MAKING SENSE OF SU LYRAE

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Abstract

SU Lyrae was discovered to vary on plates taken in 1905. Over the years it has been classified as a nova, a dwarf nova (UG?), and recently as a Mira type. Over the last 30 years both the period and amplitude have appeared to change. I have inspected over 30 years of AAVSO data. This paper summarizes the results of my investigation.

1. Introduction

SU Lyrae was discovered to vary on plates taken by G. and M. Wolf from April to June 1905. On the April plates, the star was estimated at about 10th magnitude. On a plate taken on May 5, it appeared 0.5 magnitude dimmer, and on the 19th of June it appeared to dim to 12th magnitude. Wolf referred to the star as being a probable nova.

In more recent times, both the first (Kukarkin *et al.* 1948) and second (Kukarkin *et al.* 1958) editions of the *General Catalogue of Variable Stars* (GCVS) classify the star as "UG?," with a photographic magnitude range of 12 to <16. In both the third (Kukarkin *et al.* 1969) and fourth (Kholopov *et al.* 1985) editions of the GCVS, the star is a Mira type with a period of approximately 418 days. No spectral data are given. The AAVSO preliminary "d," "e," and "f" charts classify it as an N star and refer to a paper by Darsenius (about which I have found no information).

I became interested in SU Lyr because it was a challenge to observe. Both the GCVS 4th edition and the annual *AAVSO Bulletin* gave the impression that an observer with modest equipment could follow it. The preliminary charts in use give a range of photographic magnitude 12 to <16. Unpublished AAVSO raw (unevaluated) data on SU Lyr indicate that one longtime observer reported the star at an upper limit of visual magnitude 10.8 during one maximum.

2. AAVSO data

SU Lyr has been observed by AAVSO members since the early 1960's. The AAVSO data set consisted (as of late 1995) of about 2500 observations. Nearly 1000 of those are positive observations, e.g., the variable was visible.

Figure 1 is the AAVSO raw data from 1983 through 1995 as they came from Headquarters in the form of a light curve. The light curve is a mix of positive observations obscured by a blizzard of "fainter-than" carets. In mid-1995, I received the complete unevaluated data set from 1961. I did a basic edit of the data. First, I eliminated the observations that refer to stars other than SU Lyr (those were all brighter than 10th magnitude). Most of the errors were caused by observers having written the wrong designation or name. All the "fainter-thans" were edited out. I processed all the positive observations through my cookbook Discrete Fourier Transform (DFT) program (adapted from one written by E. Belserene [1988]). Over the entire data set the star shows a peak period at 420.7 days (Figure 2), a value not too different from the 417.79 of the GCVS 4th edition.

From 1963 until 1979, most of the observations were made by two observers: Leslie

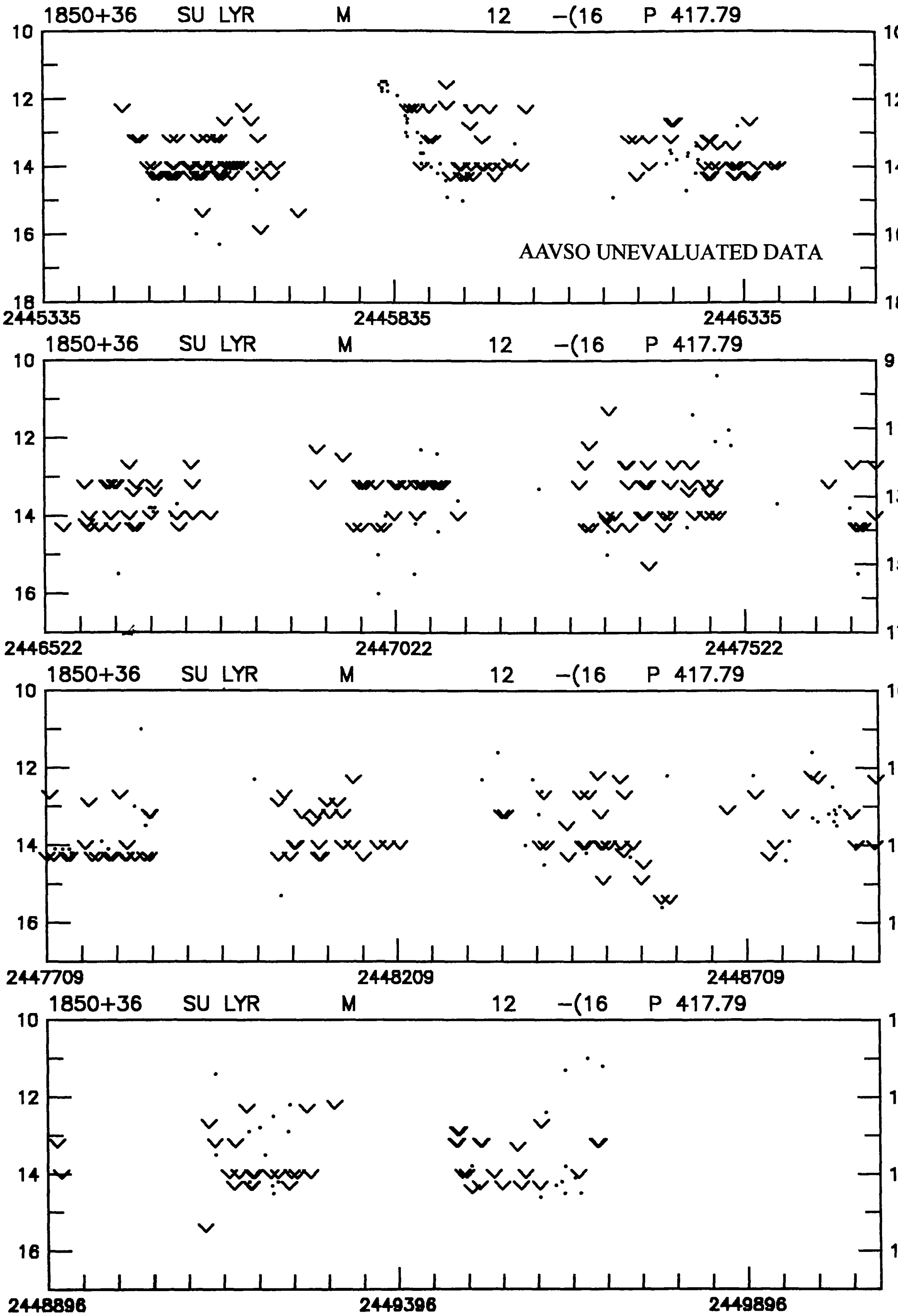

Figure 1. AAVSO light curve of raw (unevaluated) observations of SU Lyr from 1983 through 1995. A • indicates a positive observation; **v** indicates the variable was fainter than the magnitude indicated by vertex (i.e., variable was not seen).

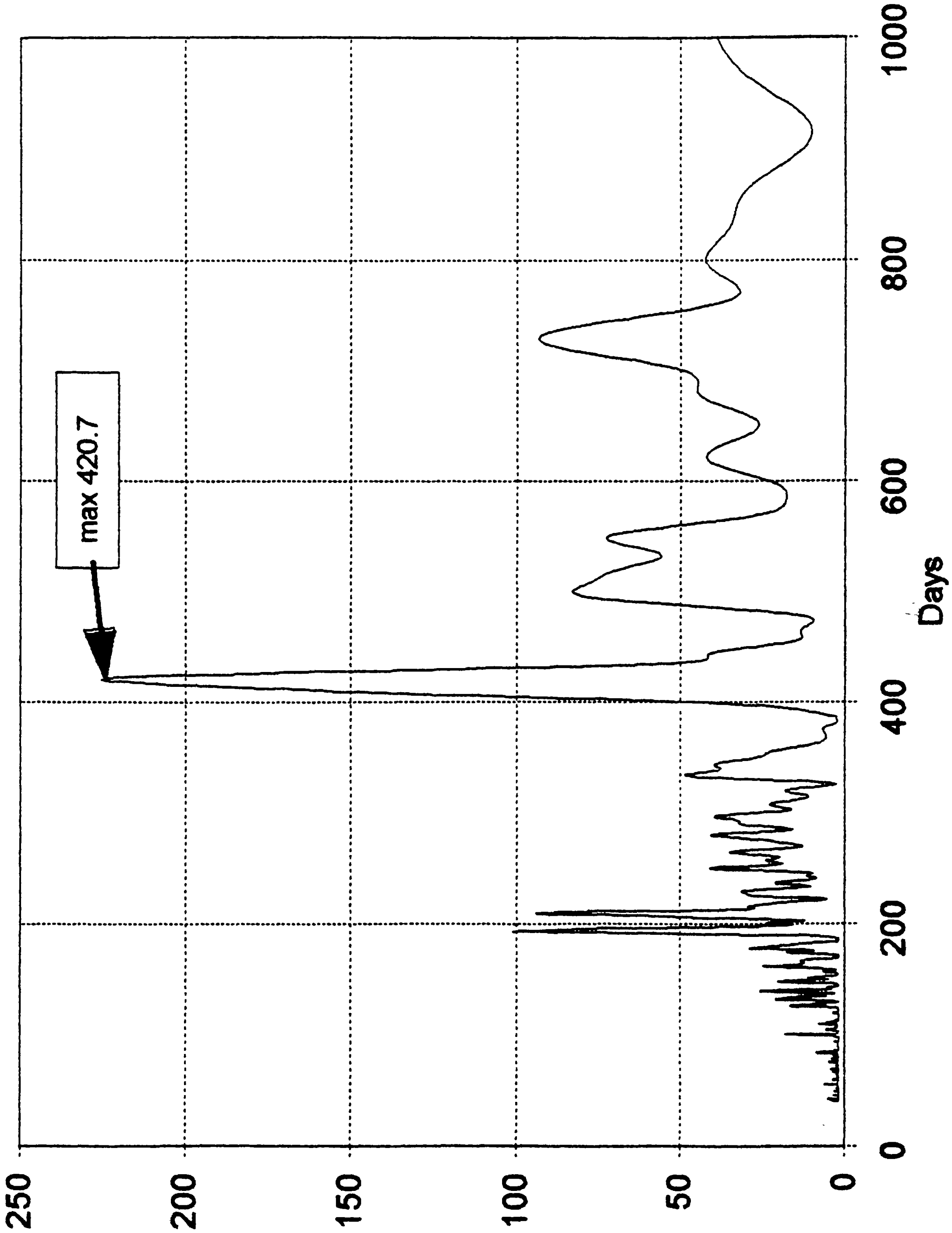

Figure 2. Discrete Fourier analysis of AAVSO raw (unevaluated) data on SU Lyr 1961–1995 (most of the discordant data have been left in the dataset), showing peak period at 420.7 days.

Peltier and Carolyn Hurless. Of 842 positive observations made from 1961 until mid-1980, 346 were made by Peltier and 284 by Hurless. The dataset is consistent, and no maxima were missed during this period.

3. The problem

SU Lyr presents a challenge to the student. The recent data are very confusing. I thought that an analysis using Belserene's DFT program (1988) would provide an easy method of cleaning up the data. I made a phase graph of all the data (Figure 3), which shows what appears to be two distinct curves with the same period, with one curve covering the bright maxima and one curve covering the dimmer maxima. Note that there are a lot of data that do not seem to fit the curve. Rather than demonstrating the aperiodicity of the star, I have felt (and assumed in my conclusions) that the data are erratic.

4. Evaluating the data

Members of the AAVSO staff suggested that I look at the Harvard plate collection for other observations. The plates I examined were from the Damon series, which are mostly blue-sensitive, and do not go deep enough to capture any other than the four or five brightest maxima. The 1984 maximum showed up well. When it was about visual magnitude 11.5, the photographic plates showed it to be as bright as the 12.4 comparison star. Using these plates, I was only able to rule out a few of the bright discordant observations. At that point I knew I needed to get at least one more good maximum.

Recalling Ronald Zissell's unpublished paper on AAVSO sequences given at an AAVSO meeting a few years back, I knew he could easily reach 16th magnitude. Using a CCD, he was able to contribute an excellent set of data from the minimum in mid-1995 through the maximum in late 1995, to the minimum in late 1996.

I developed the following criteria in evaluating the data:

a. The star is regular. During the last 30 some years it has always acted in a regular fashion when it was followed extensively. I felt that the observations that were irregularly up and down were incorrect and could be ignored.

b. The star has never shown long standstills at intermediate magnitudes (when it is well covered). Hence the apparent standstills at mid-magnitudes must be spurious.

c. In the early years there were several observers who made many observations. I could often compare an apparently discordant observation to an observation by some regular observer. In later years, that is almost impossible.

I decided that a visual inspection of the data to create an O-C table would help clarify behavior. Starting from the first AAVSO maximum in 1962, I marked all the readable maxima, the expected maximum dates, and the difference between succeeding maxima (which is called the period in Table 1). I also created an O-C graph marking the observed O-C plus O-C data using the earliest and latest maximum dates that could be found from a visual inspection of the data (the earliest and latest dates that the star was plus or minus half a magnitude from maximum. Figure 4 shows this O-C using the GCVS 4 elements.

Using the linear regression feature of a commercial spreadsheet (Quattro Pro), I found a period of 421.2 days with a new epoch of 2443320 (which was the closest epoch to the 0 point in the O-C curve). I still get a large standard deviation in the period (34 days). I have created a graph (Figure 5) which shows the O-C data of Figure 4 graphed with my newer epoch and period. Table 1 summarizes the results of my research on SU Lyr, giving the epoch, the date of maximum according to my inspection of the AAVSO raw data, the calculated date of maximum according to the elements given in the GCVS

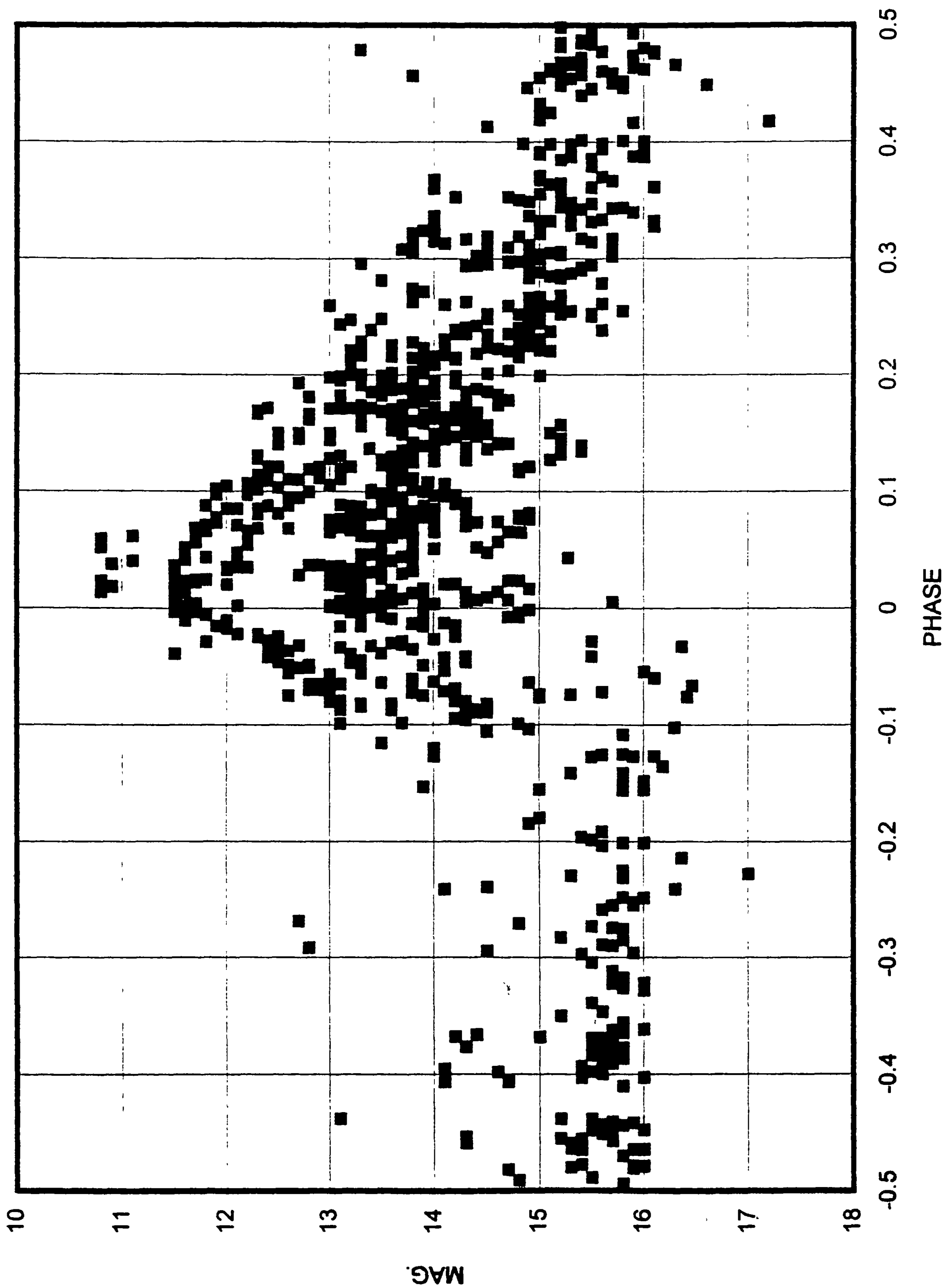

Figure 3. Phase graph of AAVSO raw (unevaluated) data on SU Lyr 1961–1995, graphed using elements in GCVS (4th edition).

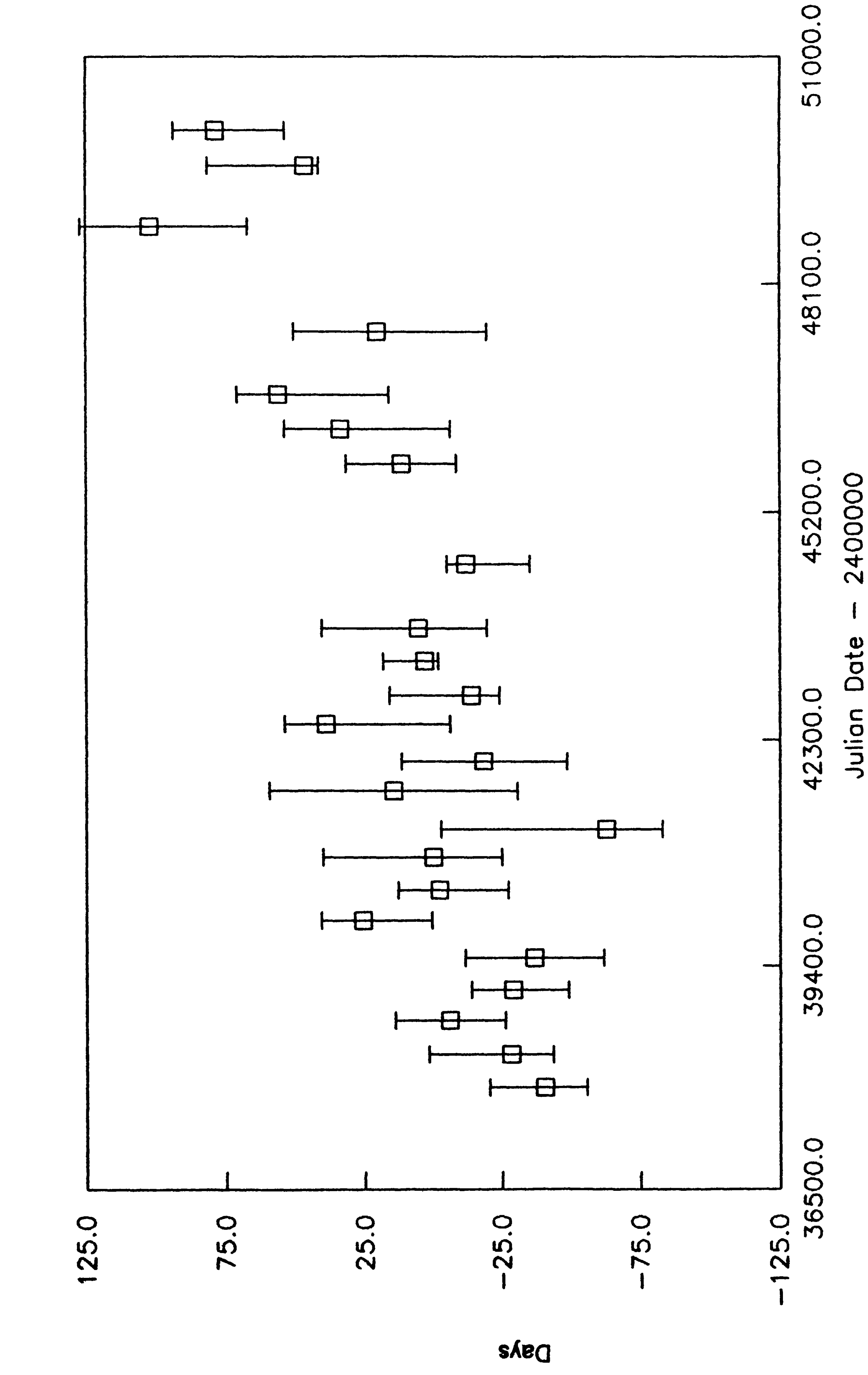

Figure 4. O-C curve for SU Lyr, using the raw (unevaluated) AAVSO data and computed from elements in GCVS (4th edition).

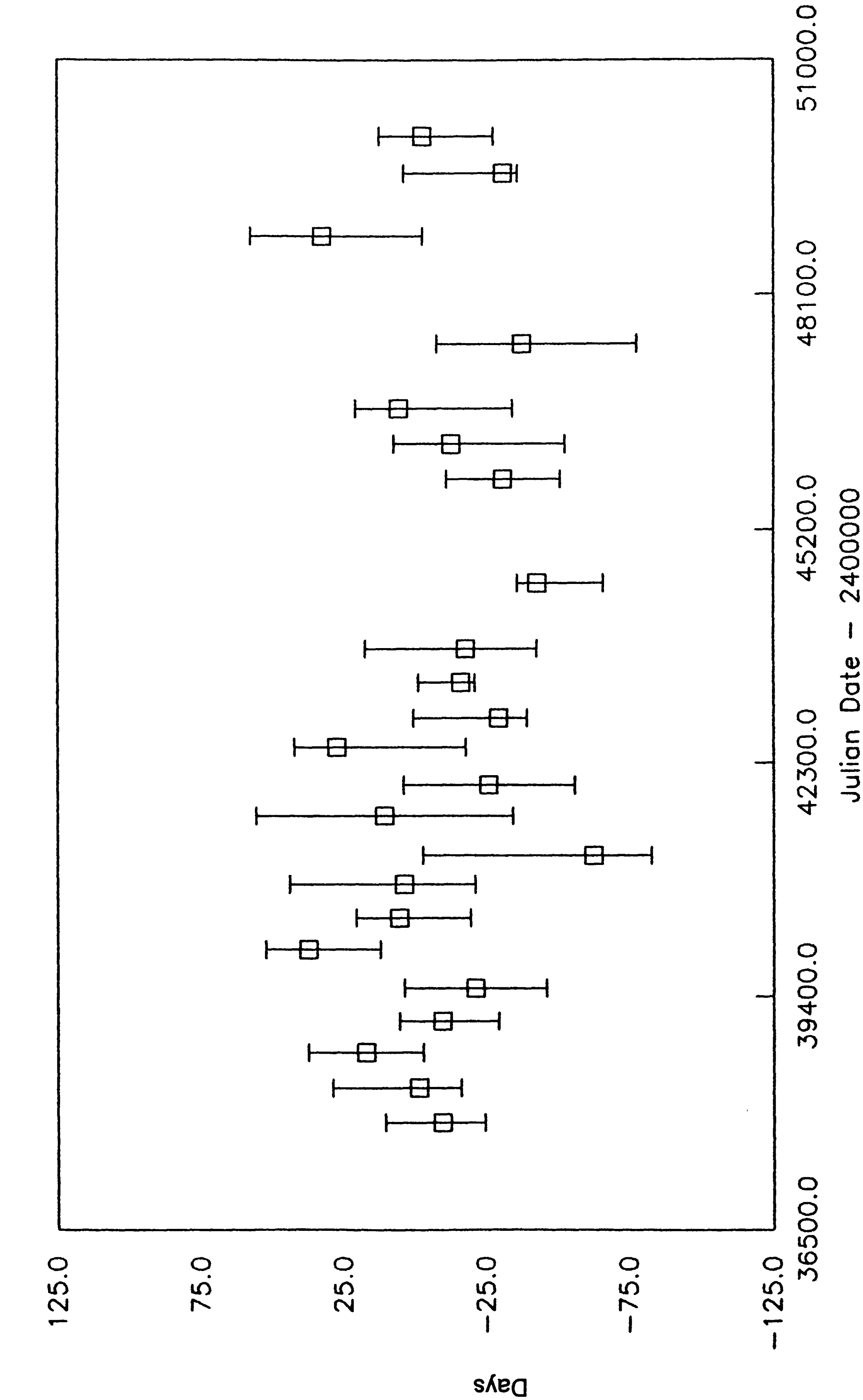

Figure 5. O-C curve for SU Lyr, using the raw (unevaluated) AAVSO data and computed from new elements.

Table 1. For SU Lyrae: Epoch, observed and calculated dates of maximum, period, and O-C.

Epoch	*Observed Max. Date**	*Calculated Max. Date***	*Period*	*O-C*	*Date*
1	2437830	2437870.47		-40.47	6/13/62
2	2438260	2438288.26	430	-28.26	8/17/63
3	2438700	2438706.05	440	-6.05	10/30/64
4	2439095	2439123.84	395	-28.84	11/29/65
5	2439505	2439541.63	410	-36.63	1/13/67
6	2439985	2439959.42	480	25.58	5/7/68
7	2440375	2440377.21	390	-2.21	6/1/69
8	2440795	2440795	420	0	7/26/70
9	2441150	2441212.79	355	-62.79	7/16/71
10	2441645	2441630.58	495	14.42	11/22/72
11	2442030	2442048.37	385	-18.37	12/12/73
12	2442505	2442466.16	475	38.84	4/1/75
13	2442870	2442883.95	365	-13.95	3/31/76
14	2443305	2443301.74	435	3.26	6/9/77
15	2443725	2443719.53	420	5.47	8/3/78
16	2444135	2444137.32	410	-2.32	9/17/79
17	2444543	2444555.11	408	-12.11	10/29/80
18		2444972.9			1/2/82
19		2445390.69			2/24/83
20	2445820	2445808.48	425.7	11.52	4/28/84
21	2446260	2446226.27	440	33.73	7/12/85
22	2446700	2446644.06	440	55.94	9/25/86
23		2447061.85			11/23/87
24	2447500	2447479.64	413	20.36	12/3/88
25		2447897.43			1/31/90
26		2448315.22			3/30/91
27	2448835	2448733.01	445	101.99	7/30/92
28		2449150.8			9/27/93
29	2449615	2449568.59	390	46.41	9/18/94
30	2450065	2449986.38	450	78.62	12/12/95
	STANDARD DEVIATION:		34.69	38.35	
	AVERAGE PERIOD		422.48		

* *From AAVSO raw (unevaluated) observations.*
** *Based on elements in the GCVS 4th edition.*

4th edition, the "period," the O-C, the Gregorian date of the AAVSO maximum, and the period I find.

5. Conclusions

What we know of SU Lyrae now is somewhat similar to what we knew before. The O-C curve shows that the period is longer than published. This paper shows that old fashioned techniques for period searching can still be useful. It also shows what can be gleaned from very spotty data.

6. Acknowledgements

I thank Janet Mattei, both for allowing me to have access to the raw AAVSO data and for her suggestions and advice; Elizabeth Waagen, for her help with references; and other AAVSO staff members who provided assistance, but whose names I do not know. My thanks also to Martha Hazen for allowing me access to the Harvard plate collection, and to Ronald Zissell both for extending the magnitude sequence and for providing a very good set of recent observations.

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