WHAT HAPPENED TO 51 PISCIUM?

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Abstract

51 Piscium was invisible on 3 January 1971 when it was predicted to undergo a grazing occultation. A search of some 1000 Harvard patrol plates failed to reveal any minima. But do not give up hope!

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A grazing occultation on 3 January 1971 had been predicted for the $5^m.7$ star, 51 Piscium (Povenmire 1979). At the appointed time the star was invisible! Povenmire, who called this to my attention, assumed that the star is an eclipsing binary. It is not listed in the GCVS nor its associated catalogues of suspected variables. I have searched Harvard patrol plates in an effort to substantiate Povenmire's surmise.

51 Piscium, long recognized as a double star ADS 449 (Aitken 1932), with components 5.7 and 9.7 separated by 28", is now believed to be a quadruple system. The primary of ADS 449 has been found by modern photoelectric occultation techniques (Africano et al, 1976) to be a probable close triple system, $6^m.6$ and $6^m.9$ separated by 0".031, the third component $8^m.8$ at 0".196. Visually these three are blended into a single image, and with small photographic instruments all four appear as one single star.

The 1971 occultation was predicted to occur at twilight when the moon was 47% illuminated. Under similar circumstances stars as faint as 9^m have been successfully observed (Dunham 1974). Hence this anticipated event had been termed "very favorable." For the star to have been completely invisible in an 8-inch portable telescope, it should probably have been fainter than 8^m.

I examined plates of the AI series taken with a 1.25-inch Ross-Xpres lens giving a scale of 1200"/mm. A decrease of two magnitudes should have been easily detectable. On plates centered at 23^h, 0^h and 1^h R.A., ± 0°, and 1^h + 15° over 1000 plates were available, spanning the interval 1920 through 1953 (very few taken thereafter). I quickly compared 51 Piscium and 34 Piscium and 35 Piscium, the two nearest stars of comparable magnitude, and coincidentally of similar other characteristics (Table I). All are close double or multiple

TABLE I

51 Psc and Comparison Stars

Name	HR	ADS	RA (1900)	Dec	m_1	m_2	Sp	Multi-plicity	Max. Sep.
51 Psc	132	449	$0^h27^m01^s$	+ 6°24'	5.7	9.7	B9.5V	quadruple	28"
34 Psc	26	122	0 04 54	+10 35	5.5	10.0	B9V	double	8
35 Psc	50	191	0 09 50	+ 8 16	6.1	7.7	FOIV	triple	12

systems and have nearly the same spectral class. 35 Piscium is a $0^d.84$ Algol star, UU Piscium, but with an amplitude of only 0.1, too slight to affect its usefulness as a comparison star for the present purpose. On none of the plates examined was 51 Piscium appreciably fainter than the two comparison stars. Small variations were at times suspected, but they could well be attributed to differences in the emulsions used over the years, and particularly to random differences in seeing conditions. On numerous plates, moreover, silhouettes of tree tops were evident in the field!

If 51 Piscium is not an Algol type, but there was indeed a deep minimum at the epoch of the frustrated occultation, what kind of a variable could it be? As to light curve, R Coronae Borealis seems a good clue, with its mildly fluctuating maximum and rare, but unpredictable, precipitous decline to minimum. The R CrB stars, however, usually have spectral classes F to K or R, not A.

In the 1969 edition of the GCVS and its three Supplements (1971-76) I looked up the forty stars that had been classified as R CrB in the earlier 1958 edition of the GCVS. Five of them (Table II) had been reclassified, primarily because they proved to have early spectral classes. Three of them are now called type Ia variables, described in the introduction to the GCVS as "irregular variables of early spectral classes (O-A). Very heterogeneous type of objects." VZ Sagittarii had been changed to Isa in the 1969 edition, but in the 2nd Supplement back to R CrB. The fifth star in Table II, EE Cephei, is now classified as EA, and it may well prove to be a prototype for 51 Piscium. In 1969 the GCVS noted that "only one minimum of 30^d duration was observed near JD 2434345." Romano (1956), who discovered the variable, had only 47 photographic and 41 photovisual estimates spanning 130 days. On the basis of the light curve and a color index of $+ 0^m.6$, corresponding to spectral class about GO, Romano had inferred the R CrB type. Subsequently Meinunger (1973; 1976) found a period of $2049^d.53$ from 5 minima, with the minima varying strongly in depth and width.

TABLE II

Subsequent Data on Stars Previously Classified R Cor Bor

Name	New Type	Max.	Min.	Sp	GCVS
SY Cep	Ia	11.2	13.0 p	A3:	1969, 3rd Ed.
BG Cep	Ia	13.4	14.2 p	B8:	1969, " "
BH Lac	Ia?	11.0	12.8 p	AO	1969, " "
VZ Sgr	Isa?	11.8	(14. p	B8	1969, " "
	RCB?	11.8	(14.0 p	C	1974, 2nd Supp.
EE Cep	E?	11.1	(13.0 p	B5:ne	1969, 3rd Ed.
	E?	9.68	(10.9 V	B8IIe	1974, 2nd Supp.
	EA	10.72	11.8 V	B5-B8II-IIIe	1976, 3rd Supp.

The period derived for EE Cephei is approximately 5.6 years. This means that the phases of successive minima come in alternate seasons of the year. Suppose, however, that we had a star with a period only one week longer than 5 years, or 5.02 years. Then each successive minimum would occur one calendar week later than at the previous cycle. If an initially observed minimum came at twilight, and daylight precluded observations for say ten weeks each year, then the star could not be observed at minimum for ten consecutive cycles or 50 years. Any period nearly commensurable with a year would give similar results, but with different intervals of unobservable minima. Ergo: Do not give up hope on 51 Piscium. Keep on looking. But do not take much time for precise magnitude determinations until you do become aware of a decline. Then promptly alert the astronomical world, both visual observers and spectroscopists. Thereafter proceed with the most accurate observations of magnitudes you can make.

At Harvard probably more than a thousand additional patrol plates are available, on peripheral regions and plates taken with larger lenses. Most will cover only the same time-interval as those already examined. Nevertheless I plan eventually to examine all of them. Meanwhile, visual observers, see if you cannot beat me to a minimum!

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51 Piscium: Note Added in Press

Correspondence with Dr. Thomas C. Van Flandern at the U.S. Nautical Almanac Office reveals that the rising branch of the light curve of 51 Piscium could have been rapid. On 3 January 1971 nine observers successfully observed the occultation. Earl S. Brooks at Union Hall, Virginia, recorded it at $22^h\ 58^m.2$ U.T., while the other observers, all in the northeastern U.S., observed it between $23^h\ 08^m.3$ and $23^h\ 14^m.5$. The predicted times for Povenmire and for Robert Wood in Florida ranged from $22^h\ 55^m.0$ to $22^h\ 56^m.3$ when the star was invisible. No magnitude estimates are given for any of these observations, but the rise from invisibility, probably around 9^m, to presumably normal 6^m might have occurred within a span of three minutes.

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