last at 3240Å; the choice of the bins ensured that features like the Mg II line at 2800Å were fully contained in a single bin. Comparison of gross and net fluxes showed that exposures of at least 20 minutes were needed to produce measurable signal at the shortest wavelengths around 1200Å. Shorter exposures were considered underexposed and spectra shortward of 1540Å were edited out. Finally, multiple spectra taken on the same day were combined.

The effect of instrumental scattering into short wavelengths was studied using the IUE descattering algorithm as applied by Altner *et al.* (1986) to Epsilon Aurigae. Five of Altner's spectra have exposures of 20 minutes or longer. Corrected and uncorrected fluxes in 5Å bins were provided by Altner. These were rebinned into 50Å bins appropriate to our light curves. Subtracting corrected fluxes from uncorrected fluxes yielded five scattering profiles. The scattering profiles were normalised at each of three different intervals: 2600-2800Å, 2300-2600Å, and 1700-1900Å, and the five profiles were averaged to yield three scattering curves. Longward of 1600Å, no difference is seen between the uncorrected and corrected fluxes, i.e. the scattered flux is negligibly small. Even shortward of 1600Å the scattered flux does not exceed 6% of the measured flux. The choice of the normalisation region has no effect on the final value of the scattered light. Hence in the discussion that follows the scattered light in the short wavelengths is considered negligible and no effort has been made to subtract it from the measured flux. The final UV light curves are presented in 200Å bins in Figure 1.

3. RESULTS

The following features are observed in the UV light curves obtained:

a. The eclipse depth is fairly constant at about 0.8 to 1.0 magn from 3000Å to 1600Å. Shortward of 1600Å the eclipse depth decreases from about 1.0 magn to 0.3 magn at 1200Å. The shallower eclipse at short wavelengths is expected to be due to the presence of a hot secondary object.

b. Earlier studies had indicated that strong Cepheid-like pulsations dominated the light curves in the UV. We do not find evidence for such pulsations. Typical Cepheid amplitudes are several magnitudes stronger in the UV compared to the visible pulsations. In Epsilon Aurigae, the irregularities in the light curves are only a few tenths to half a magnitude. We are investigating the possibility that these fluctuations may be caused by structure in the disk around the secondary star which is presumed to cause the primary eclipse.

c. Visible light curves had been interpreted to show that the eclipse ingress was much longer than the egress (Ferluga, 1990; Carroll *et al.* 1990). This is in contradiction to previous eclipses of this object which showed equal ingress and egress times. Based on this finding, the eclipsing disk has been modeled to have a slight tilt providing excess absorption at 3rd contact and an off-center hole to account for the mid-eclipse brightening. Our examination of the UV light curves shows that the time of 3rd contact may have been miscalculated because of a pulsation which occurred at this time; the pulsation is seen more clearly in the UV. The time of 3rd contact, as determined from the UV curves, equalises the times of ingress and egress, puts the mid-eclipse brightening at the center of the eclipse and hence removes the need for an off-center hole in the disk. Further, this shift of the 3rd contact time makes the UV eclipse is flat-bottomed similar to the visible eclipse.

SUMMARY

The primary purpose of this project, the examination of the low resolution UV data has been achieved. This has yielded interesting light curves and has led to the necessity for re-evalutating the eclipse geometry. This is currently in progress. We did not have sufficient time to proceed to examine the high resolution data as we had previously planned. We feel that this is a worthwhile exercise which should be carried out in the future.

REFERENCES

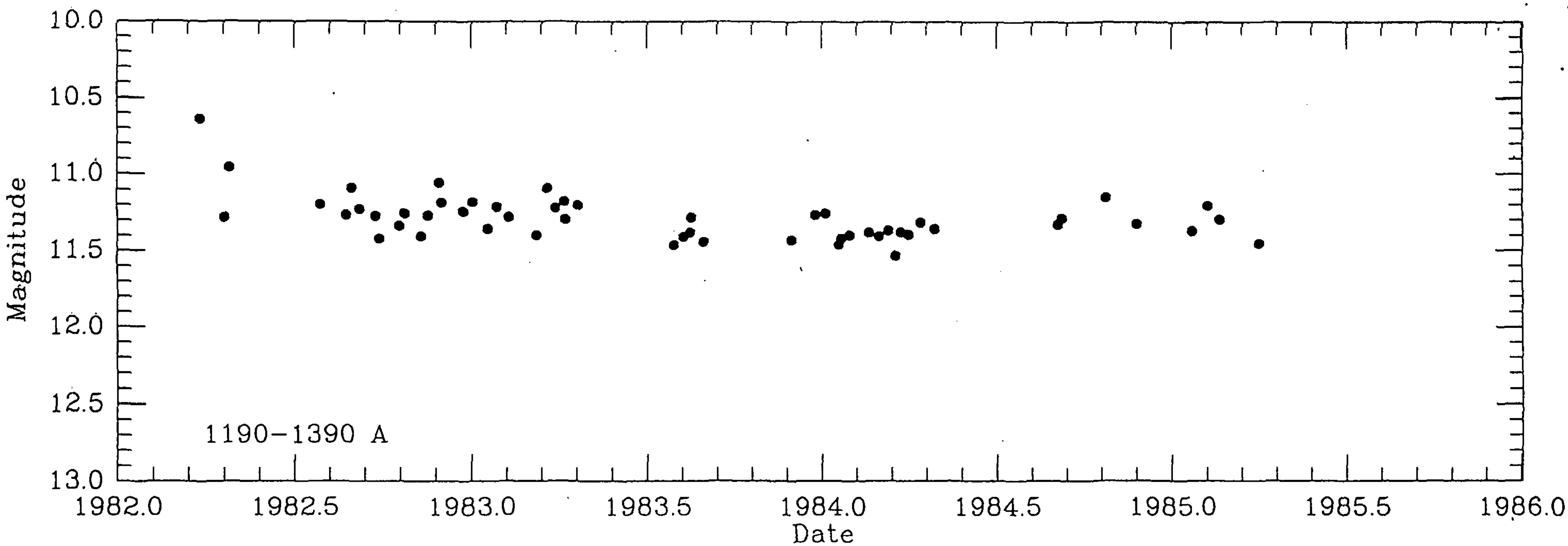
Altner, B., Chapman, R.D., Kondo, Y., and Stencel, R.E. 1986, *Astr. Ap. Suppl.*, **65**, 199.

Carroll, S.M., Guinan, E.F., McCook, G.P., and Donahue, R.A. 1991, *Ap. J.*, **367**, 278.

Ferluga, S. 1990, *Astr. Ap.*, **238**, 270.

FIGURE CAPTIONS

Fig. 1. The figure shows UV light curves in 200Å bins. The wavelength region of each bin is shown at the bottom left of each panel. The data cover the period 1982-1986.



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11.5
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1983.5
1984.0
1984.5
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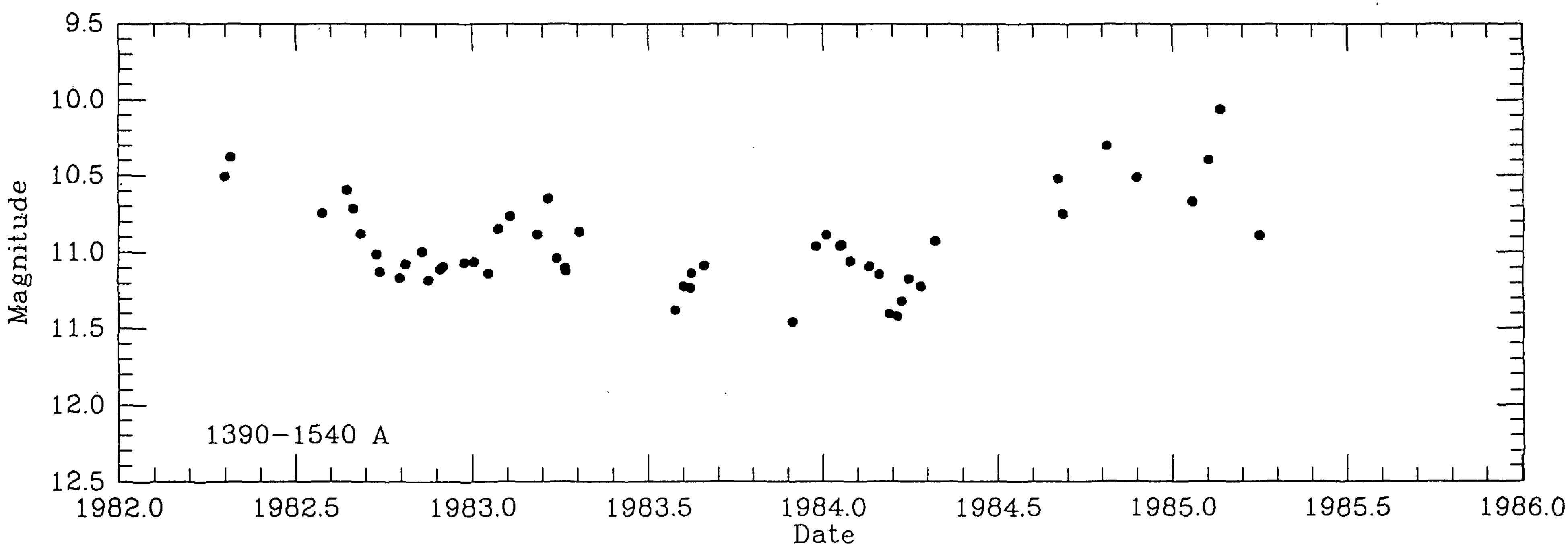
1985.5
1986.0
Date



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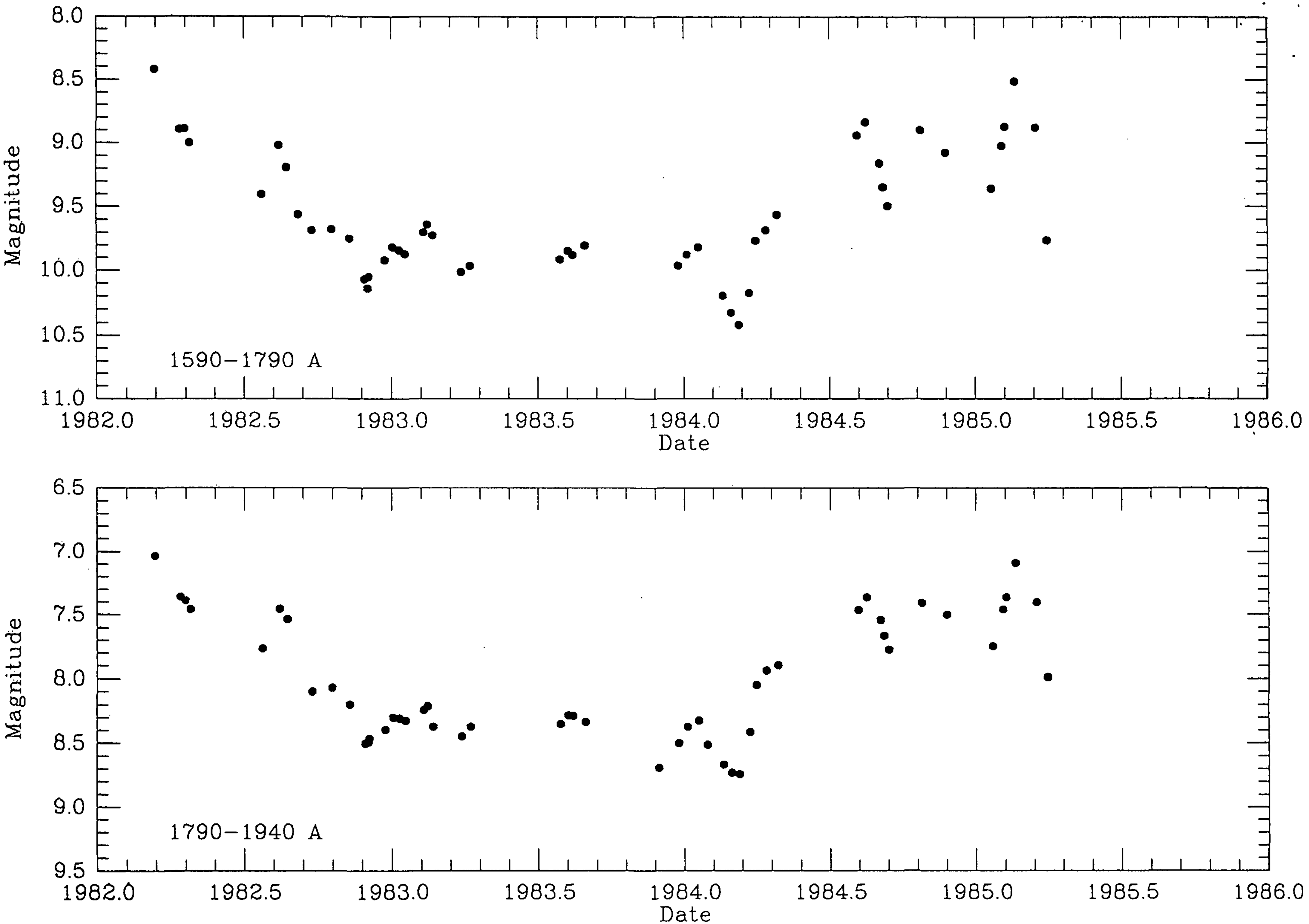
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8.5
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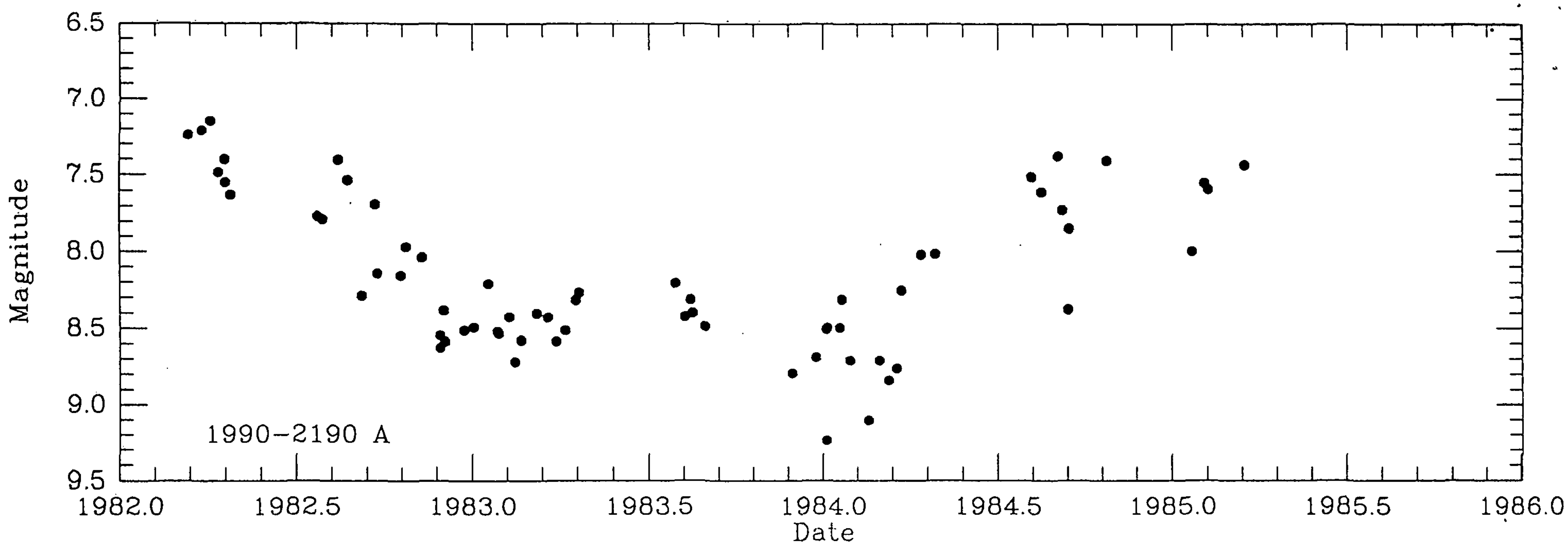
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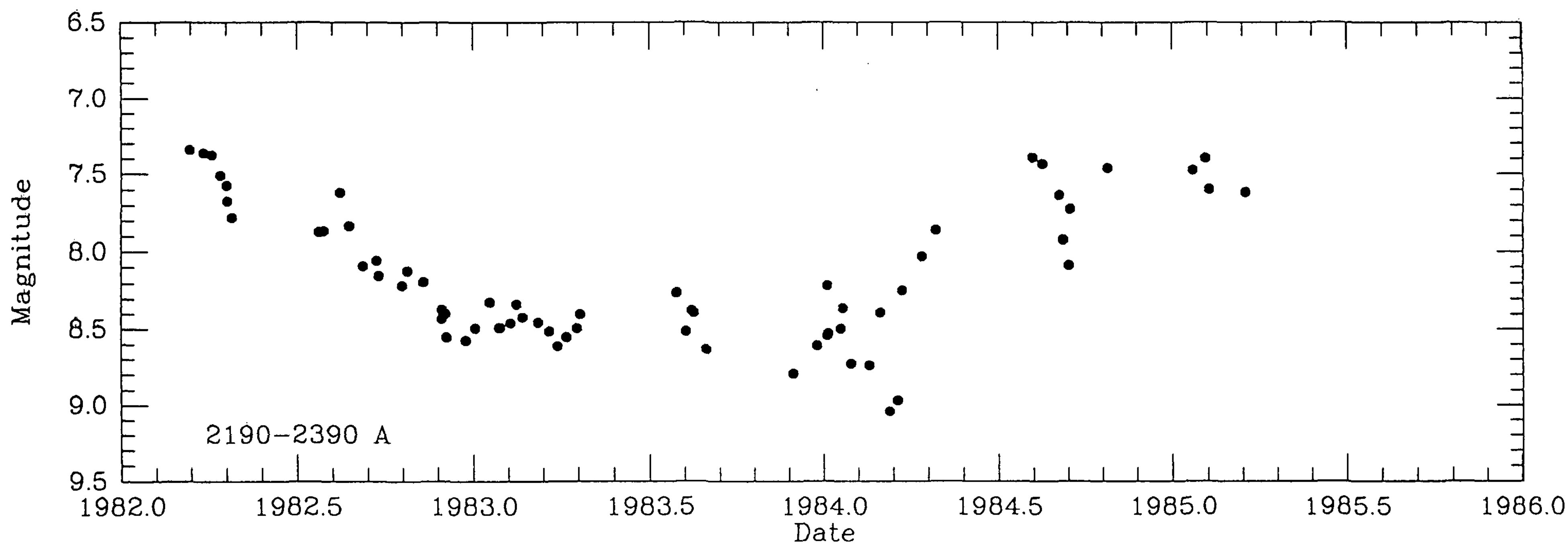
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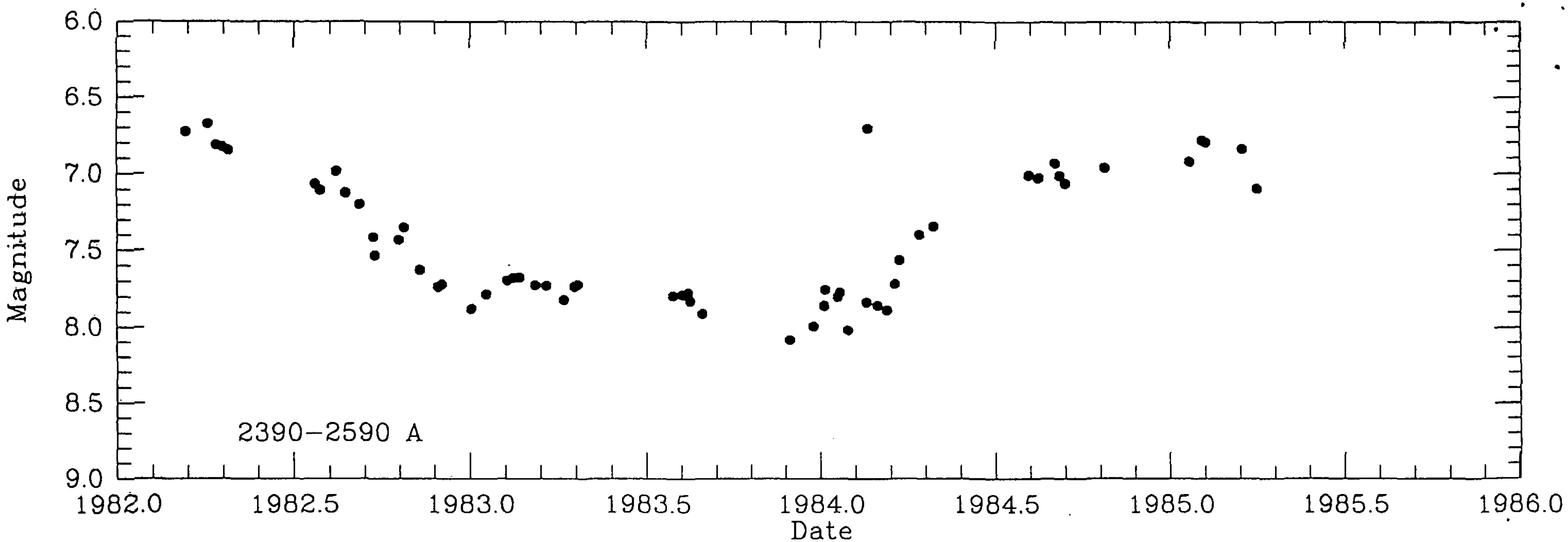

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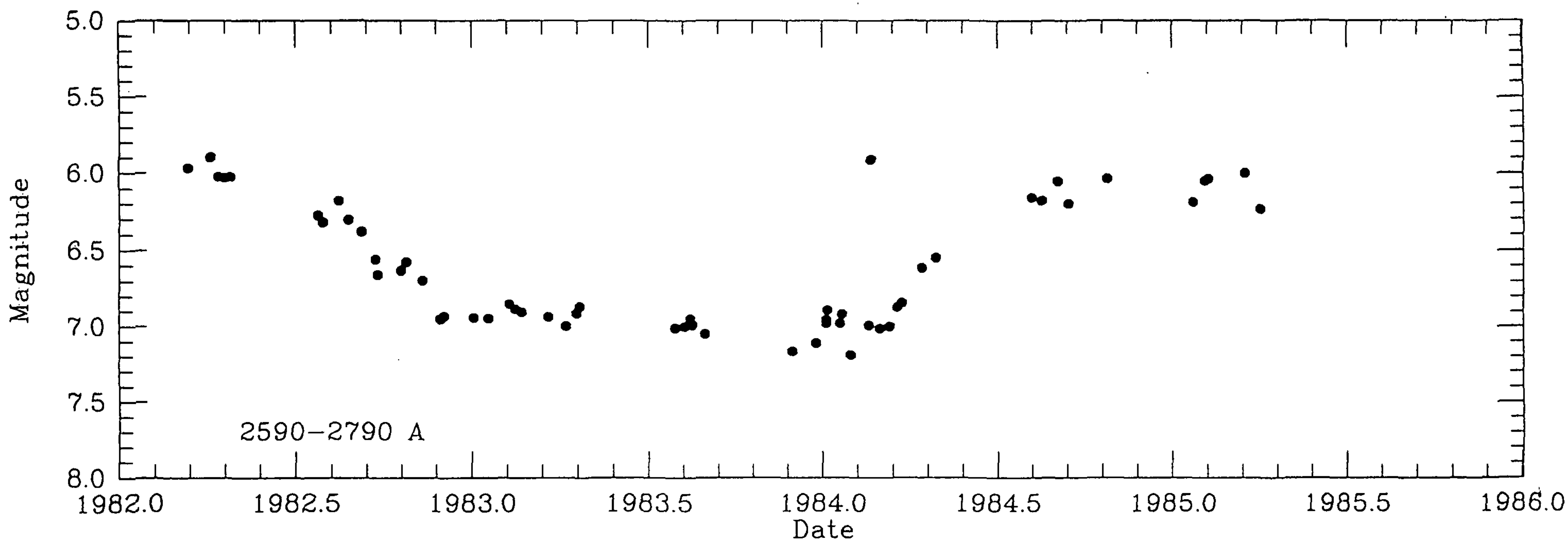

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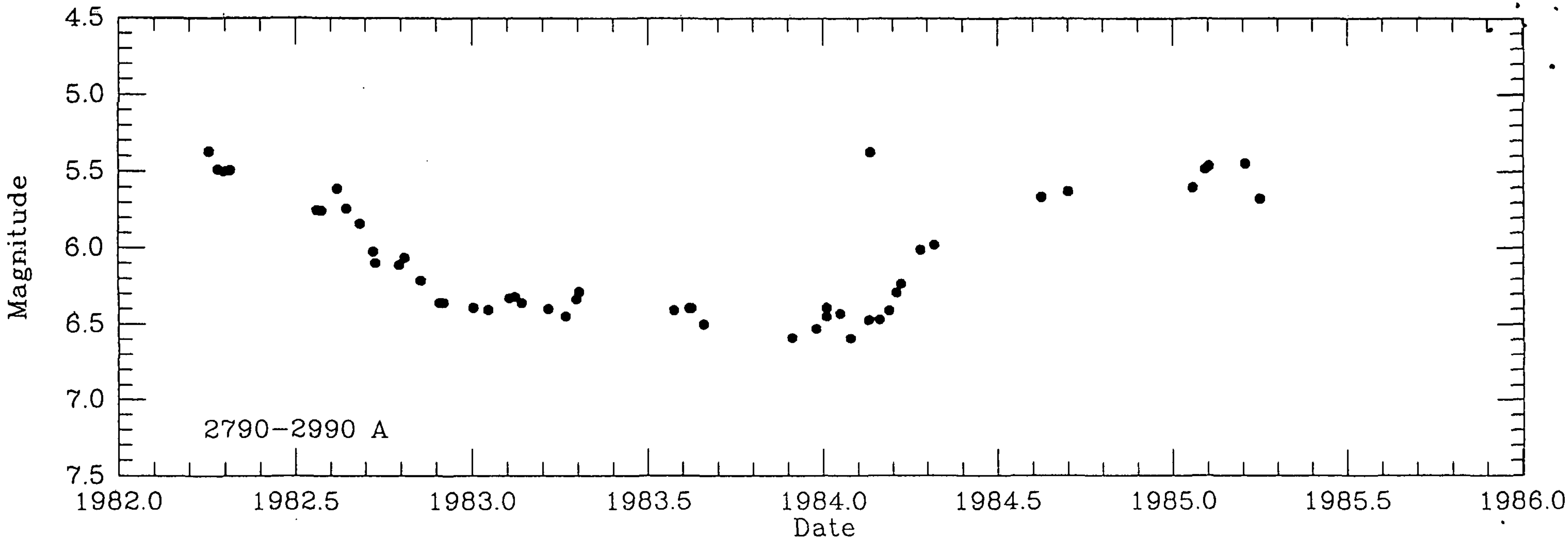
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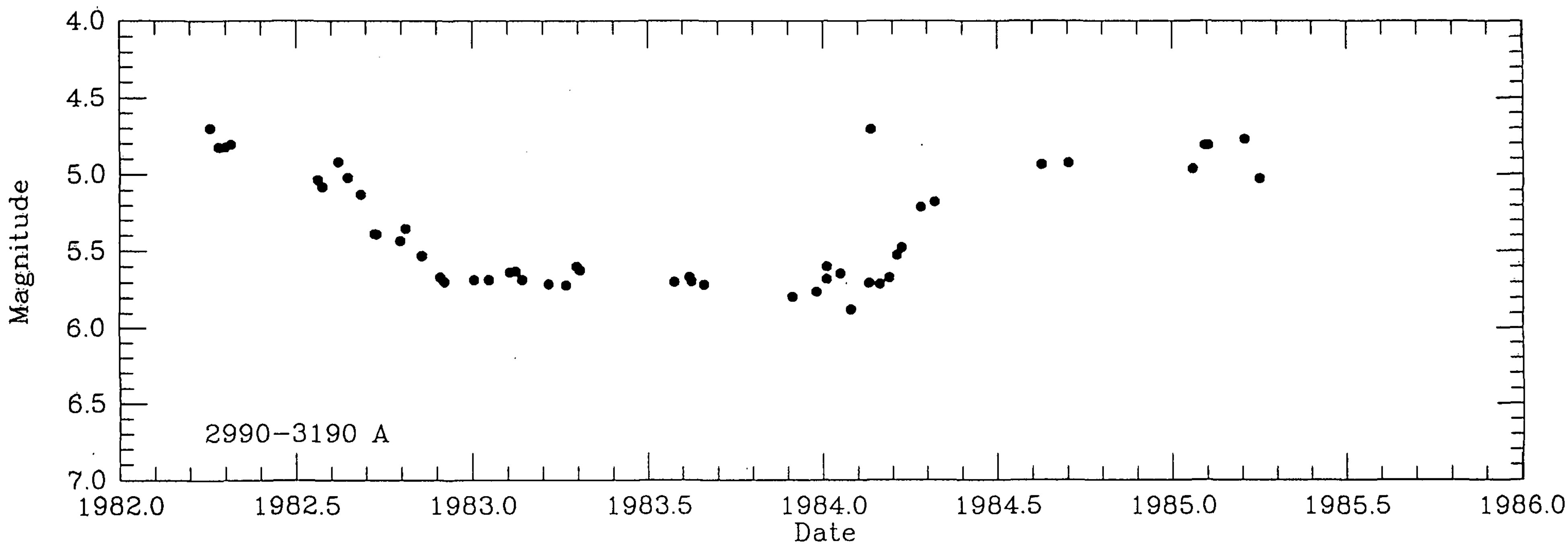
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