New Light Curve for the 1909 Outburst of RT Serpentis

Grant Luberda
Wayne Osborn
Yerkes Observatory, 373 W. Geneva St., Williams Bay, WI 53191; email correspondence should be sent to Wayne.Osborn@cmich.edu

Received October 6, 2011; revised October 24, 2011; accepted October 24, 2011

Abstract A new light curve for the 1909 outburst of the unusual nova RT Serpentis has been derived. Published observations have been compiled and new brightness measures determined from archival photographic plates. Modern photometry has been used to place the observations approximately on the *UBV* system. The outburst had an overall increase of at least 5 magnitudes and reached maximum in 1917 May with $B = 11.0$ and $V = 10.1$

1. Introduction

The unusual variable RT Serpentis (= AN 7.1917 = Nova Ser 1909; J2000 coordinates = R.A. $17^h\ 39^m\ 51.98^s$, Dec. –11° 56' 39.0") was discovered by Wolf in 1917 (Wolf 1917) and independently discovered by Barnard two years later (Barnard 1919a). A search of archival photographs showed the object was not visible on any plates prior to 1909 but after outburst remained near maximum brightness for several years (Bailey 1919, Wolf 1919, Shapley 1919) after which it began a slow decline (Shapley 1927). RT Ser is now classified as one of the rare symbiotic novae objects (Nussbaumer 1992).

Our interest in this object began when we came across a plate in the Yerkes collection with the envelope notation "Remarkable variable." Some sleuthing revealed the photograph was one of Barnard's observations of RT Ser during outburst. Our search for a light curve of the event revealed only the old one published by Payne-Gaposchkin and Gaposchkin (1938). It seemed obvious that deriving a new light curve more closely tied to the traditional *UBV* system would be worthwhile.

2. Observational Data

We have collected available observations of the magnitude of RT Serpentis within twenty-five years of its outburst in 1909, i.e., data prior to 1935. The observations are of two types: magnitudes determined from images on photographic plates and visual estimates.

2.1 Photographic Observations

Magnitudes from photographic plates have been published by Wolf (1919), Barnard (1919a, 1919b), Bailey (1919, 1921), and Shapley (1919, 1923, 1927). The published data have been supplemented in three ways. First, we have made eye estimates of the brightness of RT Ser on forty-two plates found in the Yerkes Observatory collection. Second, we have used the digital copies of the plates of the University of Heidelberg's Bruce Telescope that are available online (http://www.lsw.uni-heidelberg.de/projects/scanproject/) both to make eye estimates and to determine magnitudes through aperture photometry. Third, we have determined rough magnitudes and epochs for the "unpublished Harvard observations" plotted on the Payne-Gaposchkin and Gaposchkin (1938) light curve.

2.2 Visual Observations

Visual observations of RT Ser around the time of its outburst have been published by Mundler (1919), Barnard (1919b), Graff (1919, 1921, 1922, 1927), and Lacchini (1921, 1929, 1933). We also downloaded the 121 data points for RT Ser in the AAVSO International Database (AAVSO 2011) that are within our time window. A review of the AAVSO observations showed that all but three are visual estimates by Lacchini. They include his thirteen published magnitude estimates but with more accurate epochs. For some reason, however, his first eight observations have AAVSO magnitudes between 0.2 and 0.3 magnitude systematically fainter than his published values for those epochs, with the published data being more consistent with his subsequent brightness estimates. There is also one case of an epoch with a ten-day difference. We have adopted the published data in the discrepant cases.

3. Reductions

We endeavored to place the diverse observations approximately on the UBV system. Specifically, pseudo-B and pseudo-V magnitudes were derived for the photographic observations and the visual measures, respectively. We began by determining B and V magnitudes for a comparison star sequence that included the stars that had been used by the earlier investigators. The adopted B and V data are given in Table 1 along with the identification of the stars and the source of the BV photometry. Tycho catalogue data were transformed to the UBV system using the relations of Bessell (2000); AAVSO data are from CCD photometry on the UBVRcIc system. Given the uncertainties in the RT Ser magnitudes, the comparison sequence values are usually given only to a tenth of a magnitude.

3.1 Photographic data

The photographic data sets are from the Yerkes, Heidelberg, and Harvard plate collections. Eye estimates of the brightness of RT Ser using our comparison sequence have been made for the Yerkes plates. These data are given in Table 2 which lists the plate number, the Julian date of mid-exposure, and the pseudo-B magnitude. The first digits of the plate number indicate the aperture of the camera employed, with two or more exposures often being taken simultaneously with different lenses.

Wolf (1919) published magnitudes from Heidelberg plates taken with telescopes of three different apertures. Some plates—those taken with the 41-cm (16-inch) Bruce Telescope—have been digitized and are available online. We downloaded the digitized images of plates showing RT Ser and both performed aperture photometry and made eye-estimates using our comparison sequence; our results are given in Table 3. These data showed that a correction of +2.0 mag is needed to convert Wolf's published magnitudes to approximate B ones, and this factor was used to transform the published data for the undigitized plates.

The observations from the Harvard plates were more difficult to adjust. Magnitudes are given in six different references (Bailey 1919, 1921; Shapley 1919, 1923, 1927; Payne-Gaposchkin and Gaposchkin 1938). Several give the magnitude from the critical 1909 July 9 plate, and we compared the different values to each other and to an eye-estimate we were able to make for this plate using our comparison sequence. Our analysis indicates that all Harvard observations other than those of Shapley (1919) are on the same system (referred to as the "Harvard System"). An empirically derived adjustment of +0.6 magnitude was used to transform the Harvard system to our pseudo-B system; the correction used for the 1919 Shapley data was +0.1 magnitude.

3.2 Visual Observations

In general, the visual observers listed the comparison stars used and their adopted magnitudes. We compared the listed comparison star magnitudes with the stars' V ones to obtain corrections for transforming the visual observations approximately to the V system. The adopted corrections were +1.0 mag for Barnard's observations, +0.9 mag for Graff's, and +1.1 mag for Lacchini's and for the AAVSO data. Mundler's observations were made with a photometer; the correction averaged 0.0 mag but depended slightly on which comparison stars he used for a given observation. We estimate our zero point shifts may be uncertain by up to three tenths of a magnitude.

4. Results

Our derived B and V light curves are shown in Figure 1. The B light curve includes data from plates of the field taken before the outburst. No evidence of the precursor was seen on plates extending back to 1891 (Bailey 1919), with the deepest ones reaching past 16th magnitude. The rise to maximum took place between 1908 June, when the B magnitude was less than 16.4, and 1910 March, when the B magnitude was approximately 12. Unfortunately, few plates are available that were exposed during the time of rise. There is a Harvard plate of 1909 July 9 that definitely shows RT Ser. One of us (WO) had the opportunity to briefly examine this plate and the brightness was estimated at about 14.9 using our comparison sequence; the value from the corrected Harvard observers' estimates put it at 14.5. We also found two possible images of RT Ser at the plate limit on the digitized Heidelberg plates of 1909 June 9; these indicate a magnitude of roughly 14.5.

From 1910 to 1917, the nova's magnitude gradually increased about one magnitude, reaching a maximum of about B = 11.0 around 1917 May (JD 2421350). This was when the object was discovered by Wolf and began to be followed by the visual observers. The maximum in V was 10.1, indicating a B-V of approximately 0.9.

After maximum, the brightness began a decline, with a rate of about 0.4 magnitude/year for four years after which the rate decreased to less than 0.1 magnitude/year. By 1928 both the B and the V magnitudes had decreased to about 13.0. Thus, the B–V in the 1930s was approximately zero, indicating the nova's color shifted toward the blue as its brightness decreased. This likely reflects the gradual spectral development of strong emission lines, which by 1928 dominate the spectrum (Adams and Joy 1928); these lines would enhance the photographic brightness relative to the visual. Other novae, such T Pyx, have also shown similar color evolution (Schaefer 2010). We caution, however, that both the visual and photographic estimates for the later years are uncertain. In particular, the photographic data after JD 2425100 are from the unpublished observations plotted on Payne-Gaposchkin's graph while the visual observers no doubt relied on comparison stars for which only photographic magnitudes were available for these fainter estimates. Lastly, we note we do not find strong evidence of the brightness fluctuations previously reported.

5. Acknowledgements

We would like to thank Lee Robbins, University of Toronto; Alison Doane, curator of the Harvard plate stacks; Holger Mandel and Markus Demleitner, Zentrum für Astronomie Heidelberg; and Elizabeth Waagen, AAVSO, for their help in gathering data needed for this study. This research made use of NASA's Astrophysics Data System; the SIMBAD database, operated at CDS, Strasbourg, France; and the Digitized Sky Surveys (DSS) produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. The DSS images are from photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope through funding provided by The National Geographic Society, the National Science Foundation, the Sloan Foundation, the Samuel Oschin Foundation, the Eastman Kodak Corporation, and the UK Science and Engineering Research Council. Finally, we thank the referee for some excellent comments and questions that helped improve the paper.

References

AAVSO 2011, observations from the AAVSO International Database (http://www.aavso.org).

Adams, W. S., and Joy, A. H. 1928, *Publ. Astron. Soc. Pacific*, **40**, 252.

Bailey, S. I. 1919, *Bull. Harvard Coll. Obs.*, No. 680, 1.

Bailey, S. I . 1921, *Bull. Harvard Coll. Obs.*, No. 753, 2.

Barnard, E. E. 1919a, *Astron. J.*, **32**, 37.

Barnard, E. E. 1919b, *Astron. J.*, **32**, 48.

Bessell, M. S. 2000, *Publ. Astron. Soc. Pacific*, **112**, 961.

Graff, K. 1919, *Astron. Nach.*, **210**, 61.

Graff, K. 1921, *Beob.-Zirk. Astron. Nach.*, No. 32, 55.

Graff, K. 1922, *Beob.-Zirk. Astron. Nach.*, No. 25, 45.

Graff, K. 1927, *Beob.-Zirk. Astron. Nach.*, No. 12, 23.

Lacchini, G. 1921, *Beob.-Zirk. Astron. Nach.*, No. 35, 59.

Lacchini, G. 1929, *Beob.-Zirk. Astron. Nach.*, No. 5, 12.

Lacchini, G. 1933, *Astron. Nach.*, **248**, 366.

Mundler, M. 1919, *Astron. Nach.*, **210**, 157.

Nussbaumer, H. 1992, in *Evolutionary Processes in Interacting Binary Stars*, Proc. IAU Symp. 151, eds. Y. Kondo, R. F. Sistero, R. S. Polidan, Kluwer, Dordrecht, and Boston, 429.

Payne-Gaposchkin, C., and Gaposchkin, S. 1938, *Variable Stars*, Harvard Monogr., No. 5, 263.

Schaefer, B. E. 2010, *Astrophys. J., Suppl. Ser.*, **187**, 275.

Shapley, H. 1919, *Publ. Astron. Soc. Pacific*, **31**, 226.

Shapley, H. 1923, *Bull. Harvard Coll. Obs.*, No. 789, 3.

Shapley, H. 1927, *Bull. Harvard Coll. Obs.*, No. 851, 3.

Wolf, M. 1917, *Astron. Nach.*, **204**, 293.

Wolf, M. 1919, *Astron. Nach.*, **208**, 363.

Table 1. Comparison star sequence for RT Ser.

Other ID	R.A. (2000) h m s	Dec. (2000) ° ′ ″	B	V	Photometry Source
BD–11 4436	17:40:31.79	–12:04:51.2	11.3	9.95	Tycho, Heidelberg
BD–11 4426	17:38:40.93	–11:49:36.5	11.65	10.1	Tycho, Heidelberg
BD–11 4433	17:39:48.19	–11:50:22.1	10.75	10.15	Tycho, Heidelberg
BD–12 4801	17:40:07.36	–12:05:05.5	11.2	10.65	Tycho, Heidelberg
BD–11 4434	17:39:56.77	–11:46:26.3	12.5	10.95	Tycho, Heidelberg
AAVSO 110	17:40:48.90	–11:58:33.0	11.5	11.0	Tycho, Heidelberg
TYC 5668-51-1	17:39:55.85	–12:08:20.9	11.55	11.25	Tycho, Heidelberg
AAVSO 114	17:40:48.67	–12:05:54.0	12.0	11.4	Tycho, Heidelberg
AAVSO 120	17:40:03.12	–11:55:55.6	12.9	11.95	AAVSO
AAVSO 123	17:39:36.41	–11:52:26.6	13.2	12.3	AAVSO
AAVSO 130	17:39:32.60	–12:01:26.4	14.5	13.0	AAVSO
AAVSO 132	17:40:13.09	–11:57:23.9	14.7	13.2	AAVSO
AAVSO 136	17:39:43.93	–11:52:16.2	14.4	13.6	AAVSO
AAVSO 139	17:39:32.47	–11:53:51.3	15.0	13.9	AAVSO
AAVSO 145	17:39:38.53	–11:56:44.1	15.6	14.5	AAVSO
AAVSO 150	17:39:54.62	–11:57:24.2	16.2	15.0	AAVSO
AAVSO 153	17:39:45.19	–11:58:01.7	16.4	15.3	AAVSO
AAVSO 160	17:39:52.31	–11:53:56.3	17.3	16.0	AAVSO
AAVSO 164	17:39:52.27	–11:57:16.0	17.9	16.4	AAVSO
AAVSO 174	17:39:49.93	–11:57:10.5	18.5	17.4	AAVSO

Photometry references: AAVSO = sequence star magnitudes listed by AAVSO from CCD photometry, Heidelberg = values from our aperture photometry of Heidelberg plates, Tycho = data in Tycho–2 catalog transformed as per Bessell (2000).

Table 2. Magnitudes of RT Ser from eye-estimates of Yerkes plates.

Plate	Julian Date	B	Plate	Julian Date	B
6B-12	2414813.708	<14.4	10B-979	2420684.697	11.2
10B-89	2416664.717	<12.0	6B-979	2420684.697	11.0
6B-89	2416664.717	<12.9	10B-1268	2421780.695	11.2
10B-90	2416674.733	<15.6	6B-1268	2421780.695	11.2
6B-90	2416674.733	<15.6	10B-1331.5	2421998.938	11.1
10B-99	2416693.635	<15.0	6B-1331.5	2421998.938	11.1
6B-99	2416693.635	<15.6	10B-1340	2422020.930	11.1
10B-100	2416695.6	<14.7	6B-1340	2422020.930	11.0
6B-100	2416695.6	<14.7	10B-1345	2422045.887	11.1
10B-224	2417017.717	<17.3	6B-1345	2422045.887	11.0
6B-224	2417017.717	<14.7	10B-1355	2422088.852	11.0
3B-224	2417017.717	<14.7	6B-1355	2422088.852	11.0

table continued on next page

Table 2. Magnitudes of RT Ser from eye-estimates of Yerkes plates, cont.

Plate	*Julian Date*	*B*	*Plate*	*Julian Date*	*B*
10B-457	2418122.720	<16.4	10B-1366	2422249.551	11.1
6B-457	2418122.720	<16.2	6B-1366	2422249.551	11.1
10B-689	2419158.816	11.8	10B-1423	2422470.866	11.2
6B-689	2419158.816	11.8	6B-1423	2422470.866	11.3
10B-702	2419209.736	11.8			
6B-702	2419209.736	11.7	10R-44	2424319.667	12.4
10B-977	2420681.682	11.2	10R-346	2425449.822	12.9
6B-977	2420681.682	11.2			
10B-978	2420683.702	11.2	24R-5434	2429455.673	14.8
6B-978	2420683.702	11.2	24R-5435	2429455.709	14.8

Table 3. Magnitudes of RT Ser from aperture photometry of digital copies of Heidelberg plates.

Plate	*Julian Date*	*B*	*Plate*	*Julian Date*	*B*
B479a	2415910.459	<14.7	B1784a	2417742.506	<14.7
B480b	2415910.460	<14.7	B1785b	2417742.506	<15.5
B483a	2415912.522	<15.3	B2338a	2418467.467	14.5
B484b	2415912.522	<15.3	B2339b	2418467.467	14.5
B996a	2416636.461	<15.0	B3945a	2421375.485	11.0
B997b	2416636.461	<15.0	B3946b	2421375.485	11.0
B1002a	2416645.479	<15.0	B3949a	2421394.468	11.0
B1003b	2416645.479	<14.7	B3950b	2421394.468	11.0
B1225a	2416994.544	<13.2	B4765a	2423608.478	11.3
B1226b	2416994.544	<13.2	B4766b	2423608.478	11.3
B1249a	2417025.479	<16.4	B4878a	2423936.477	11.5
B1250b	2417025.479	<16.4	B4879b	2423936.477	11.4

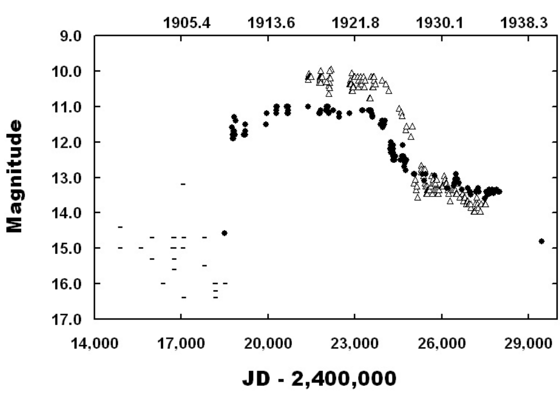

Figure 1. The new light curve of the 1909 outburst of RT Ser. Open triangles are V magnitudes, filled circles are B magnitudes, and the dashes show the B magnitude plate limit when the star was too faint to be detected.