A STUDY OF AY LYRAE

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Abstract

A study of the AAVSO data on the U Gem star AY Lyrae from 1935 to mid-1977 shows that it varies with a mean period of 23.7 days. It shows two types of outbursts: narrow-and-faint and wide-and-bright (supermaxima). A mean period of 205.5 days exists between supermaxima.

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AY Lyrae, at position $\alpha = 18^h41^m01^s$, $\delta = +37°54'2"$ (~~1950~~), was discovered by C. Hoffmeister on Sonneberg plates in 1928. In the third edition of the General Catalog of Variable Stars (GCVS) its period is given as 24 days, the brightness range between $12^m.6$ and 17^m photographic, and the spectrum as G type.

U Gem stars are believed to be close spectroscopic binaries, although the duplicity of AY Lyrae has not yet been observed, perhaps because the star is very faint.

Observations

Observers of AAVSO made over 20,000 observations on AY Lyrae from 1935 to mid-1977 (J.D. 2,428,000 to 2,443,300). It is easily located in the sky, being less than 30' north of ζ Lyrae, thus it is well monitored from April to December, when it is sufficiently far from the sun. The yearly total of observations in the AAVSO data file rises exponentially, showing a remarkable coverage from 1970 to the present.

From 1935 to 1960, the positive observations were mostly those of outbursts. The quiescent periods were determined by "fainter than" or negative observations, where the variable is fainter than the faintest comparison star. For this interval the faintest comparison star on AAVSO charts was $14^m.5$. Since then the addition of faint comparison stars, down to $15^m.5$, on the "e" scale AAVSO chart enabled observers with moderately large telescopes to follow its behavior well at minimum.

Discussion

The outbursts of AY Lyrae for the 15,300 days studied were recorded. Observations 14^m and brighter were considered to be outbursts. The Julian date, maximum magnitude and type of outburst are listed in Table 1. Each outburst was weighted from 1 to 5, with 5 being the best observed. An outburst denoted by one observation was given the weight of 1, regardless of the observer.

From 1935 to June, 1977, 348 outbursts were recorded. The mean period between outbursts is 23.7 days. The intervals greater than 49 were not included in the average, since there is a definite possibility of missed outbursts. The shortest interval between outbursts is 4 days.

Between the dates 2,442,300 and 2,443,300 - when AY Lyrae was monitored extremely well - the 32 consecutive outbursts gave an average of 23.5 days. Excluding gaps that exist when the variable is not favorably located for observing, observations are recorded for almost every night. In most cases, the nights that are missed are either a few days before or after an outburst, when the occurrence of another outburst is unlikely. Thus we believe that 23.7 days is a good estimate of its mean period. Although the possibility exists of a shorter period, we do not believe the average period to be as short as 10.6 days, as claimed by Howarth (1977).

A histogram was prepared showing the frequency of the intervals between recorded consecutive outbursts used in determining the mean period. Figure 1 shows that the frequency of intervals between outbursts peaks between 23 and 27 days. Another favored interval lies between 15 and 17 days, and still another one at 32 days.

The outbursts of AY Lyrae are distinctly divided into two groups depending upon their duration and brightness: narrow-and-faint and wide-and-bright. Figure 2 is an AAVSO light curve covering an interval of 200 days (May 1 to Nov. 17, 1976) that shows quite well the two types of maxima.

The majority of the outbursts are narrow, with a duration of 1 to 2 days. (There are 2 outbursts of 3-day and 2 of 4-day duration.) The average maximum magnitude of narrow outbursts is $13^{m}.2$, and the range of the maximum is from $12^{m}.8$ to $14^{m}.0$. The narrow outbursts have a very rapid rise and decline, the complete outburst lasting only one day in several cases. Therefore, it is difficult to measure the exact durations, the rate of rise and decline, and the maximum magnitude, unless the outburst is observed very well. And unless there are observations every night, to a limiting magnitude of 14^{m}, one cannot say with certainty that no outburst has been missed.

The star fluctuates between $15^{m}.2$ and $15^{m}.9$ with a mean of $15^{m}.5$ at minimum. However, several reliable observers reported brightenings up to $14^{m}.5$ magnitude. On several occasions, 3 days before a narrow outburst, the star was observed to be between $14^{m}.5$ and $14^{m}.2$ followed by fainter observations and then an outburst.

Wide-and-bright outbursts, observed particularly in U Gem stars with periods with less than 30 days, have been named "supermaxima." Forty-six supermaxima have been observed from 1935 to June 1977, in AY Lyrae. These outbursts have an average brightness of $12^{m}.6$ with a range from $12^{m}.2$ to $12^{m}.9$. There were only two outbursts observed in 1936 and 1938, which reached $13^{m}.0$ and $13^{m}.2$, respectively. There appears to be an average period of $205^{d}.5$ in the occurrence of the supermaxima, with a range from 181 to 232 days. The average period was determined both by averaging the dates at maximum magnitude and the dates at 14 magnitude on the ascending branch of the outbursts. Both methods gave the same result.

The average width of supermaxima at $14^{m}.0$ is $12^{d}.2$ (calculated using those that are well observed), and ranges from 6 to 17 days. The rise to maximum takes generally 2 to 3 days, but can range from 1 to 8 days. The rate of the rise effects the shape of the supermaxima, where most supermaxima can be divided into four classes as is shown in Figure 3. The observations during supermaxima indicate that the brightness of the variable fluctuates, however, it is not possible to obtain periods for these fluctuations due to the scatter in the brightness estimates.

It is believed that in U Gem stars there may be a relationship between the interval preceding and/or following an outburst and the maximum brightness of the outburst. To determine whether such a relationship exists in AY Lyrae, first the intervals up to 49 days preceding the outbursts versus the brightness was graphed, Figure 4. Narrow outbursts are indicated by dots and supermaxima by open circles. There appears to be no relationship between preceding intervals and brightness of outbursts both for narrow outbursts and supermaxima. Figure 5 is the graph of the intervals, up to 49 days, following the outburst and the brightness of outburst. Again, no positive relationship exists for narrow outbursts, however there appears to be a weak relationship between intervals following and the brightness of the supermaxima. The brighter the supermaximum, the longer is the interval to the next outburst. There is the possibility of missed outbursts between the recorded outbursts, which would nullify the relationship.

Conclusion

We can summarize our findings as follows:

AY Lyrae is a dwarf nova with a mean period of 23.7 days between outbursts. It varies between 12.2 and 15.9 magnitude. It has two types of outbursts: narrow-and-faint with a mean magnitude of 13.2 and durations between 1 and 2 days, and supermaxima, which are wide-and-bright with a mean magnitude of 12.6, mean duration of 12.2 days, and a mean period of 205.5 days. There is a suggestion that the brighter the supermaxima, the longer the interval to the next outburst, however this relationship is in need of verification.

Recommendation for Future Observations

a) Observers with moderately large telescopes should monitor AY Lyrae every observable night. Through very close monitoring, the above findings can be confirmed or refined.

b) If the variable appears brighter than 15^m, exact timing up to 3 decimal places of the day should be given. (Decimal of a day table may be obtained from AAVSO Headquarters.)

c) If the variable is brighter than 14^m, it should be observed several times during the night. Throughout its outburst, on the ascending, maximum, and descending branches, timing to 3 decimal places of a day should be given for each estimate.

d) If possible, another observer should be alerted to increase the coverage of outbursts.

e) When reporting observations to AAVSO Headquarters, at the end of each month, dates and magnitudes should be checked and re-checked to avoid typographical errors.

References

Howarth, I. 1977, Journ. Brit. Ast. Assoc., 88, 79.

Kukarkin, B. V., et al, 1969, General Catalog of Variable Stars, Moscow.

TABLE 1

OUTBURSTS OF AY LYRAE

Max. JD 2400000+	Maximum Magnitude	Type	Weight	Max. JD 2400000+	Maximum Magnitude	Type	Weight
28012	13m0	N?	5	32029	13.2	?	1
8039	13.7	N	2	2095	13.3	?	1
8396	13.0	W	5	2120	13.6	?	1
8478	13.7	?	1	2316	13.7	?	1
8614	13.7	?	1	2349	12.8	?	3
8697	13.6	?	3	2449	13.0	?	1
8715	13.5	N	4	2524	12.8	W	4
*8725	12.5	N	3	2544	13.2	?	1
*8757	13.0	N	2	2740	12.9	?	3
8784	12.5	W	5	2970	12.9	?	1
*8792	12.2	W	3	3062	13.2	N	1
8800	13.6	?	4	3158	12.9	W?	3
*9000	12.5	W	4	3367	12.9	?	1
9058	13.4	N	4	3507	13.6	N	1
9105	13.5	N	5	3530	13.5	?	1
9131	13.7	N	3	3535	13.8	?	1
9169	13.5	N	3	3558	12.6	W	5
9202	13.2	W	5	3739	13.8	?	1
9262	13.4	N	1	3772	12.7	W	4
9425	12.6	W	4	3799	13.6	N	1
9461	13.2	N	3	3863	13.6	N	1
9481	13.1	N	4	3895	13.3	N	2
9510	13.1	N	3	3917?	13.0?	?	1
9525	13.2	N	2	3929	13.4	?	2
9547	13.1	N	2	3975	12.5	W	5
9580	13.0	N	2	4123?	13.6	?	1
9604	13.7	?	1	4132	13.3	?	1
9641	13.1	?	1	4162?	13.1	?	1
9788	13.6	?	1	4186	12.7	W	5
9810	13.5	?	1	4225?	13.5?	?	1
9833	13.0	?	2	4253	13.3	?	3
9883	12.0	W?	1	4262	12.3	N	1
30246	13.2	?	3	4277	13.1	N	4
0645	13.8	?	1	4294	13.7	N	3
0652	13.2	?	1	4306	13.2	N	3
0666?	13.2	?	1	4328	13.1	N	3
0672	12.6	W	5	4363?	12.5?	?	1
0705	13.4	?	1	4518?	13.8	?	1
0742	13.6	?	1	4536	13.9	?	1
0846	13.0	?	1	4568	13.4	?	2
0880	12.6	W	5	4597	12.1	W	5
0941	13.8	N	2	4627	13.0	N	1
0963	13.6	N	1	4655?	13.4	N	1
0967	13.2	?	3	4713	13.2	N	1
0985	13.6	?	1	4779	13.5	?	2
1002	13.2	?	1	4803	12.0	?	1
1201	13.2	N	3	4863?	13.5	?	1
1288	13.4	N	3	4888?	13.9	?	1
1295	13.2	N	3	4920?	13.8	?	1
1311	12.6	W	5	4943	13.4	?	1
1432	13.2	?	1	4951	13.9	N	1
1525	13.2	?	1	4986	13.4	?	1
1672	12.8	W?	3	5003	12.9	W	5
1681	13.6	?	1	5033	13.2	N	3
1706	13.2	?	2	5088	13.3	?	1
1943	13.2	?	1	5158	13.3	?	1
1967	13.6	?	1	5187	13.9	?	1

*Photographic observations.

TABLE 1 (Continued)

Max. JD 2400000+	Maximum Magnitude	Type	Weight	Max. JD 2400000+	Maximum Magnitude	Type	Weight
35196	13.4	?	1	37524	12.8	N	5
5213	12.8	W	4	7537	12.4	?	1
5316	13.5	N	1	7545	13.0	N	4
5339	13.2	N	4	7563?	13.4	N	2
5366	13.0	N	3	7578	13.4	N	3
5380	13.2	N	2	7627	12.7	N	5
5417	12.2	W	5	7750	13.3	N	1
5609	12.4	W?	3	7783	13.7	N	3
5623	13.0	?	1	7817	13.7	N	3
5669	13.2	N	1	7840	12.5	W	5
5721	13.0	N	4	7884	13.5	N	5
5743	13.1	N	1	7899	13.7	N	5
5753	13.2	N	4	7918	13.2	N	4
5780	12.8	W	5	7943	13.1	N	1
5961	13.1	?	1	8026?	12.0?	?	1
5966	13.2	?	1	8152	13.2	N	4
5979	13.6	?	3	8179	13.1	N	5
6009	13.8	N	2	8207	13.0	N	5
6023	12.9	N	2	8225	12.6	W	5
6044	13.2	N	3	8247	13.2	?	1
6073	13.4	N	3	8254	12.8	N	2
6100	13.6	N	2	8260	13.4	N	5
6127	13.8	N	3	8297	13.0	N	5
6154	13.4	N	3	8367	13.2	N	3
6172	12.6	W	4	8416	13.2	W?	3
6290	13.2	?	1	8441	13.2	N	3
6311	13.7	N	3	8510	12.5	?	1
6343	12.9	?	1	8544	13.1	N	5
6348	13.8	?	1	8566	12.8	N	2
6362	14.2	N	3	8610	12.4	W	5
6376	12.0	W	3	8640	13.1	N	4
6409	13.5	?	1	8665	13.1	N	3
6425	13.8	N	3	8698	13.0	N	3
6452	13.5	N	2	8724	13.3	N	3
6470	13.6	?	1	8864	13.3	N	3
6479	13.5	?	1	8886	12.7	?	4
6483	13.4	?	1	8910	13.2	N	4
6536	13.2	?	1	8918	13.2	N	3
6644	13.6	?	1	8943	13.3	N	3
6726	13.2	N	2	8957	13.4	N	5
6746	13.5	N	1	8974	13.0	N	1
6778	13.5	N	2	8990	12.4	W	5
6801	12.6	W	5	9039	12.9	N	1
6819?	13.3	N	2	9047	13.2	N	3
6832	13.7	N	2	9063	13.1	N	5
6862?	13.0	N?	2	9084	13.2	N	1
7014	12.8	W	3	9111	13.2	?	1
7111	13.5	N	4	9121	13.1	?	1
7128	13.4	N	2	9176	12.2	N	1
7144	13.0	N	5	9201	12.5?	W?	3
7178	12.9	N	5	9217	13.5	?	1
7215	12.5	W	5	9231	13.8	N	3
7260	13.6	N	2	9253	13.4	N	1
7383	14.0	N	2	9269	13.3	N	3
7398	13.1	?	1	9285	13.0	N	2
7420	13.3	W	3	9300	13.0	N	2
7440	12.7	N	3	9309	13.5	N	1
7472	13.0	N	3	9325	12.5	N	3

TABLE 1 (Continued)

Max. JD 2400000+	Maximum Magnitude	Type	Weight	Max. JD 2400000+	Maximum Magnitude	Type	Weight
39330	13.3	N	5	41196	13.4	N	4
9358	12.8	N	5	1223	12.7?	N	2
9404	12.5	W	5	1249	13.0	N	4
9427?	13.0	N	1	1397	12.7	?	1
9434	13.3	N	3	1434	13.2	N	1
9609	13.1	W?	4	1462	14.0	N	1
9654	13.8	N	5	1487	12.8	N	3
9675	13.4	N	5	1506	13.4	N	5
9686	13.4	N	3	1545	13.3	N	1
9696?	13.0	N	2	1558	12.3	W	5
9716	13.8	N	2	1598	13.5	N	5
9740	13.1	N	4	1634	13.6	N	1
9769	13.2	N	5	1716	13.1	?	1
9786	13.1	N	5	1765	12.7	W?	4
9821	12.9	W?	5	1869	13.3	N	5
9887	13.4	?	1	1901	13.1	N	5
9977	13.2	N	4	1937	12.8	N	5
40000	13.4	N	1	1951	13.6	?	2
0027	13.5	N	5	1970	12.6	W	5
0042	12.6	W	5	2122	13.3	?	1
0073	13.3	N	1	2161	12.5	W	5
0118	13.0	N	1	2210	13.2	N	5
0144	13.2	N	3	2248	13.1	N	5
0184	13.5	N	1	2271	13.0	N	5
0197	13.8	N	2	2308	13.1	N	5
0361	12.6	N	1	2328	13.4	N	5
0388	13.3	N	3	2348	13.1	N	4
0408	13.4	N	4	2373	12.2	W	4
0440	12.7	N	5	2394	13.1	?	1
0465	12.5	W	5	2487	13.2	N	3
0500	13.3	N	4	2522	13.0	N	5
0515	13.4	N	1	2565	12.2	W	5
0530?	12.2	N	3	2596	13.3	N	5
0550?	12.2	N	2	2621	13.2	N	5
0560?	12.8	N	1	2641	13.5	N	1
0569?	12.2	?	1	2660	13.3	N	5
0578?	12.8	?	1	2683	13.0	N	5
0593?	12.2	N	2	2708	13.0	N	5
0673?	12.2	?	1	2732	13.2	N	1
0683	12.7	W?	5	2738	12.8	N	5
0718	13.2	N	1	2779	12.5	W	5
0736	13.5	N	1	2811	13.5	N	1
0771	13.7	N	3	2865	13.3	?	1
0816	13.5	N	1	2899	13.2	N	5
0835	12.7	N	5	2925	13.2	N	5
0858	14.0?	N	5	2942	13.1	N	5
0883	12.4	N	5	2952	13.6	N	2
0898	13.0	N	3	2965	13.0	N	5
0915	12.5	W	5	2984	12.6	W	5
0936?	13.8	N	3	3012	13.2	N	5
0945	13.0	?	1	3038	13.6	N	3
1045	13.4	N	4	3048	13.3	N	3
1058	13.8	N	1	3074	13.0	N	5
1079	13.3	N	1	3108	13.0	N	4
1085?	13.5?	?	1	3158	12.8	N	4
1120	12.5	W	5	3220	13.6	N	1
1139?	13.5	?	1	3234	13.4	N	1
1153	13.3	N	5	3242	13.3	N	4
1172	13.8	N	5	3264	13.9	?	1
				3281	13.3	N	1

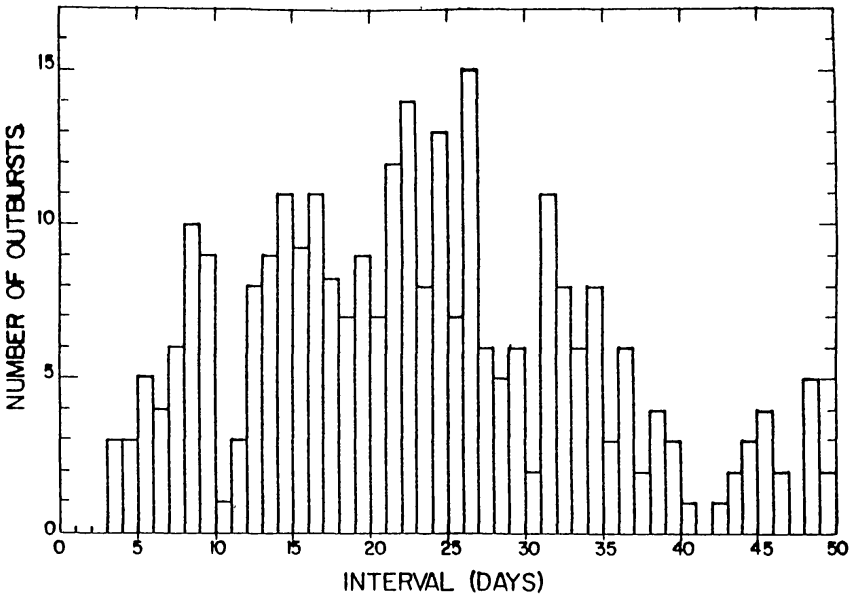

Figure 1. Histogram of the frequency of intervals (in days) between outbursts.

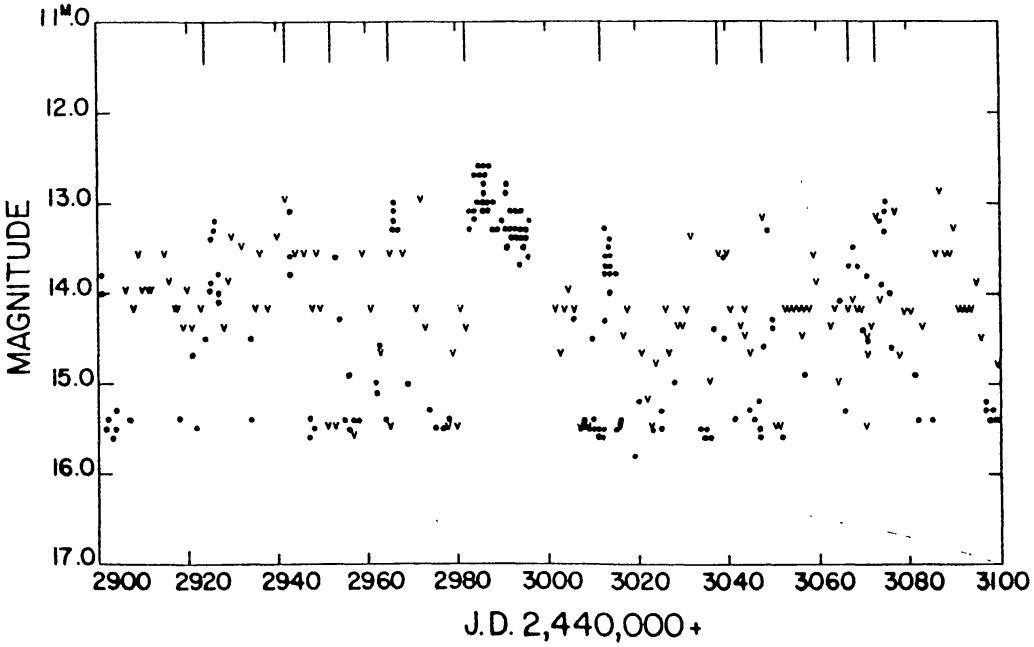

Figure 2. The AAVSO light curve of AY Lyrae between May 1 and November 17, 1976, where the narrow-and-faint, and wide-and-bright outbursts show distinctly. The long vertical tick marks on the upper horizontal axis, mark the dates of outbursts.

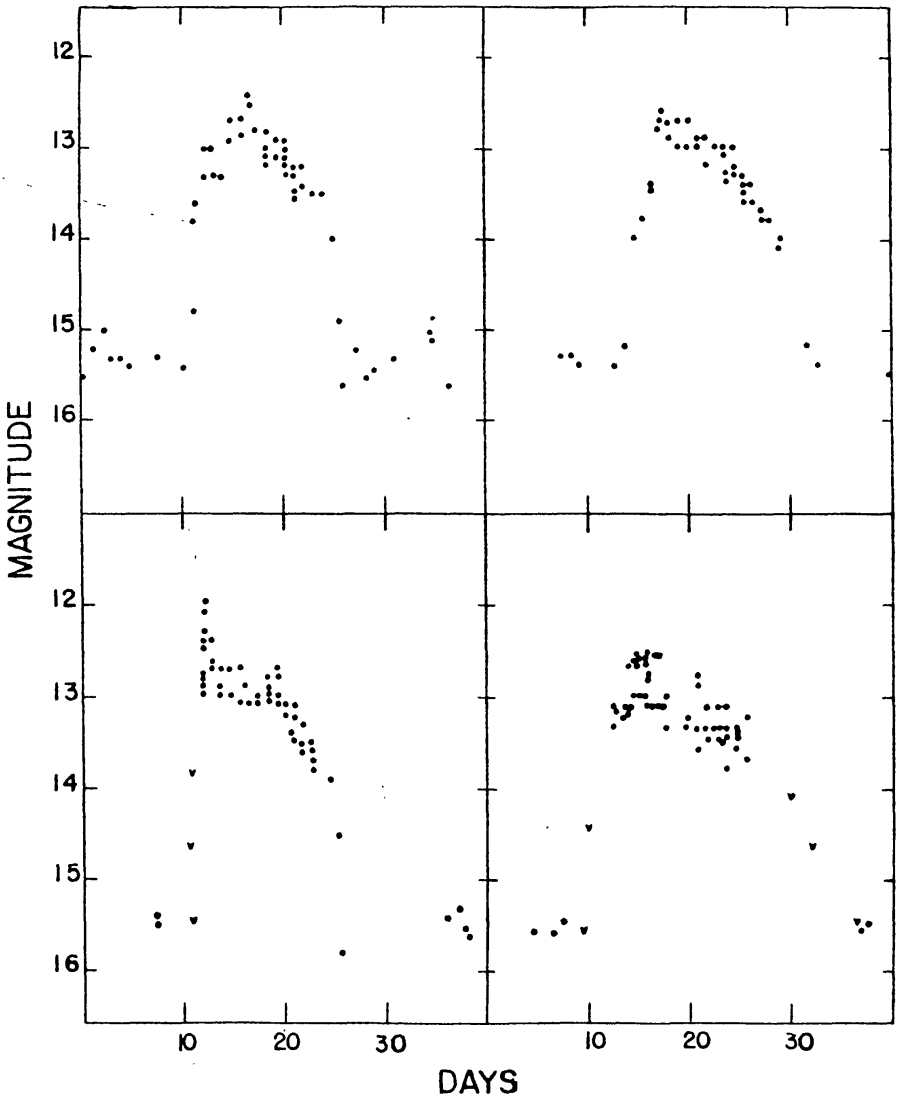

Figure 3. Examples of the different classes of supermaxima. Each dot represents one observation in the samples of light curves of four well observed supermaxima occurring on J.D. 2,438,610 (upper left), 2,438,225 (upper right), 2,442,567 (lower left), and 2,442,984 (lower right).

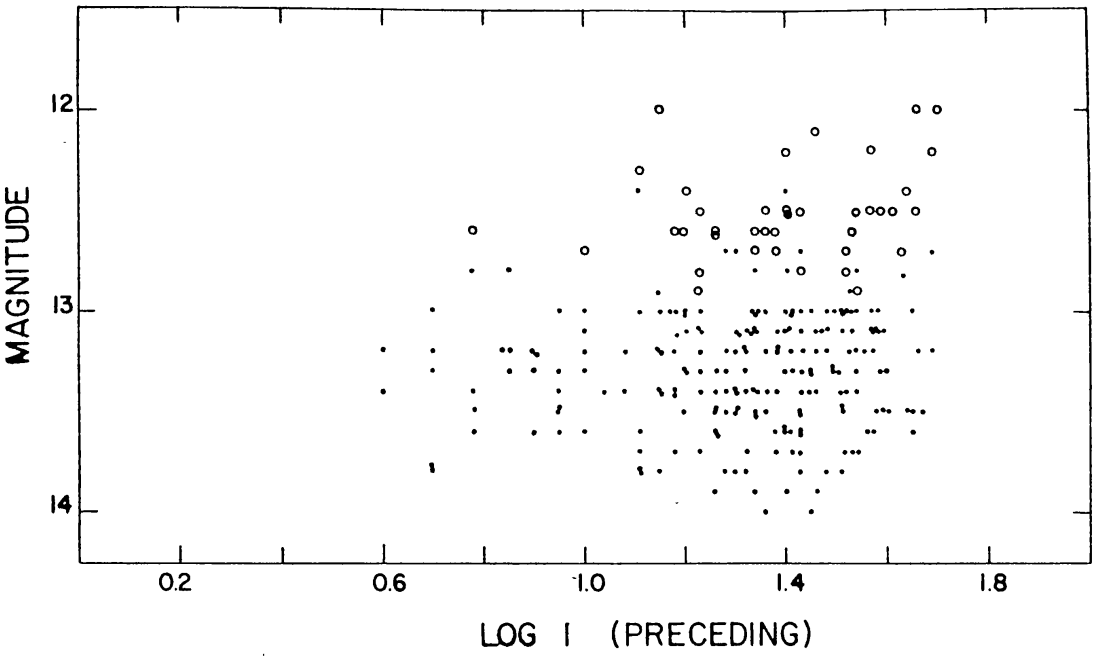

Figure 4. Relationship between maximum brightness and the interval preceding outbursts. Narrow outbursts are indicated by filled dots, and the supermaxima by open circles.

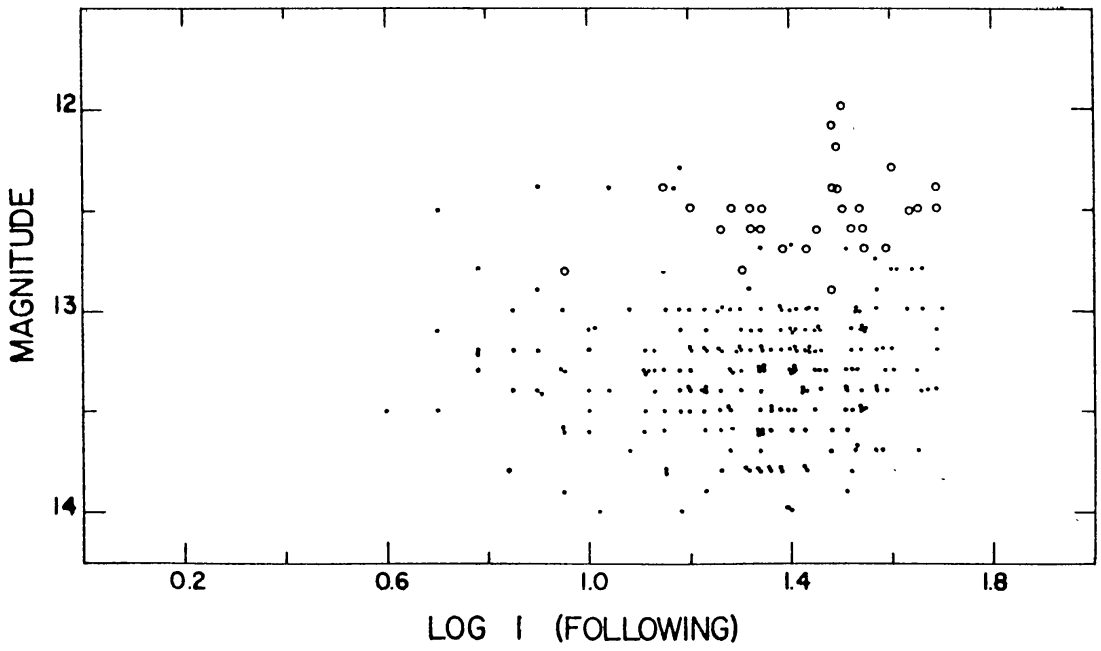

Figure 5. Relationship between maximum brightness and the interval following the outbursts. Narrow outbursts are indicated by filled dots, and the supermaxima by open circles.