Multi-color Photometry of the Hot R Coronae Borealis Star and Proto-planetary Nebula V348 Sagittarii

Arlo U. Landolt
Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803; landolt@phys.lsu.edu

Visiting astronomer, Kitt Peak National Observatory, National Optical Astronomical Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

Visiting astronomer, Cerro Tololo Inter-American Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

Visiting astronomer; this work makes use of observations obtained at the Las Campanas Observatories.

James L. Clem
Department of Physics and Astronomy, Louisiana State University, Baton Rouge, LA 70803
(Current address: Department of Physics, Grove City College, Grove City, PA 16127); jclem@phys.lsu.edu

Visiting astronomer, Cerro Tololo Inter-American Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

Received April 10, 2019; revised May 17, 2019; accepted May 17, 2019

Abstract A long term program of precision photoelectric UBVRI photometry has been combined with AAVSO archival data for the hot, R CrB-type hydrogen deficient star and proto-planetary nebula, V348 Sgr. CCD data also are described. Since V348 Sgr is one of only four hot R CrB stars, it and other group members deserve continued attention by observers.

1. Introduction

The star now known as V348 Sgr was discovered to be variable in light by Woods (1926), and later, independently, by Schajn (1929). The discovery name assigned by Woods was HV 3976. She found the star's brightness to vary between 11th and fainter than 16.5 magnitude. Woods' discovery note does not state the kind of emulsion utilized, and hence the type of magnitude. (History describing the Harvard College Observatory (HCO) telescopes, leading to an enhanced understanding of the kinds of magnitudes produced by the HCO patrol telescopes may be found at the Digital Access to a Sky Century @ Harvard (DASCH), dasch.rc.fas.harvard.edu/photometry.php, leadingto dasch.rc.fas.harvard.edu/lightcurve.php. Additional insight is located in Laycock *et al.* (2010).)

V348 Sgr appears in the DR2 release of the *Gaia Catalogue* which appears in VizieR in catalogue I/345/gaia2 (Gaia Collab. *et al.* 2016, 2018). V348 Sgr is source number 4079151545960427264 with coordinates R.A. = 18^h 40^m 19.92705^s, Dec. = –22° 54' 29.3880", J2000. It is a member of a small subset of four hot hydrogen-deficient stars. These four stars, MV Sgr, V348 Sgr, DY Cen, and HV 2671, possess the R CrB-type of light curve, that is, they spend the majority of the time at maximum brightness, with occasional excursions to fainter magnitudes (De Marco *et al.* 2002, and references therein).They differ from most R CrB stars in that on average their effective temperatures are 10,000 to 15,000 K hotter. Therefore, these four stars are of special interest, and should continue and remain on observing programs.

V348 Sgr also appears in the literature as AN 21.1929, AAVSO 1834-23, 2MASS J18401992-2254292, and ASAS J184020-2254.5. V348 Sgr does not appear in the UCAC4 catalogue or in the corresponding APASS data release.

A finding chart for V348 Sgr is given in Figure 1. The chart is based on a digitized version of the Palomar Sky Survey I (POSS I) blue survey (Palomar Observatory 1950–1957). The size of the field as presented in the chart is about ten arc minutes on a side.

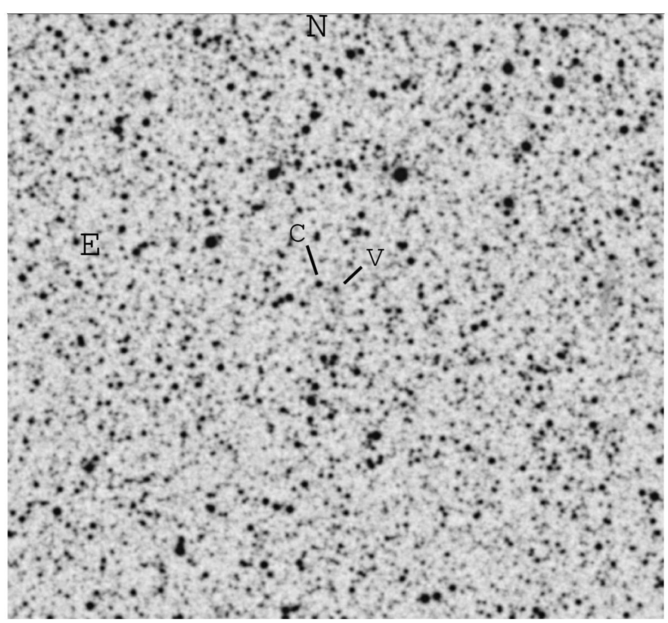

Figure 1. Finding Chart for V348 Sgr identified as V, and a nearby faint star UCAC4 336-170138 identified by C. The field of view is approximately 10 arc minutes on a side.

Excellent and definitive summaries of the characteristics of R CrB stars, including the four stars listed above, have appeared in Clayton (1996, 2012). De Marco *et al.* (2002) thoroughly describe this four-member subset of R CrB stars. They write that these four stars are quite different from each other as evidenced by their spectra. They indicate that the "only common characteristics are their temperatures and light variation." Finally, they found that MV Sgr, V348 Sgr, and DY Cen all exhibit a long-term downward trend in brightness over the time frame under study. Schaefer (2016) has searched archival files and also has discussed the long term behavior of this four-star group of hot R CrB stars. Pollacco *et al.* (1990) showed that the nebulosity surrounding V348 Sgr was an old planetary nebula of extent some 30 arc seconds. Clayton *et al.* (2011) discuss the properties of the dust involved with V348 Sgr via use of Spitzer/IRS spectra. The data in this paper are based on precision photometry in standard bandpasses covering years for which such observations are minimal.

2. Observations

Photoelectric observations of V348 Sgr were taken by AUL in the interval 1982 September 14 to 2001 October 16 ($2445226.53 \leq HJD \leq 2452198.57$), a range of 6,972 days, or 19.1 years. The data were collected at Cerro Tololo Inter-American Observatory's (CTIO's) 0.9-m, 1.0-m (Yale), 1.5-m, and 4.0-m telescopes, and at the Kitt Peak National Observatory 1.3-m telescope.

The dates upon which data were taken, and observatories, telescopes, detectors, and filters utilized all are listed in Table 1. These data were tied into *UBVRI* standard stars as defined in Landolt (1983). All *R* and *I* measures herein are on the Kron-Cousins system. The data, using detectors described in Landolt (1983, 1992), were reduced following precepts outlined in Landolt (2007).

CCD data were taken on 22 nights at the Las Campanas Observatory (LCO) telescopes, 16 nights at the Swope 1.0-m, and 6 at the DuPont 2.5-m. The 1992 October and 1996 August CCD data were obtained at the Swope 1.0-m telescope. The detector was a Texas Instrument (TI#1) 800×800 pixel chip whose plate scale was 0.435" pixel^{-1}. The field size was 5.8' on a side. The data were binned 2×2. A 2×2 inch *UBVRI* filter set borrowed from CTIO meant that the same filter set was used for AUL's CTIO and LCO programs at that time. The composition of the filter set is described in Table 1 in Landolt and Clem (2017). The June 1994 CCD data were obtained at the LCO DuPont 2.5-m telescope, using the same chip and filters as at the Swope telescope.

The CTIO CCD data, calendar years 2008 through 2010, were obtained at the CTIO Yale 1.0-m telescope by JLC, using the Y4KCam CCD. The equipment, data acquisition, and reduction processes were described in Clem and Landolt (2013).

Data were obtained the night of UT 1993 May 11 at the KPNO 0.9-m using the CCDPhot program. This was an IRAF program which used a CCD instead of a photomultiplier as the detector, and apertures defined by software rather than by an aperture wheel. An excellent description of the program and technique was written by Tody and Davis (1992).

The CCDPhot instrumentation included a Tek 2 chip, T5HA, serial number 1115-8-3. For a chip size of 512×512 with 27 micron pixels, and a scale of 0.77 arc sec per pixel, the field of view was 6.6×6.6 arc min on a side. A more complete description may be found at https://www.noao.edu/noao/noaonews/sep95/art37.html. It was a neat instrumental set-up. A figure illustrating the quantum efficiency of T5HA may be found at https://www.noao.edu/noao/noaonews/jun96/node38.html. Data through the *U* filter did not transform satisfactorily, and are not included herein.

3. Discussion

Data for V348 Sgr in the AAVSO International Database (Kafka 2019) begin on JD 2434917.0, 1954 June 23 UT. We have downloaded data in the interval 1996 April 23 to 2017 November 24 ($2450196.718 \leq 2458082.498$), an interval of 7885.78 days, or 21.6 years, since this subset of data in the AAVSO database is similar in time extent to ours. Visual observations indicating "fainter than" and those taken through filters other than "Johnson *V*" then were eliminated from the listing. The remaining AAVSO observations have been displayed in Figure 2 as black circles.

The photoelectric reduction process recovered the magnitudes and color indices of the standard stars that were observed each night. The rms errors calculated from those recovered magnitude and color indices are listed in Table 2. The first and second columns give the UT date of observation and the corresponding Julian Date, respectively. The telescope at which the data were collected is given in the third column, and the filters through which the data were taken are in the fourth column. The last six columns list the rms errors of the recovered standard stars' magnitude and color indices for that night. The last two lines in Table 2 show that the accuracy of the recovered standard star photometry was one percent or less, except for (*U–B*). When at maximum brightness, V348 Sgr was similar in brightness to the standard stars; when at minimum, it was as much as six magnitudes fainter.

On the night of 2000 May 23 UT, at $08^h\ 09^m\ 00^s$ *UT*, HJD 2451687.83958, V348 Sgr was too faint to measure at the CTIO

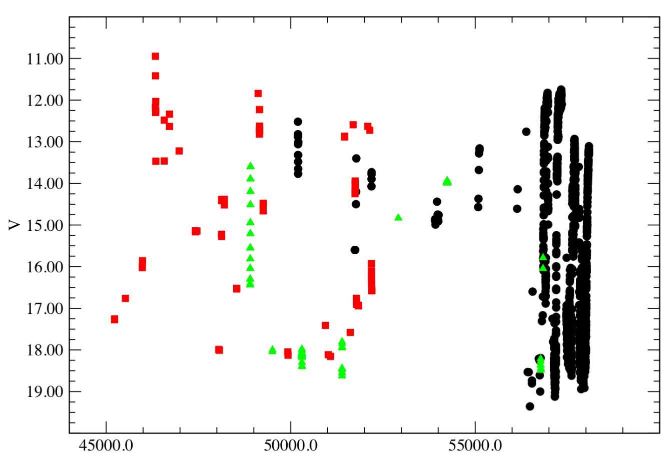

Figure 2. AAVSO V database magnitudes plus *V* photoelectric and CCD magnitudes from this paper for V348 Sgr. Black circles indicate AAVSO data, red squares indicate photoelectric data, and green triangles indicate CCD data.

Table 1. Telescopes, detectors, and filters.

UT (mmddyy)	*Observatory Telescope*	*Detector Set-up*	*Filter Identification*
091482	CTIO 1.5-m	RCA 31034A-02; coldbox 58	(Landolt 1983), Table III
070583	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
100584	CTIO 0.9-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
101184	CTIO 0.9-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
092585	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
093085	CTIO 4.0-m	RCA 31034A-05; coldbox 70	(Landolt 1983), Table III
100385	CTIO 4.0-m	RCA 31034A-05; coldbox 70	(Landolt 1983), Table III
100585	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
100785	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
052486	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
101286	CTIO 1.5-m	RCA 31034A-02; coldbox 59	(Landolt 1983), Table III
070187	KPNO 1.3-m	RCA 31034A-02; coldbox 51	(Landolt 2007), Table 1
091688	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
102388	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
092689	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
060890	CTIO 1.0-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
062690	KPNO 1.3-m	RCA 31034A-02; coldbox 51	(Landolt 2007), Table 1
082490	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
082690	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
110790	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
110890	CTIO 1.5-m	Hamamatsu R943-02; coldbox 71	(Landolt 1983), Table III
061791	KPNO 1.3-m	RCA 31034A-02; coldbox 51	(Landolt 2007), Table 1
100791	KPNO 1.3-m	RCA 31034A-02; coldbox 51	(Landolt 2007), Table 1
062992	KPNO 1.3-m	RCA 31034A-02; coldbox 51	(Landolt 2007), Table 1
061593	CTIO 1.5-m	RCA 31034; coldbox 58	(Landolt 1983), Table III
061693	CTIO 1.5-m	RCA 31034; coldbox 58	(Landolt 1983), Table III
061793	CTIO 1.5-m	RCA 31034; coldbox 58	(Landolt 1983), Table III
092493	CTIO 1.0-m	Hamamatsu R943-02; coldbox 50	(Landolt 1983), Table III
092593	CTIO 1.0-m	Hamamatsu R943-02; coldbox 50	(Landolt 1983), Table III
072495	CTIO 1.5-m	Hamamatsu R943-02; coldbox 50	(Landolt 1983), Table III
073195	CTIO 1.0-m	Hamamatsu R943-02; coldbox 50	(Landolt 1983), Table III
092997	CTIO 1.5-m	Burle Industries 31034A-02; coldbox 60	(Landolt 1983), Table III
050898	CTIO 1.5-m	Burle Industries 31034A-02; coldbox 60	(Landolt 1983), Table III
072598	CTIO 1.5-m	Burle Industries 31034A-02; coldbox 60	(Landolt 1983), Table III
092598	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101099	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101299	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
031000	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
052300	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
052900	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
071900	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
072000	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
072300	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
072400	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
072500	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082500	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082600	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082700	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082800	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082900	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
083000	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
102000	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
102100	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
062801	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
072501	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
082201	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
100701	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
100801	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
100901	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101001	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101101	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101301	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101501	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III
101601	CTIO 1.5-m	RCA 31034A-02; coldbox 53	(Landolt 1983), Table III

Table 2. RMS photometric errors per night recovered from standard stars.

UT (mmddyy)	*HJD 2400000.0+*	*Telescope*	*Filter*	*RMS Errors Recovered Standards* *V*	*(B–V)*	*(U–B)*	*(V–R)*	*(R–I)*	*(V–I)*
091482	45226.5	CTIO 1.5-m	UBVRI	0.016	0.014	0.050	0.008	0.008	0.008
070583	45520.5	CTIO 1.5-m	UBVRI	0.006	0.007	0.006	0.003	0.004	0.004
100584	45978.5	CTIO 0.9-m	UBVRI	0.010	0.006	0.015	0.008	0.005	0.007
101184	45984.5	CTIO 0.9-m	UBVRI	0.016	0.005	0.027	0.005	0.003	0.004
092585	46333.5	CTIO 1.5-m	UBVRI	0.012	0.011	0.032	0.014	0.011	0.018
093085	46338.5	CTIO 4.0-m	UBVRI	0.012	0.020	0.100	0.007	0.012	0.017
100385	46341.5	CTIO 4.0-m	UBVRI	0.037	0.040	0.054	0.035	0.043	0.068
100585	46343.5	CTIO 1.5-m	UBVRI	0.010	0.007	0.043	0.003	0.006	0.008
100785	46345.5	CTIO 1.5-m	UBVRI	0.007	0.011	0.052	0.009	0.005	0.012
052486	46574.5	CTIO 1.5-m	UBVRI	0.004	0.008	0.025	0.006	0.017	0.017
101286	46715.5	CTIO 1.5-m	UBVRI	0.010	0.014	0.036	0.007	0.011	0.009
070187	46977.5	KPNO 1.3-m	UBVRI	0.019	0.022	0.020	0.016	0.019	0.021
091688	47420.5	CTIO 1.5-m	UBVRI	0.004	0.010	0.032	0.006	0.006	0.007
102388	47457.5	CTIO 1.5-m	UBVRI	0.009	0.010	0.042	0.008	0.006	0.009
092689	47795.5	CTIO 1.5-m	UBVRI	0.009	0.011	0.041	0.005	0.006	0.010
060890	48050.5	CTIO 1.0-m	UBVRI	0.006	0.011	0.028	0.006	0.010	0.012
062690	48068.5	KPNO 1.3-m	UBVRI	0.020	0.007	0.017	0.005	0.009	0.013
082490	48127.5	CTIO 1.5-m	UBVRI	0.011	0.009	0.032	0.006	0.005	0.006
082690	48129.5	CTIO 1.5-m	UBVRI	0.010	0.008	0.029	0.005	0.008	0.009
110790	48202.5	CTIO 1.5-m	UBVRI	0.007	0.008	0.034	0.007	0.008	0.011
110890	48203.5	CTIO 1.5-m	UBVRI	0.008	0.014	0.038	0.006	0.007	0.010
061791	48424.5	KPNO 1.3-m	UBVRI	0.006	0.006	0.023	0.005	0.006	0.008
100791	48536.5	KPNO 1.3-m	UBVRI	0.012	0.007	0.022	0.007	0.008	0.013
062992	48802.5	KPNO 1.3-m	UBVRI	0.008	0.007	0.014	0.007	0.003	0.006
051193	49118.5	KPNO 0.9-m	UBVRI	0.015	0.016	0.051	0.023	0.007	0.022
061593	49153.5	CTIO 1.5-m	UBVRI	0.008	0.009	0.022	0.004	0.014	0.016
061693	49154.5	CTIO 1.5-m	UBVRI	0.007	0.004	0.016	0.005	0.009	0.011
061793	49155.5	CTIO 1.5-m	UBVRI	0.008	0.007	0.028	0.006	0.005	0.009
092493	49254.4	CTIO 1.0-m	UBVRI	0.009	0.010	0.028	0.008	0.032	—
092593	49255.5	CTIO 1.0-m	UBVRI	0.010	0.008	0.031	0.011	0.024	—
072495	49922.5	CTIO 1.5-m	UBVRI	0.007	0.009	0.020	0.004	0.010	0.011
073195	49929.5	CTIO 1.0-m	UBV	0.004	0.008	0.020	—	—	—
092997	50720.5	CTIO 1.5-m	UBVRI	0.006	0.009	0.031	0.004	0.007	0.008
050898	50941.5	CTIO 1.5-m	UBVRI	0.008	0.009	0.014	0.004	0.005	0.004
072598	51019.5	CTIO 1.5-m	UBVRI	0.015	0.014	0.020	0.006	0.011	0.014
092598	51081.5	CTIO 1.5-m	UBVRI	0.008	0.009	0.032	0.007	0.011	0.014
101099	51461.5	CTIO 1.5-m	UBVRI	0.004	0.010	0.033	0.003	0.007	0.005
101299	51463.5	CTIO 1.5-m	UBVRI	0.005	0.006	0.033	0.004	0.008	0.008
031000	51613.5	CTIO 1.5-m	UBVRI	0.010	0.008	0.016	0.006	0.005	0.006
052300	51687.5	CTIO 1.5-m	UBVRI	0.008	0.010	0.019	0.006	0.012	0.015
052900	51693.5	CTIO 1.5-m	UBVRI	0.008	0.012	0.023	0.004	0.006	0.007
071900	51744.5	CTIO 1.5-m	UBVRI	0.007	0.007	0.020	0.004	0.004	0.007
072000	51745.5	CTIO 1.5-m	UBVRI	0.006	0.009	0.026	0.003	0.010	0.011
072300	51748.5	CTIO 1.5-m	UBVRI	0.004	0.008	0.016	0.004	0.005	0.006
072400	51749.5	CTIO 1.5-m	UBVRI	0.007	0.007	0.015	0.004	0.006	0.008
072500	51750.5	CTIO 1.5-m	UBVRI	0.005	0.008	0.020	0.003	0.004	0.006
082500	51781.5	CTIO 1.5-m	UBVRI	0.010	0.011	0.036	0.005	0.008	0.009
082600	51782.5	CTIO 1.5-m	UBVRI	0.006	0.009	0.031	0.004	0.007	0.008
082700	51783.5	CTIO 1.5-m	UBVRI	0.009	0.010	0.033	0.003	0.011	0.010
082800	51784.5	CTIO 1.5-m	UBVRI	0.006	0.010	0.036	0.003	0.006	0.005
082900	51785.5	CTIO 1.5-m	UBVRI	0.007	0.008	0.031	0.004	0.006	0.007
083000	51786.5	CTIO 1.5-m	UBVRI	0.010	0.009	0.014	0.004	0.002	0.005
102000	51837.5	CTIO 1.5-m	UBVRI	0.008	0.009	0.033	0.003	0.005	0.006
102100	51838.5	CTIO 1.5-m	UBVRI	0.007	0.010	0.031	0.003	0.006	0.006
062801	52088.5	CTIO 1.5-m	UBVRI	0.007	0.011	0.022	0.006	0.004	0.008
072501	52115.5	CTIO 1.5-m	UBVRI	0.007	0.007	0.023	0.004	0.008	0.010
082201	52143.5	CTIO 1.5-m	UBVRI	0.008	0.011	0.031	0.005	0.008	0.011
100701	52189.5	CTIO 1.5-m	UBVRI	0.010	0.010	0.034	0.005	0.014	0.015
100801	52190.5	CTIO 1.5-m	UBVRI	0.009	0.013	0.033	0.004	0.016	0.017
100901	52191.5	CTIO 1.5-m	UBVRI	0.009	0.013	0.035	0.005	0.005	0.007
101001	52192.5	CTIO 1.5-m	UBVRI	0.010	0.008	0.031	0.005	0.009	0.011
101101	52193.5	CTIO 1.5-m	UBVRI	0.007	0.011	0.033	0.005	0.011	0.012
101301	52195.5	CTIO 1.5-m	UBVRI	0.005	0.010	0.033	0.005	0.006	0.007
101501	52197.5	CTIO 1.5-m	UBVRI	0.007	0.010	0.037	0.007	0.029	0.031
101601	52198.5	CTIO 1.5-m	UBVRI	0.009	0.012	0.040	0.007	0.012	0.016
			ave.	0.009	0.010	0.030	0.006	0.009	0.011
			±	0.005	0.005	0.013	0.005	0.007	0.009

Table 3. V348 Sgr photoelectric data.

HJD	*V*	*(B–V)*	*(U–B)*	*(V–R)*	*(R–I)*	*(V–I)*
2445226.53218	12.744	+0.559	–0.375	+0.398	+0.363	+0.761
2445226.53466	12.726	+0.562	–0.370	+0.409	+0.363	+0.772
2445520.76341	13.238	+0.664	–0.249	+0.459	+0.444	+0.903
2445978.59159	13.977	+0.911	–0.033	+0.645	+0.566	+1.213
2445984.54833	14.143	+1.161	–0.185	+0.596	+0.569	+1.167
2446333.52951	19.053	+0.272	–1.532	+2.078	+0.743	+2.856
2446333.53762	17.825	+0.532	–0.960	+1.211	+0.340	+1.574
2446338.51876	18.583	+1.090	–0.426	+1.104	+0.746	+1.854
2446341.53179	17.702	+0.613	–0.912	+0.952	+0.512	+1.491
2446341.53922	17.755	+0.634	–0.989	+0.915	+0.607	+1.541
2446343.54113	17.967	+0.056	–1.026	+1.697	+0.763	+2.475
2446345.52463	16.532	+0.822	–0.595	+1.041	+0.659	+1.707
2446574.87950	17.519	+0.197	—	—	—	—
2446574.88446	16.538	+1.426	—	—	—	—
2446715.52914	17.367	+2.075	—	—	—	—
2446715.53758	17.662	+0.855	–0.560	+1.189	+0.702	+1.895
2446977.79809	16.778	+0.577	–0.757	+1.072	+0.536	+1.622
2447420.52371	14.837	+1.256	+0.850	+0.711	+0.694	+1.408
2447420.52916	14.862	+1.189	+1.036	+0.726	+0.677	+1.400
2447457.54620	14.857	+1.426	—	+0.682	+0.667	+1.344
2448050.71173	12.011	+0.362	–0.650	+0.317	+0.281	+0.594
2448068.81702	11.992	+0.394	–0.603	+0.300	+0.297	+0.596
2448127.65392	14.722	+0.756	–0.260	+0.575	+0.497	+1.070
2448127.65874	14.776	+0.720	–0.284	+0.621	+0.468	+1.086
2448129.67057	15.614	+0.685	–0.448	+0.697	+0.547	+1.239
2448129.67842	15.582	+0.687	–0.473	+0.677	+0.551	+1.222
2448202.52816	15.616	+0.937	–0.236	+0.825	+0.653	+1.474
2448203.53091	15.482	+0.994	–0.190	+0.620	+0.793	+1.403
2448536.61322	13.478	+0.811	–0.028	+0.545	+0.500	+1.046
2448536.61628	13.463	+0.825	–0.113	+0.558	+0.452	+1.013
2449118.97954	18.13	–0.20	—	+1.86	+0.79	+2.62
2449153.78668	17.183	+0.594	–0.773	—	—	—
2449153.79625	17.282	+0.618	–0.850	—	—	—
2449154.75816	17.273	+0.456	–0.781	+1.176	+0.695	+1.864
2449154.77087	17.274	+0.441	–0.763	+1.070	+0.529	+1.592
2449155.80644	17.375	+0.555	–0.964	+1.060	+0.492	+1.551
2449155.81863	17.772	+0.375	–1.067	+1.528	+0.598	+2.125
2449254.56876	15.49	+0.8	—	—	—	—
2449254.57160	15.34	+1.6	—	—	—	—
2449255.50394	15.52	+0.9	—	—	—	—
2449922.67670	11.951	+0.353	–0.668	+0.284	+0.281	+0.564
2449922.68047	11.948	+0.365	–0.704	+0.276	+0.296	+0.571
2449929.50884	11.874	+0.323	–0.694	—	—	—
2450941.82178	12.590	+0.529	–0.402	+0.401	+0.399	+0.799
2451019.74143	11.885	+0.401	–0.608	+0.280	+0.298	+0.578
2451081.53852	11.845	+0.337	–0.695	+0.268	+0.266	+0.534
2451461.53119	17.113	+0.517	–0.827	+0.933	+0.309	+1.247
2451463.54158	17.133	+0.365	–0.673	+0.943	+0.532	+1.476
2451613.86655	12.421	+0.490	–0.438	+0.366	+0.331	+0.698
2451693.77032	17.407	+0.321	–0.895	+0.922	+0.105	+1.027
2451744.73326	15.752	+1.547	+0.087	+0.981	+0.833	+1.819
2451745.75336	15.811	+1.256	+0.172	+0.881	+0.728	+1.610
2451748.64006	15.976	+1.006	–0.457	+0.943	+0.714	+1.658
2451748.65226	16.056	+1.119	–0.428	+0.936	+0.846	+1.780
2451749.66877	15.997	+0.965	–0.474	+0.965	+0.673	+1.637
2451750.71958	15.901	+1.053	–0.456	+0.941	+0.778	+1.721
2451781.52578	13.240	+0.717	–0.217	+0.470	+0.465	+0.937
2451782.54509	13.173	+0.691	–0.230	+0.451	+0.453	+0.905
2451783.61339	13.164	+0.665	–0.218	+0.456	+0.440	+0.892
2451784.59330	13.098	+0.665	–0.241	+0.461	+0.442	+0.900
2451785.57684	13.113	+0.658	–0.232	+0.459	+0.433	+0.892
2451786.61392	13.134	+0.652	–0.244	+0.454	+0.446	+0.900
2451837.53474	13.071	+0.644	–0.225	+0.464	+0.443	+0.912
2451838.54138	13.059	+0.650	–0.253	+0.458	+0.441	+0.894
2452088.79054	17.370	+0.575	–0.696	+0.918	+0.099	+1.019
2452143.56922	17.277	+0.494	–0.827	+1.197	+0.844	+2.042
2452189.53989	14.072	+0.915	+0.026	+0.606	+0.487	+1.089
2452190.55294	13.896	+0.918	–0.050	+0.614	+0.566	+1.182
2452191.57834	13.782	+0.882	+0.007	+0.587	+0.510	+1.105
2452192.57987	13.731	+0.864	–0.010	+0.580	+0.510	+1.085
2452193.57090	13.647	+0.857	–0.011	+0.566	+0.511	+1.093
2452195.57484	13.587	+0.817	–0.128	+0.509	+0.488	+1.017
2452197.57594	13.428	+0.773	–0.125	+0.518	+0.487	+0.989
2452198.57746	13.420	+0.736	–0.140	+0.507	+0.419	+0.928

1.5-m telescope. Also on the night of 2001 July 25, at $03^h 22^m 00^s$ *UT*, HJD 2452115.64028, V348 Sgr was barely visible, and too faint to measure. In each of these two instances, the observing log indicates that it was estimated that *V* ~ 16th magnitude.

Johnson *V* magnitude photoelectric data from the observations reported in this manuscript, Table 3, then were overlayed in Figure 2 onto the AAVSO database observations. Our photoelectric observations are plotted in red. One is reminded that the AAVSO database observations are in Julian Days (JDs), whereas the authors' are in Heliocentric Julian Days (HJDs).

CCD data for V348 Sgr, from Table 4 and plotted with green symbols in Figure 2, were obtained by JLC at the CTIO Yale 1.0-m telescope in the interval 2008 June 29 to 2010 May 13 *UT* (2454646.7 < *UT* < 2455329.7). Figure 2, therefore, is a composite of the *V* data with the AAVSO data shown in black, the photoelectric data in red, and the CCD data in green.

Figure 3 is the result of 33 images taken over an eleven-night run at the LCO Swope 1.0-m telescope in the time interval UT 1992 October 5 through 1992 October 15 (2448901 < HJD < 2448911). V348 Sgr serendipitously was caught brightening some three magnitudes over these eleven nights (Landolt and Uomoto 1992). These data are in Table 4.

Figure 4 finds V348 Sgr more or less constant near 18th *V* magnitude over a six-night interval, UT 1996 August through 1996 August 11 (2450301 < HJD < 2450306), from data also taken at the Swope telescope. The scale of the figure matches that of Figure 3 for ease of comparison. These data are in Table 4.

Figures 5 and 6 illustrate the behavior of the *UBVRI* photoelectric color indices as a function of Heliocentric Julian Day (HJD), using the same HJD scale as in Figure 2. These data are in Table 3. Except for (*R–I*), each color index exhibits a maximum change of two magnitudes. These differences arise since at maximum brightness, the hot R CrB star dominates, whereas at minimum light, the planetary nebulosity dominates.

Figures 7 (60 images), 8 (81 images), and 9 (141 images) present the *V* filter CCD data obtained by JLC at the CTIO Yale 1.0-m telescope on the successive nights of UT 2007 May 21 and 22. These data are in Table 4. Several of the data points in Figure 7 exhibit larger error bars which resulted from intermittent clouds at that point in the night. The purpose of Figure 9 is to show V348 Sgr's behavior near maximum brightness on successive nights. Although not periodic, real variations through the *V* filter are visible at the three percent level. Percy and Dembski (2018) note that "most or all RCrB

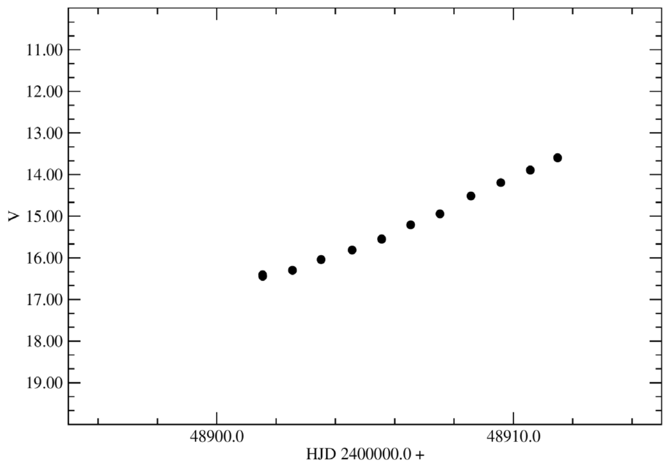

Figure 3. CCD data from the Las Campanas Observatory's Swope 1.0-m telescope for eleven nights in the interval 2448901 ≤ HJD ≤ 2448911.

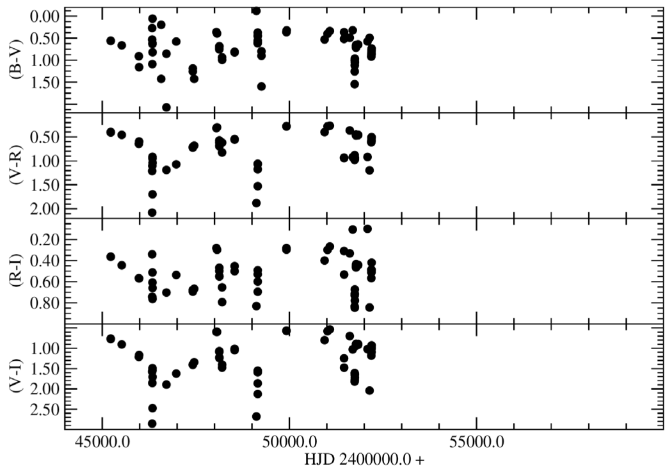

Figure 6. Photoelectric ($B–V$), ($V–R$), ($R–I$), and ($V–I$) color index data as a function of HJD for V348 Sgr from this paper.

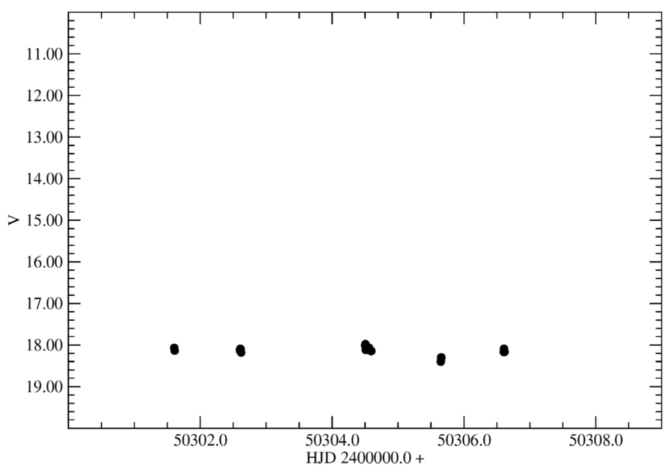

Figure 4. CCD data from the Las Campanas Observatory's Swope 1.0-m telescope for six nights in the interval 2450301 ≤ HJD ≤ 2450306.

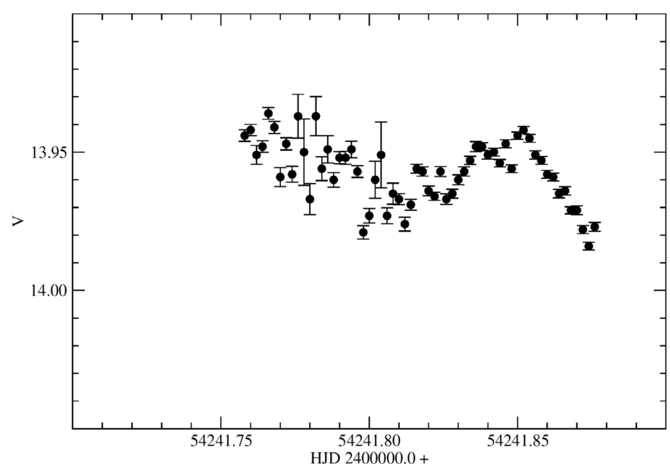

Figure 7. CCD data from the CTIO Yale 1.0-m telescope for UT 2007 May 21 (HJD 2454241).

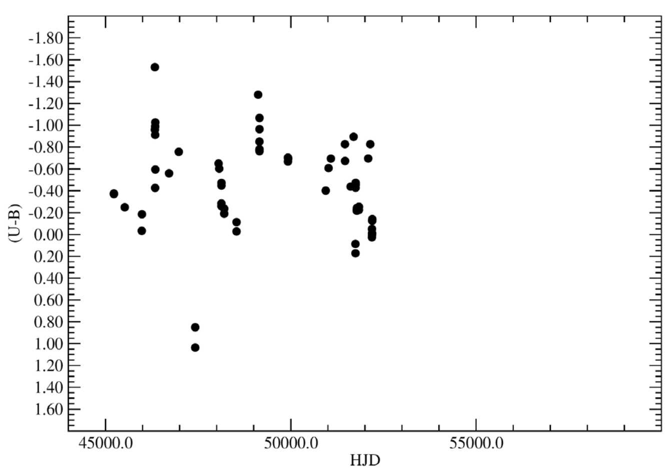

Figure 5. Photoelectric ($U–B$) color index data as a function of HJD for V348 Sgr from this paper.

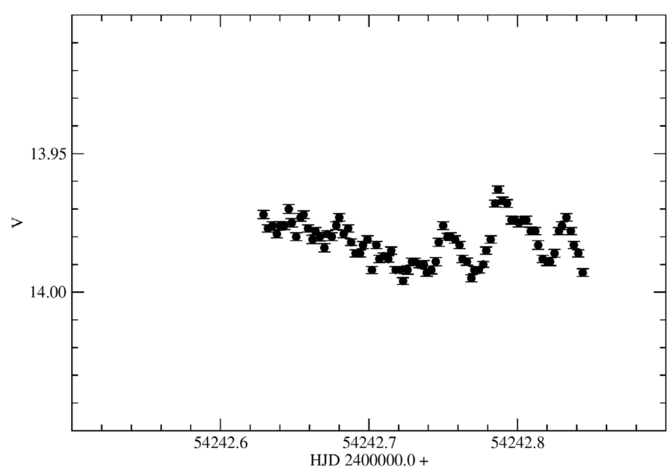

Figure 8. CCD data from the CTIO Yale 1.0-m telescope for UT 2007 May 22 (HJD 2454242).

Table 4. V348 Sgr CCD data.

HJD	*V*	*SDev*	*HJD*	*V*	*SDev*	*HJD*	*V*	*SDev*
2448901.547356	16.401	0.0138	2454241.762122	13.951	0.0034	2454242.672442	13.979	0.0012
2448901.548930	16.435	0.0168	2454241.764096	13.948	0.0021	2454242.675115	13.980	0.0014
2448901.550446	16.445	0.0136	2454241.766075	13.936	0.0021	2454242.677788	13.976	0.0014
2448902.551609	16.292	0.0088	2454241.768054	13.941	0.0022	2454242.680462	13.973	0.0013
2448902.553136	16.302	0.0100	2454241.770034	13.959	0.0034	2454242.683137	13.979	0.0014
2448902.554652	16.301	0.0093	2454241.772013	13.947	0.0022	2454242.685810	13.977	0.0013
2448903.516791	16.040	0.0104	2454241.773988	13.958	0.0029	2454242.688483	13.982	0.0012
2448903.518341	16.046	0.0108	2454241.775970	13.937	0.0079	2454242.691154	13.986	0.0013
2448903.519915	16.036	0.0101	2454241.777949	13.950	0.0120	2454242.693826	13.986	0.0013
2448904.562916	15.813	0.0094	2454241.779927	13.967	0.0056	2454242.696498	13.983	0.0013
2448904.564467	15.812	0.0104	2454241.781907	13.937	0.0071	2454242.699171	13.981	0.0013
2448904.565994	15.810	0.0136	2454241.783887	13.956	0.0043	2454242.701844	13.992	0.0013
2448905.557783	15.550	0.0070	2454241.785862	13.949	0.0049	2454242.704516	13.983	0.0013
2448905.559288	15.540	0.0067	2454241.787841	13.960	0.0026	2454242.707190	13.988	0.0013
2448905.560804	15.557	0.0086	2454241.789819	13.952	0.0022	2454242.709863	13.987	0.0012
2448906.535650	15.213	0.0072	2454241.791799	13.952	0.0024	2454242.712602	13.988	0.0012
2448906.537201	15.208	0.0063	2454241.793773	13.949	0.0030	2454242.715273	13.985	0.0013
2448906.538728	15.200	0.0052	2454241.795753	13.957	0.0021	2454242.717948	13.992	0.0012
2448907.523631	14.938	0.0047	2454241.797731	13.979	0.0024	2454242.720620	13.992	0.0012
2448907.525147	14.941	0.0038	2454241.799711	13.973	0.0026	2454242.723293	13.996	0.0012
2448907.526663	14.947	0.0041	2454241.801689	13.960	0.0067	2454242.725964	13.992	0.0015
2448908.567627	14.510	0.0071	2454241.803670	13.951	0.0119	2454242.728635	13.989	0.0012
2448908.569143	14.515	0.0080	2454241.805650	13.973	0.0029	2454242.731309	13.989	0.0012
2448908.570659	14.512	0.0072	2454241.807630	13.965	0.0038	2454242.733983	13.990	0.0012
2448909.574543	14.196	0.0084	2454241.809610	13.967	0.0020	2454242.736654	13.990	0.0014
2448909.576059	14.191	0.0067	2454241.811591	13.976	0.0025	2454242.739329	13.993	0.0013
2448909.577633	14.193	0.0090	2454241.813570	13.969	0.0020	2454242.742000	13.992	0.0014
2448910.568671	13.885	0.0021	2454241.815549	13.956	0.0016	2454242.744677	13.989	0.0015
2448910.570187	13.889	0.0022	2454241.818235	13.957	0.0017	2454242.747347	13.982	0.0015
2448910.571692	13.898	0.0020	2454241.820215	13.964	0.0018	2454242.750024	13.976	0.0014
2448911.490260	13.590	0.0019	2454241.822195	13.966	0.0015	2454242.752699	13.980	0.0012
2448911.491787	13.593	0.0021	2454241.824173	13.957	0.0018	2454242.755370	13.980	0.0014
2448911.493303	13.603	0.0022	2454241.826152	13.967	0.0019	2454242.758043	13.981	0.0013
2449506.815125	17.995	0.0155	2454241.828131	13.965	0.0016	2454242.760722	13.983	0.0013
2449506.816201	18.042	0.0173	2454241.830110	13.960	0.0018	2454242.763400	13.988	0.0013
2450301.606179	18.067	0.0286	2454241.832084	13.957	0.0017	2454242.766083	13.989	0.0013
2450301.611734	18.137	0.0328	2454241.834063	13.953	0.0015	2454242.768760	13.995	0.0013
2450302.602382	18.126	0.0340	2454241.836039	13.948	0.0018	2454242.771430	13.992	0.0013
2450302.607127	18.091	0.0317	2454241.838019	13.948	0.0014	2454242.774107	13.992	0.0011
2450302.610171	18.154	0.0314	2454241.839999	13.951	0.0015	2454242.776777	13.990	0.0011
2450302.613226	18.101	0.0334	2454241.841977	13.950	0.0014	2454242.779453	13.985	0.0013
2450302.620876	18.182	0.0364	2454241.843955	13.954	0.0013	2454242.782125	13.981	0.0013
2450304.500927	18.011	0.0238	2454241.845930	13.947	0.0015	2454242.784798	13.968	0.0012
2450304.506204	17.977	0.0209	2454241.847910	13.956	0.0014	2454242.787470	13.963	0.0013
2450304.511169	18.119	0.0323	2454241.849886	13.944	0.0013	2454242.790142	13.967	0.0013
2450304.521065	18.115	0.0310	2454241.851865	13.942	0.0013	2454242.792919	13.968	0.0014
2450304.525428	18.065	0.0270	2454241.853844	13.945	0.0014	2454242.795594	13.974	0.0014
2450304.558736	18.064	0.0243	2454241.855824	13.951	0.0015	2454242.798267	13.974	0.0013
2450304.562497	18.080	0.0244	2454241.857804	13.953	0.0014	2454242.800942	13.975	0.0015
2450304.591616	18.150	0.0299	2454241.859784	13.958	0.0014	2454242.803615	13.974	0.0013
2450304.595632	18.145	0.0321	2454241.861764	13.959	0.0014	2454242.806288	13.974	0.0014
2450305.647652	18.403	0.0704	2454241.863741	13.965	0.0015	2454242.808960	13.978	0.0014
2450305.650696	18.377	0.0701	2454241.865715	13.964	0.0015	2454242.811634	13.978	0.0013
2450305.653635	18.299	0.0562	2454241.867698	13.971	0.0013	2454242.814307	13.983	0.0016
2450305.656991	18.297	0.0621	2454241.869673	13.971	0.0016	2454242.816980	13.988	0.0013
2450306.604062	18.168	0.0336	2454241.871654	13.978	0.0015	2454242.819781	13.989	0.0014
2450306.607985	18.090	0.0284	2454241.873629	13.984	0.0014	2454242.822440	13.989	0.0014
2450306.617510	18.166	0.0346	2454241.875611	13.977	0.0016	2454242.825117	13.986	0.0014
2451390.685563	18.627	0.0382	2454242.629041	13.972	0.0015	2454242.827790	13.978	0.0013
2451390.687126	18.619	0.0410	2454242.632351	13.977	0.0013	2454242.830463	13.976	0.0014
2451391.654418	18.484	0.0328	2454242.635026	13.976	0.0014	2454242.833141	13.973	0.0013
2451391.693443	18.556	0.0386	2454242.637699	13.979	0.0014	2454242.835814	13.978	0.0013
2451391.695110	18.550	0.0364	2454242.640372	13.976	0.0015	2454242.838489	13.983	0.0013
2451392.689621	18.453	0.0382	2454242.643045	13.976	0.0014	2454242.841163	13.986	0.0013
2451392.691288	18.436	0.0379	2454242.645717	13.970	0.0016	2454242.843837	13.993	0.0014
2451393.690630	17.952	0.0289	2454242.648391	13.975	0.0015	2456774.977437	18.212	0.0262
2451393.692123	17.946	0.0315	2454242.651062	13.980	0.0014	2456774.983091	18.272	0.0267
2451393.780509	17.848	0.0196	2454242.653735	13.973	0.0014	2456774.987899	18.353	0.0287
2451393.781991	17.802	0.0162	2454242.656407	13.972	0.0014	2456775.984039	18.367	0.0287
2451394.692395	17.924	0.0241	2454242.659079	13.977	0.0013	2456779.979752	18.492	0.0402
2452918.485326	14.830	0.0055	2454242.661752	13.981	0.0015	2456779.982046	18.460	0.0466
2452918.486622	14.835	0.0051	2454242.664424	13.978	0.0013	2456780.968839	18.434	0.0462
2454241.758161	13.944	0.0021	2454242.667097	13.980	0.0015	2456838.835146	16.047	0.0056
2454241.760140	13.942	0.0021	2454242.669770	13.984	0.0015	2456839.817621	15.787	0.0027

stars undergo small amplitude pulsations with periods of a few weeks." However, Figures 7, 8, and 9 illustrate that light variations also occur on the time scale of tens of minutes, say in the range of 0.01 to 0.1 day. Intensive monitoring should be filter-defined with integration times short enough to resolve short time variations, but long enough to obtain adequate signal to noise. Well calibrated observations through the Johnson *V* filter are recommended, thereby permitting easier comparison to the majority of the photometric data in the literature.

It should be noted that the short timescale variations discovered herein contrast with those of the cooler R CrB stars (Clayton 1996). Many of the cooler R CrB stars have pulsation periods on the order of 40 to 100 days. It could be, of course, that such periods, mostly dependent upon observations in databases such as the AAVSO's, are more the result of the observing technique, a measurement per night over days and weeks. Intensive well-calibrated short timescale observations of the cooler R CrB stars also might be fruitful.

Looking at recent data displayed in the AAVSO database for V348 Sgr, in the time interval 2457100 < HJD < 2458400 (2008 December 8 to 2018 September 25), one notes the simultaneous decline in brightness in the *V* and *I* photometric passbands as V348 Sgr approaches minimum brightness. The decline in the *B* passband is less. The *U* photometric band data in this paper are the only such data known to the authors for V348 Sgr in this time frame.

Figures 10, 11, 12, 13, and 14 illustrate the behavior of the (*U–B*), (*B–V*), (*V–R*), (*R–I*), and (*V–I*) color indices as a function of the *V* magnitude. The ordinate scale is the same for these figures to better illustrate the photometric behavior of V348 Sgr. As V348 Sgr fades, (*U–B*) initially reddens and then, during the final five magnitudes of decline, becomes more blue.

Two points in Figure 10 stand out. The two reddest points are from 1988 September 16 UT. The data points taken at the CTIO 1.5-m on HJD 2447420.52371 and 2447420.52916 are at *V* = 14.837, (*U–B*) = +0.850 and *V* = 14.862, (*U–B*) = +1.036. Those data were taken through a 1.4-mm diaphragm (14 arc seconds), as were the other photoelectric data. The observing log indicated raw data errors of 2% in *V*, 4.8% in (*B–V*), 13% in (*U–B*), 1% in (*V–R*), 2% in (*R–I*), and 0.6% in (*V–I*), as support for the validity of the plotted data points for this night's data. The two measures were taken 7.5 minutes of time apart. The standard star photometry errors were less than one percent for that night, except 3% for (*U–B*). The sky was clear all night, with seeing between 2.5^s and 3^s of arc. Additional precise and accurate data taken when V348 Sgr is faint are needed.

Whereas the (*U–B*) color index data points stand out in Figure 10, for V348 Sgr on UT 1988 September 16, measures in the (*B–V*), (*V–R*), (*R–I*), and (*V–I*) color indices do not in Figures 11, 12, 13, and 14, respectively. The AAVSO database observations of this date do not provide aid in interpretation. However, perusal of recent AAVSO database multicolor data in the time interval 2457100 < HJD < 2458400 show color indices for a magnitude of *V* ~ 14.85 to be similar to those found herein. There are no comparable (*U–B*) data points in the AAVSO database. An interpretation is that the measured (*U–B*) color index on 1988 September 16 results from the planetary nebula which surrounds V348 Sgr, not a satisfactory statement.

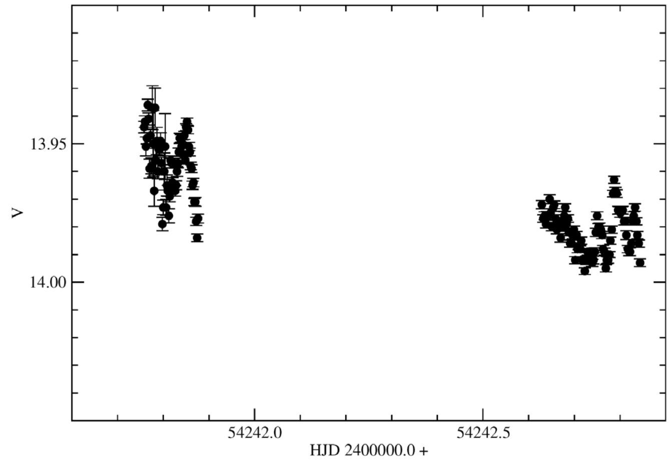

Figure 9. CCD data from the CTIO Yale 1.0-m telescope for UT 2007 May 21 and 22 (HJD 2454241 and 2454242).

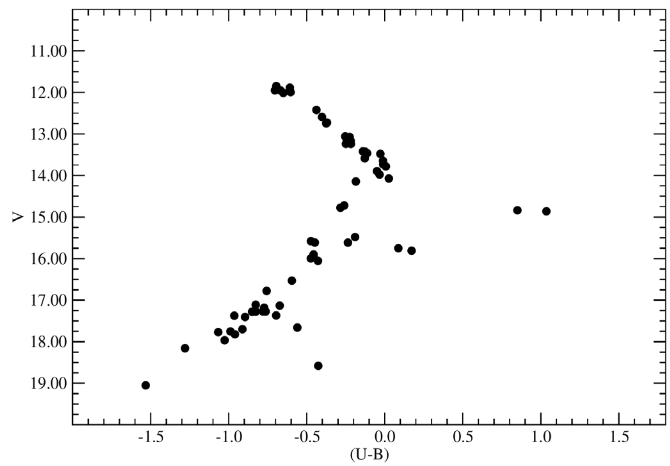

Figure 10. *V* magnitudes vs (*U–B*) color index for the photoelectric data for V348 Sgr in this paper.

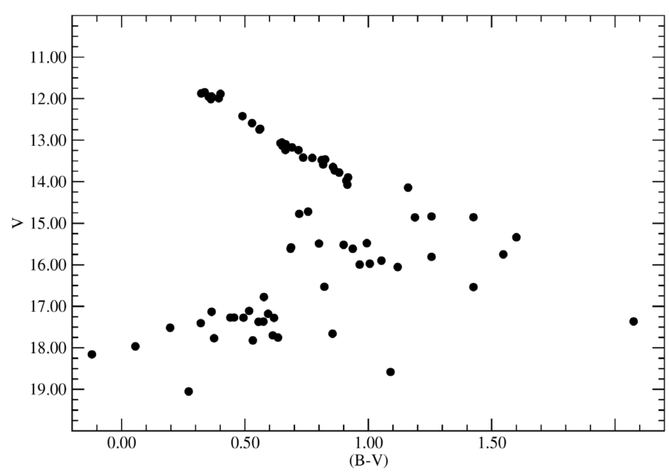

Figure 11. *V* magnitudes vs (*B–V*) color index for the photoelectric data for V348 Sgr in this paper.

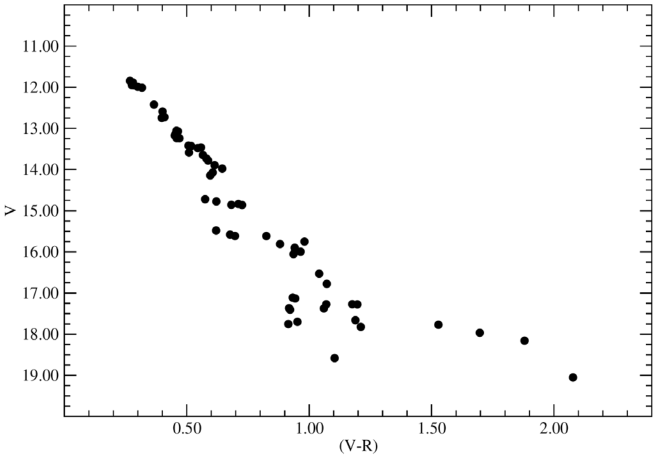

Figure 12. *V* magnitudes vs (*V–R*) color index for the photoelectric data for V348 Sgr in this paper.

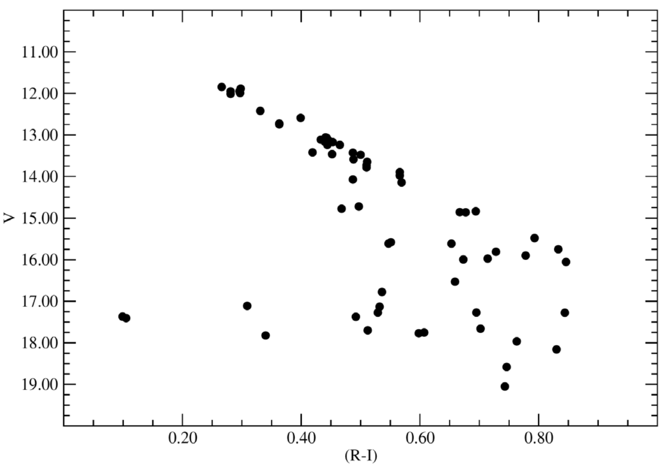

Figure 13. *V* magnitudes vs (*R–I*) color index for the photoelectric data for V348 Sgr in this paper.

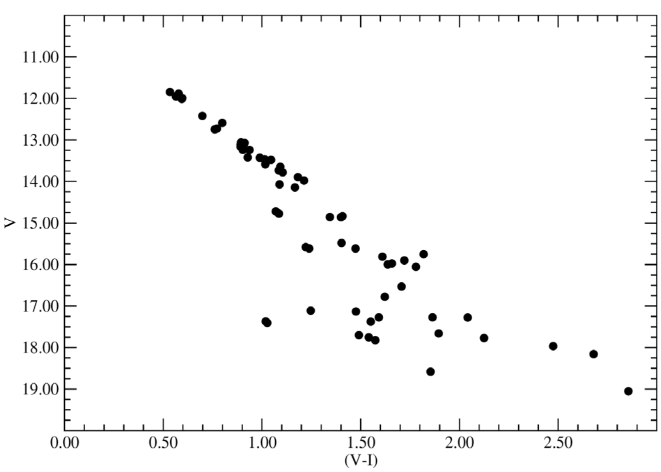

Figure 14. *V* magnitudes vs (*V–I*) color index for the photoelectric data for V348 Sgr in this paper.

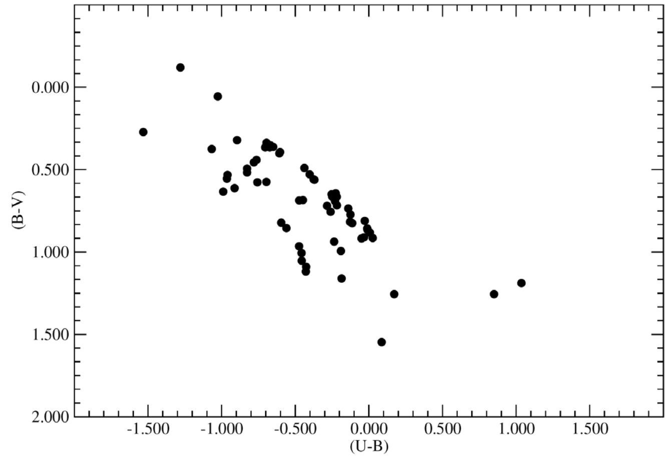

Figure 15. (*B–V*) vs (*U–B*) photoelectric data herein for V348 Sgr.

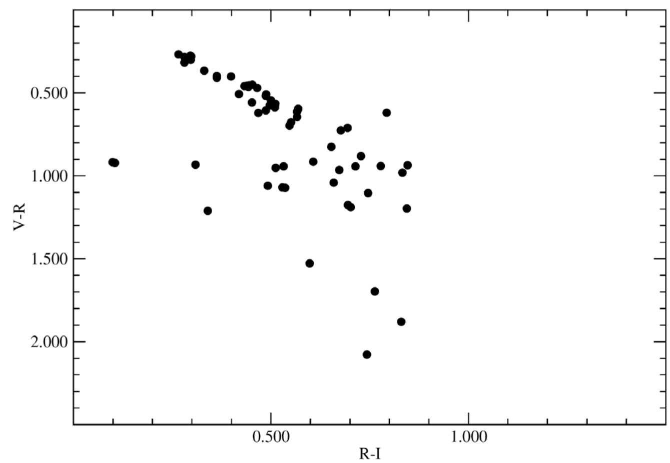

Figure 16. (*V–R*) vs (*R–I*) photoelectric data herein for V348 Sgr.

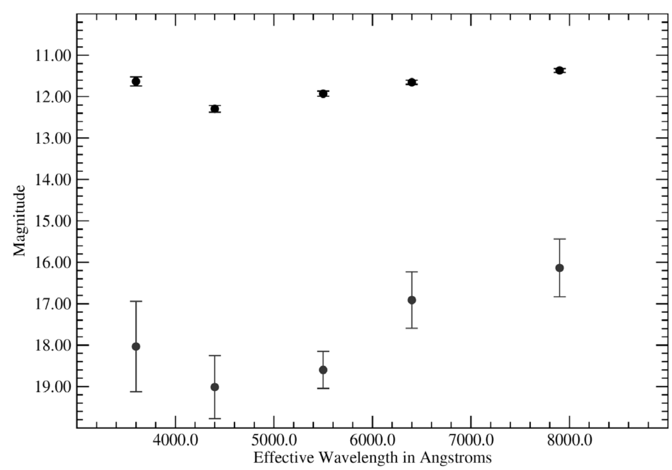

Figure 17. Maximum and minimum brightness of V348 Sgr as a function of effective wavelengths of UBVRI filters.

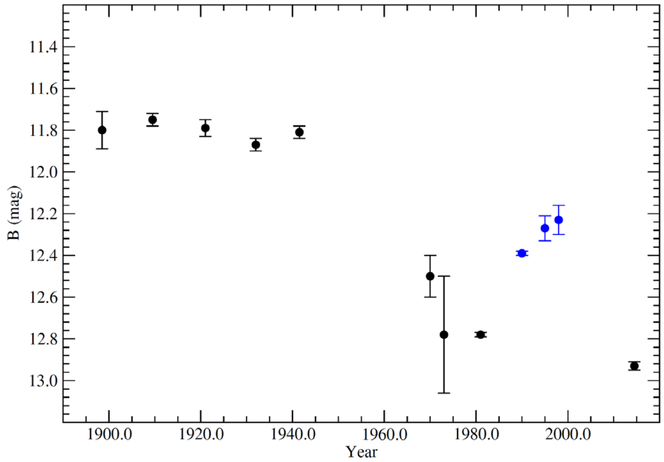

Figure 18. Behavior of *B* magnitude near maximum light for V348 Sgr between 1896 and 1998; black circles from Schaefer (2016) and blue circles from data herein.

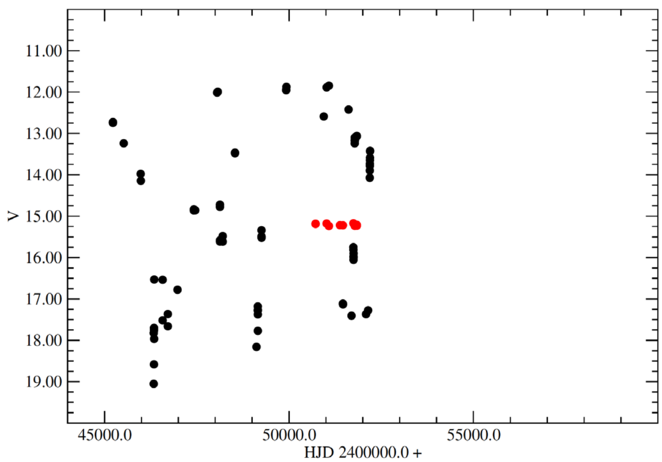

Figure 19. Behavior of *V* magnitude of star C (red filled circles) on nights when it was observed along with V348 Sgr (black filled circles).

Figure 15 and Figure 16 show that as the shorter wavelength color index becomes more red, so does the longer wavelength color index. Figure 15 presents a definite but broad relationship between (*B*–*V*) as a function of (*U*–*B*) as both become more red. The relationship is tight in Figure 16 in the color index interval (+0.3 < (V–R) < +0.7; +0.3 < (R–I) < +0.6), after which scatter increases due to the faintness of the star. As the referee wrote, "The bewildering pattern of data points in Figures 15 and 16 suggests a path for future investigation." What is needed is a series of well calibrated observations, particularly when V348 Sgr is faint.

The CCDphot data from UT 1993 May 11 are included in Table 3 at HJD 2449118.97954. Since these data were obtained at KPNO's 0.9-m telescope at an air mass of 1.8, the magnitude and color indices of a nearby star, C (see description of star C below), were adjusted to match that star's average magnitude and color indices as determined at CTIO, where the star was high in the sky. Such determined differences then were applied to the measured magnitude and color indices of V348 Sgr taken at KPNO, resulting in the values to be found in Table 3. The nearest in time observation, ten days earlier in the AAVSO database, to which this photometry may be compared is an observation by Thomas Cragg where he determined a visual observation of fainter than 15.5 on JD 2449108.2.

Figure 17 is a summary, based on the data herein, of the brightness of V348 Sgr at maximum and minimum brightness as a function of wavelength through the U, B, V , R, and I Johnson Kron filters. The maxima were taken from dates where *V* ≈ 12th magnitude or brighter. The minima were taken from dates where *V* ≈ 18th magnitude or fainter. The error bars at minima light are larger just because the photometry is less accurate. Nevertheless, V348 Sgr is fainter at the *B* wavelength at both maxima and minima when compared to the other filters. And V348 Sgr brightens at both maxima and minima as one proceeds from the *V* to the *R* to the *I* filter. This follows from the discussion in Clayton *et al.* (2011).

Schaefer (2016) described a long term decline in the average *B* magnitude of V348 Sgr. He illustrated this decline with archival data (his Table 2) and displayed in his Figure 2. These same data are presented as black filled circles in Figure 18 herein. Similar data from Table 3 herein are displayed as blue filled circles. The current data confirm the long term, but indicate a less steep decline. Actually the current photoelectric data show the maximum *B* magnitude to have brightened somewhat. At least a partial explanation lies in the difficulty in identifying a time interval of maximum brightness.

A star, identified in Figure 1 as C, located to the north and east of V348 Sgr, at $\Delta\alpha = +1.075^s$ and $\Delta\delta = +5.53''$, was used as a comparison star. It was intermediate in brightness between the bright and faint limits of the light variations of V348 Sgr. This star appears in the UCAC4 Catalogue as UCAC4 336-170138 (Zacharias *et al.* 2013). Its coordinates from the Gaia proper motion catalogue, VizieR's catalogue I/343/gps1, are R.A. = $18^h\,40^m\,21.02934^s$, Dec. = –22° 54' 24.1221", J2000. This same catalogue lists this star's proper motion as $\mu_\alpha = -5.586 \pm 1.322$ and $\mu_\delta = +9.709 \pm 1.532$ mas yr^{-1}. The star labeled C herein is identified as star 12 in Figures 3a and 3b in Heck *et al.* (1985).

Ten photoelectric observations of star C, all taken at the CTIO 1.5-m telescope, over a three-year interval provided an average magnitude and color indices of *V* = 14.788 ± 0.024, (*B*–*V*) = +1.231 ± 0.056, (*U*–*B*) = +0.872 ± 0.054, (*V*–*R*) = +0.668 ± 0.031, (*R*–*I*) = +0.653 ± 0.019, and (*V*–*I*) = +1.321 ± 0.044. Figure 19 illustrates the behavior of star C on nights when it was observed along with V348 Sgr itself.

As a byproduct of the CCD observations of V348 Sgr, 219 data points were obtained of star C through a Johnson *V* filter on 31 nights. The resulting magnitude was *V* = 14.791 ± 0.013, in good agreement with the photoelectric results. The corresponding color indices from star C's CCD data are (*B*–*V*) = +1.224 ± 0.002, (*U*–*B*) = +0.880 ± 0.006, (*V*–*R*) = +0.685 ± 0.002, (*R*–*I*) = +0.655 ± 0.0025, and (*V*–*I*) = +1.340 ± 0.002.

This is particularly gratifying since star C is faint for photoelectric measurements at a 1.5-m telescope, especially in as crowded a field as is evidenced in Figure 1. Identifying the same spot for a photoelectrically-based sky background reading consistently night to night over years is tricky. That is why CCDs excel in crowded fields, as if additional evidence is needed.

4. Summary

Calibrated photometric photoelectric, CCDphot, and CCD data of the hot R CrB star V348 Sgr have been obtained by the authors over an interval of 21.6 years. The current data confirm a long term decline in brightness, but with a smaller slope than heretofore determined. These accurate multicolor photometric data aid in the zero point determination of data in databases and in the definition of the long-term photometric behavior of the light and color curves for V348 Sgr. Intensive monitoring is crucial for understanding the apparent short time variations. These data should be calibrated and filter defined.

5. Acknowledgements

It is a pleasure to thank the staffs of CTIO, KPNO, and LCO for their help in making the observing runs a success. The authors note with appreciation G. Clayton's comments, and recognize with gratitude the long term observation efforts of the AAVSO community. The authors thank the referee for helpful comments.

The data reported in this paper came from observing runs supported by AFOSR grant 82-0192, Space Telescope Science Institute grant STScI CW-0004-85, and NSF grants AST 9114457, 9313868, 9528177, 0097895, and 0803158.

References

Clayton, G. C. 1996, *Publ. Astron. Soc. Pacific*, **108**, 225.
Clayton, G. C. 2012, *J. Amer. Assoc. Var. Star Obs.*, **40**, 539.
Clayton, G. C., *et al.* 2011, *Astron. J.*, **142**, 54.
Clem, J. L., and Landolt, A. U. 2013, *Astron. J.*, **146**, 88.
De Marco, O., Clayton, G. C., Herwig, F., Pollacco, D. L., Clark, J. S., and Kilkenny, D. 2002, *Astron. J.*, **123**, 3387.
Gaia Collaboration, *et al.* 2016, *Astron. Astrophys.*, **595A**, 1.
Gaia Collaboration, *et al.* 2018, *Astron. Astrophys.*, **616A**, 1.
Heck, A., Houziaux, L., Manfroid, J., Jones, D. H. P., and Andrews, P. J. 1985, *Astron. Astrophys., Suppl. Ser.*, **61**, 375.
Kafka, S. 2019, variable star observations from the AAVSO International Database (https://www.aavso.org/aavso-international-database).
Landolt, A. U. 1983, *Astron. J.*, **88**, 439.
Landolt, A. U. 1992, *Astron. J.*, **104**, 340.
Landolt, A. U. 2007, in *The Future of Photometric, Spectrophotometric, and Polarimetric Standardization*, ed., C. Sterken, ASP Conf. Ser. 364, Astronomical Society of the Pacific, San Francisco, 27.
Landolt, A. U., and Clem, J. L. 2017, *J. Amer. Assoc. Var. Star Obs.*, **45**, 159.
Landolt, A. U., and Uomoto, A. K. 1992, *IAU Circ.*, No. 5640, 2.
Laycock, S., Tang, S., Grindlay, J., Los, E., Simcoe, R., and Mink, D. 2010, *Astron. J.*, **140**, 1062.
Percy, J. R., and Dembski, K. H. 2018, *J. Amer. Assoc. Var. Star Obs.*, **46**, 127.
Pollacco, D. L., Tadhunter, C. N., and Hill, P. W. 1990 *Mon. Not. Roy. Astron. Soc.*, **245**, 204.
Schaefer, B. E. 2016, *Mon. Not. Roy. Astron. Soc.*, **460**, 1233.
Schajn, P. 1929, *Astron. Nachr.*, **235**, 417.
Tody, D., and Davis, L. E. 1992, in *Astronomical Data Analysis Software and Systems I*, eds. D. M. Worrall, C. Biemesderfer, J. Barnes, ASP Conf. Ser. 25, Astronomical Society of the Pacific, San Francisco, 484.
Woods, I. E. 1926, *Bull. Harvard Coll. Obs.*, No. 838, 11.
Zacharias, N., Finch, C. T., Girard, T. M., Henden, A., Bartlett, J. L., Monet, D. G., and Zacharias, M. I. 2013, *Astron. J.*, **145**, 44.