V407 Scorpii: A Revised Period and Epoch for Maximum Brightness

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Abstract Visual observations of the neglected Mira variable V407 Sco during the ten-year interval 1997 through 2006 provide a revised period and epoch for maximum brightness. The dates of maximum are represented by the elements JD 2453612 ± 401.5 (± 4 days) · E. The brightness range is from magnitude 10.2 to fainter than 14.5.

1. Introduction

V407 Sco was first reported by Swope (1936) as HV 07011 and has received subsequent designations including HD 320767, Hen 4-181, GSC 07386-00621, ASAS J175225-3503.3, and IRAS17490-3502. A photographic brightness range of 12.8 to fainter than 16.5, a mean period of 396 days, and epoch of JD 2428705 were given. The period and epoch for maximum shown in the current *General Catalogue of Variable Stars* (GCVS; Kholopov *et al.* 1985) are those derived by Swope and are at this time some seven decades old. Little further investigation into the optical behavior of this star appears to have been made.

The true position of V407 Sco is subject to some confusion in the literature. To resolve this uncertainty, Robert McNaught at the Uppsala Telescope of the Siding Spring Survey, Australian National University at Siding Spring Observatory, kindly imaged this field and measured its position. The derived coordinates are in excellent agreement with those appearing currently in the online GCVS (http:// www.sai.msu.su/groups/cluster/gcvs/gcvs/), namely $17^h\ 52^m\ 25.5^s$ –35° 03' 17.4" (J2000).

My attention was directed to V407 Sco by Robert Price of Bethanga, Victoria, Australia, who in 1996 noted it near maximum brightness on photographs he had taken during the early part of that year. These images suggested V407 Sco was at maximum brightness, some two months removed from the date predicted by the catalogue data. This prompted the author to monitor this star on a regular basis with the aim of establishing its current behavior.

2. Observations

V407 Sco is shown on charts for several nearby Mira stars, including SV, SY, and BN Sco (Bateson *et al.* 1960; Bateson and Morel 1986) in the region of the well-known star cluster Messier 7. None of the available charts are, however, truly suitable as they are not intended for observing this star and therefore do not show the immediate area surrounding V407 Sco in sufficient detail.

A detailed chart (Figure 1) is provided to allow for the positive identification of V407 Sco. Comparison stars have *V* magnitudes determined from the ASAS3 data (Pojmański 2002) and the visual observations have been reduced using these *V* magnitudes.

V407 Sco was observed on a regular basis during the normal observing season of April through October from 1997 through 2006 with occasional observations outside of these months. A seasonal gap is therefore present in the data.

A total of 159 observations were obtained during the ten years of regular monitoring and of these eighty-two were positive estimates. The remaining seventy-seven provide upper limits where the variable is invisible through the author's telescope, usually to a limiting visual magnitude near 14.5.

The dates of maximum brightness were measured directly from large-scale plots and the details are shown in Table 1. Column 1 gives the cycle number relative to Swope's initial epoch, Column 2 gives the date determined for maximum, and Column 3 gives the probable error in days. Column 4 gives the interval to the following maximum, and Column 5 gives the maximum magnitude. Columns 6, 7, and 8 show the O–C values relative to Swope's initial epoch of JD 2428705 for periods of 396, 402, and 401.5 days, as described below.

A mean period of 402 days is evident from the eight observed cycles. Individual cycles range between 394 and 415 days, which is behavior typical of longer period Mira-type variable stars.

Using this 402-day mean cycle and Swope's initial epoch, it is apparent that sixty-three cycles have occurred through to the maximum of JD 2454002 (September 2006). This equates to a mean period of 401.5 days over sixty-nine years and is in good agreement with the results of the current investigation.

The O–C values derived in Columns 7 and 8 of Table 1 also demonstrate the cumulative effects of small period inaccuracies over an extended time span, assuming the mean period has not changed during that time. The observations have been plotted according to the phase determined by the 401.5-day period. This phase plot is shown in Figure 2 and indicates the epoch and period derived here satisfy the current observed behavior of V407 Sco.

Also, the mean period determined here is approximately twice the value currently appearing in The International Variable Star Index, or VSX (Watson *et al.* 2006), which may be accessed through the AAVSO web page. At the times of alternate maximum predicted by the VSX period, the visual observations show V407 Sco is invisible and generally fainter than magnitude 14, therefore indicating this period to be invalid.

The visual magnitude at maximum is considerably brighter than the photographic values indicated in the catalogue data, a visual range of magnitude 10.2 to fainter than 14.5 being found.

An interesting coincidence of the 5.5-day difference between the 396-day catalogue period and the 401.5 days derived here is the gradual "creeping" of the O–C so that in just a few more cycles, perhaps by cycles 70 to 75, the O–C value would appear close to zero and all may have appeared (misleadingly) well.

3. Conclusion

Visual observations of the Mira star V407 Sco during the ten-year interval 1996 through 2006 provide a revised period and elements for maximum brightness. The current behavior of V407 Sco is represented by $JD_{max} = 2453612 \pm 401.5 (\pm 4.0) \times E$. The observed visual brightness range is 10.2 to fainter than 14.5.

4. Acknowledgements

My thanks to Robert Price for drawing attention to V407 Sco, and to Mati Morel for providing the comparison star *V* magnitudes. Also to William Liller, Viña del Mar, Chile, who drew attention to the confusion over the position of V407 Sco, and Rob McNaught, who imaged and measured V407 Sco to resolve this issue.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

References

Bateson, F. M., Jones, A. F., Stranson, I., Sumner, B., and Winnett, R. 1960, *Charts For Southern Variables, Series 2*, Astronomical Research Ltd., Tauranga, New Zealand.

Bateson, F. M., and Morel, M. 1986, *Charts For Southern Variables, Series 19*, Astronomical Research Ltd., Tauranga, New Zealand.

Kholopov, P. N. *et al.* 1985, *General Catalogue of Variable Stars*, 4th ed., Moscow.

Pojmański, G. 2002, *Acta Astron.*, **52**, 397.

Swope, H. H. 1936, *Ann. Harvard Coll. Obs.*, **90**, 207.

Watson, C. L., Henden, A. A., and Price, A. 2006, The International Variable Star Index (VSX), http://www.aavso.org/vsx.

Table 1. Details of observed maxima for V407 Sco, 1997 through 2006, cycle number and O–C values for different periods relative to Swope's (1936) initial epoch.

Cycle	*Max. 2440000+*	*Error ± Days*	*Interval*	*Mag.*	*O–C 396*	*O–C 402*	*O–C 401.5*
55	50795:	5	(801)	—	–86	–20	+7.5
57	51597	5	415	—	–76	–22	+6.5
58	52012	5	401	10.6	–57	–9	+2.0
59	52413	4	394	11.6	–52	–10	+19.5
60	52807	4	397	10.2	–54	–18	+12.0
61	53204	4	408	10.7	–53	–23	+7.5
62	53612	4	390	11.1	–41	–17	+14.0
63	54002	3	—	10.7	–47	–29	+2.5

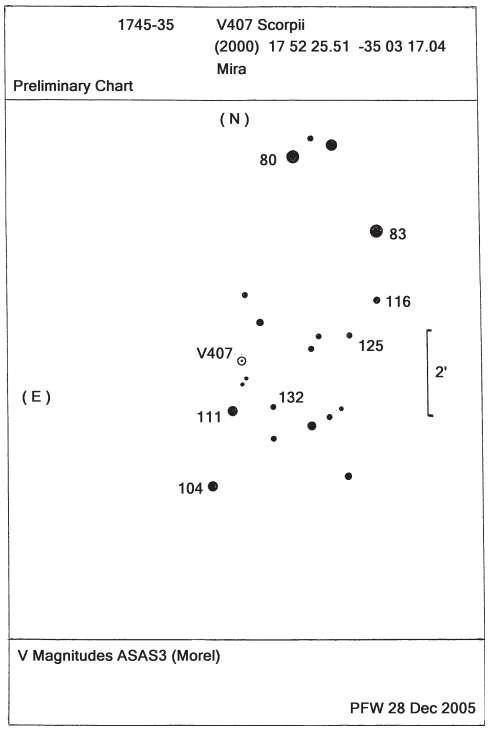

Figure 1. Identification chart for V407 Sco, adapted from RASNZ charts (Bateson *et al.*1960; Bateson and Morel 1986).

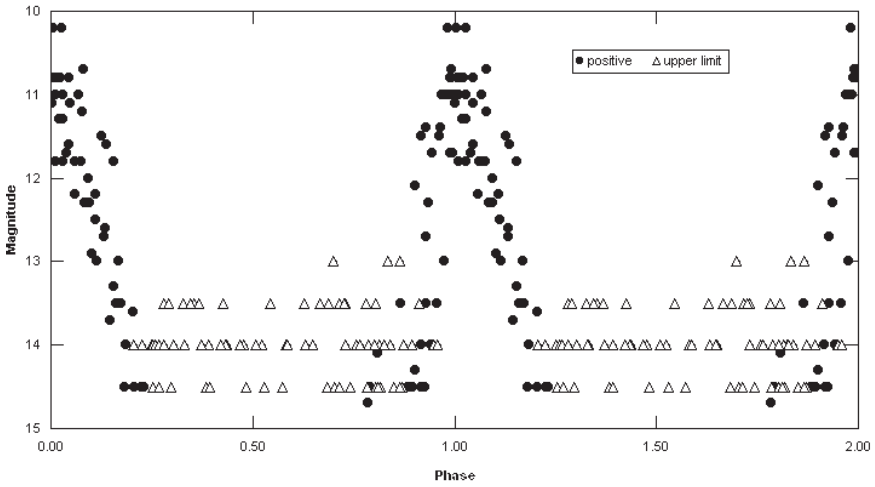

Figure 2. V407 Sco phase plot based on a 401.5-day period and using the author's data.