Bull. Astr. Soc. India (2000) **28**, 329-333

Studies of classical novae and related objects

U. S. Kamath

Physical Research Laboratory, Navrangpura, Ahmedabad 380 009, India

Abstract. This thesis is based on studies of two classical novae - V1425 Aquilae (J H K photometry and optical spectroscopy) and V723 Cassiopeiae (J H K photometry) and a sample of symbiotic stars (J H K photometry and Circular Variable Filter spectroscopy). The infrared data have been obtained from Mt. Abu IR Observatory of Physical Research Laboratory, Ahmedabad, and the optical spectra from Vainu Bappu Observatory of Indian Insitute of Astrophysics, Bangalore.

Key words : Variable stars: Novae, Symbiotic; Photometry: Infrared; Spectroscopy: Optical

1. Introduction

Classical novae are close binary systems consisting of a white dwarf primary and a Roche-lobe filling main sequence secondary. A nova outburst is the result of a thermonuclear runaway in the accreted matter on the surface of the white dwarf component. Gaseous ejecta is expelled with velocities of hundreds to a few thousand km s^{-1} during the outburst. Symbiotic stars are wide binary systems consisting of a hot compact component, a cool giant and an ionized nebula. They show irregular brightness variations and some also exhibit nova-like outbursts.

This research work was undertaken :

(i) To study the temporal evolution of novae by studying various phases they go through after outburst, and

(ii) To study the nature of cool components of symbiotic stars throughout their orbital cycle.

2. Nova V1425 Aquilae 1995

This was a moderately fast nova (t_3 = 23 days) belonging to the "FeII" type, classified based on the presence of strong, permitted FeII emission lines in the optical spectra. The HeI 5876/4471 line ratio implies an extinction of E_{B-V} = 0.76 to the nova. Combining this with the magnitude-decay time relations, a distance of 2.7 kpc has been obtained. Other parameters of the nova such as temperatures in the neutral and ionized zones, neutral and ionized gas masses and Helium abundance have been derived from the optical spectra. Analysis of the near-IR photometry shows that optically thin (τ_{dust} ~ 0.02 – 0.04) carbon dust was present in the ejecta as early as day 22, the earliest observed so far in an "FeII" nova. Figure 1 brings out the importance of our observations in the context of the overall infrared development of the nova. The J H K fluxes have been explained by a three-component model (pseudophotosphere, gas shell and dust shell) and the nature of the dust (onset of formation, temperature, mass) has been studied. Clumpy nature of the ejecta seems to have played a role in early condensation of dust. Increasing ionization of the ejecta is reflected in the optical spectra, which evolved from auroral (A_0; days 51-114) to nebular (N_0; day 844) phase. The hardening of the radiation field could have been partially responsible for the destruction of dust after day 80. Table 1 summarizes our results.

Table 1. Nova V1425 Aql - Summary of results.

Parameter		Value	Method
Date of outburst	t_0	JD 2449742.70[a]	light curve, optical spectra
Decay time	t_3	23 days	V light curve
Ejection velocity	v_{ej}	1300 km s^{-1}	spectra
Absolute magnitude	M_V^{max}	–8.4±0.4	MMRD relations
Extinction	E_{B-V}	0.76	HeI line ratio
Distance	D	2.7±0.6 kpc	E_{B-V} & M_V^{max}
Luminosity	L	1.49 $\times 10^5$ $L_\odot$	from M_V^{max}
Temperature	$T_{neutral\ zone}$	3800 K	optical spectra
	$T_{ionized\ zone}$	120000 K[a]	optical spectra
Gas mass	M_{H+}	1×10^{-4} $M_\odot$[b]	optical spectra
	M_{O^o}	3×10^{-4} $M_\odot$[c]	optical spectra
Helium abundance	N(He)/N(H)	0.26±0.06	optical spectra
Dust formation			
time	t_d	22 days	J H K photometry
Dust temperature	T_d	1625 K[d]	J H K photometry
Optical depth	τ_{dust}	~ 0.02 – 0.04[e]	V and K data
Dust mass	M_{dust}	0.6–7.22 $\times 10^{-9}$ $M_\odot$[e]	IR data
Dust / gas		~ 10^{-3}	

[a] 1995 Jan 25. 2
[b] Day 843.8
[c] Day 50.5
[d] Day 21.82
[e] Day 21.82 – 44.82

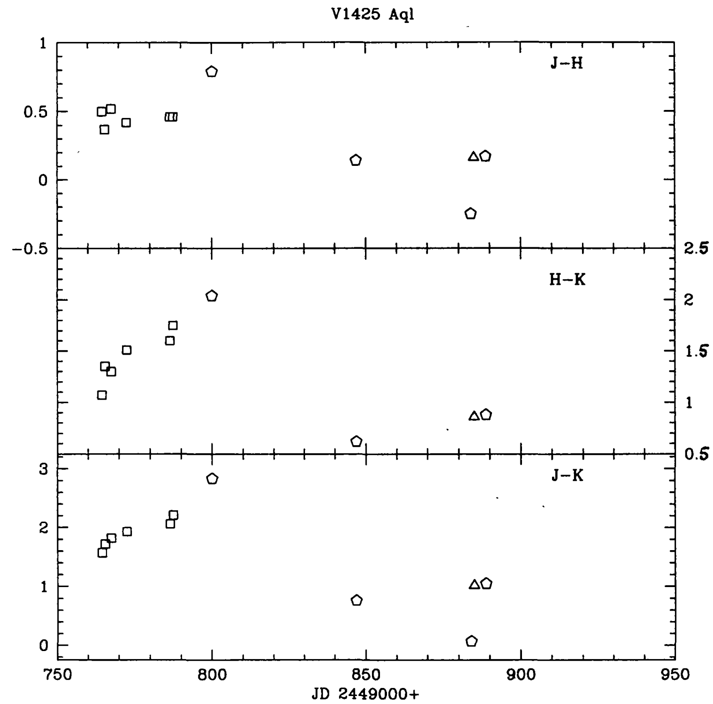

Figure 1. Evolution of the colour indices based on all available J H K photometry for V1425 Aql. Squares are our data, pentagons are from Mason et al. (1996) and triangles are from Kolotilov et al. (1996). The reddening of colours in the initial stages is because of dust formation. This trend reaches its peak at dust shell maximum and then reverses after destruction of dust. The trend towards blue colours at later times is due to the prominence of emission lines in various bands.

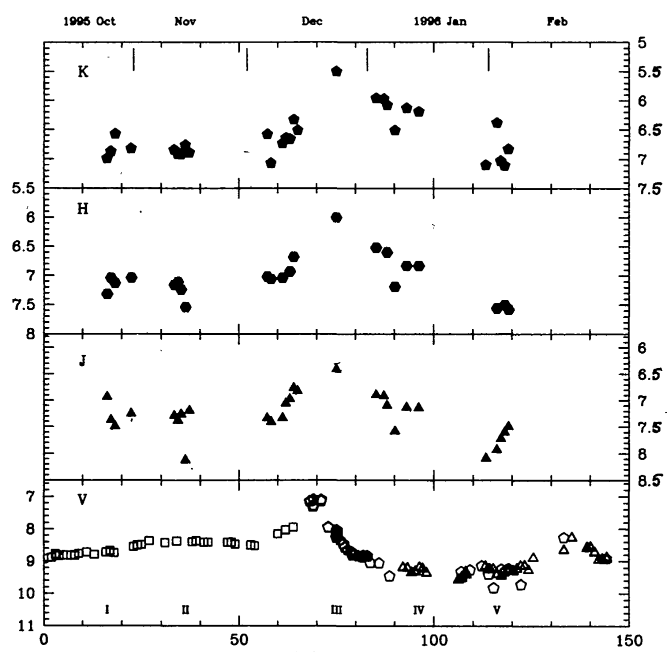

Figure 2. Optical and IR evolution of nova V723 Cas during the first two flares. V magnitudes have been taken from Ohsima, Akazawa & Ohkura 1996 (squares) and data circulated over VSNET (triangles – V. Goranskij and collaborators; pentagons - others). IR data are our observations. Epochs I-V, chosen for modelling the fluxes, are labelled. Large ticks on the top box denote different months as labelled above it.

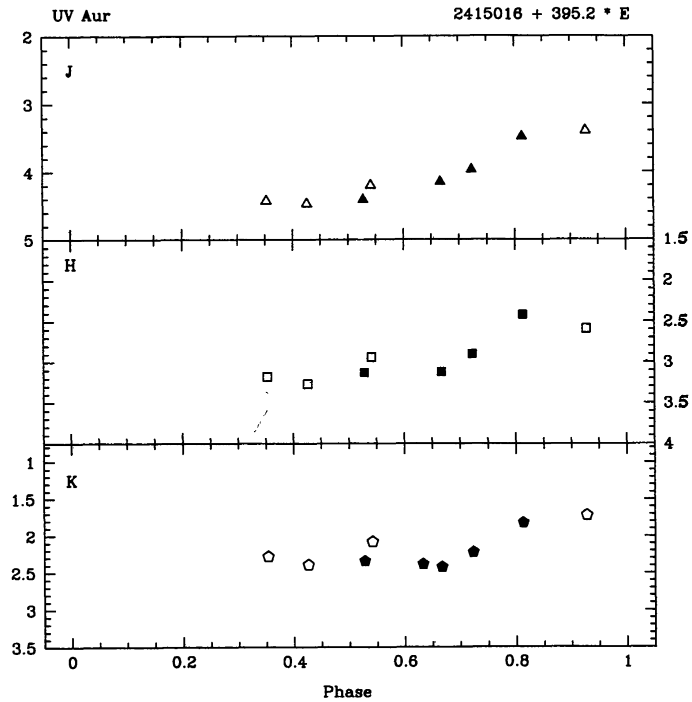

Figure 3. Phase plot for UV Aur based on the ephemeris of Zakarov (1951). It became clear in later studies that the period refers to the pulsational period and not the orbital one. The pulsational nature of the carbon star can be seen despite the incomplete phase coverage. Filled symbols denote our data; open symbols are data in literature.

3. Nova V723 Cassiopeiae 1995

J H K photometric observations of this slow nova (t_3 ~ 650 days) were begun two months after outburst and were continued for fifteen months thereafter (October 1995 to January 1997). As a result of episodic mass ejections, the nova showed five flares in the optical in the post-outburst phase. The first two of these are covered by our observations (Fig. 2). Increased flux levels are also seen in the J H K bands during these periods. The periodic mass-injections enabled the pseudophotosphere to maintain itself at immediate post-outburst conditions. The J H K fluxes over the first seventeen months after outburst can be explained by a combination of pseudophotospheric and free-free emission. A pseudophotosphere whose temperature is in the range 7000-15000 K and ionized gas at 10000 K together give rise to different spectral energy distributions at different epochs. The similarity of the light curve of this nova with that of the unusual slow nova HR Del enables one to determine some of its parameters like absolute magnitude and distance. The nova had not formed dust till the time of our last observations. No dust condensation episode has been reported thereafter. The temporal coverage of V723 Cas shows the persistence of the pseudophotospheric phase and enables us to set a lower limit to the timescale of possible dust formation. The results are summarized in Table 2.

4. Symbiotic stars

J H K photometry of 30 symbiotic stars and related objects at various orbital phases has been obtained. The data cover important phases like conjunctions and quadratures of the cool star for many objects in our sample. Figure 3 shows the phase plot for UV Aur; it brings out the pulsational nature of the carbon star giant in the system. Our data have been combined with those available in literature to study the variability of symbiotic stars. Besides contributing valuable data, this study has brought out the importance of a complete phase coverage of these objects by pointing out the deficiencies in existing data. Circular Variable Filter spectroscopy (1.7 – 3.4 μm) of 10 bright symbiotics in the above sample has also been undertaken. spectral

Table 2. Nova V723 Cas – Summary of results.

Parameter		Value	Method
Date of outburst	t_0	JD 2449919[a]	Munari et al. 1996
Decay time	t_3	~ 650 days	V light curve
Absolute magnitude	M_V^{max}	−6±1	similarity with HR Del
Extinction	E_{B-V}	0.6	Gonzalez-Riestra et al. (1996)
Distance	D	3.9 kpc	E_{B-V} & M_V^{max}
Luminosity	L	$2.07 \times 10^4\ L_\odot$	from M_V^{max}

[a]1995 July 20

types of the late type giants in these systems have been related to the depth of the 2.3 μm CO absorption band based on the calibration of Kenyon & Gallagher (1983). Short discussions on objects in the sample are given in the thesis.

This thesis has been submitted to Gujarat University. The research was carried out under the supervision of Dr. N. M. Ashok.

References

Gonzalez-Riestra R., Shore S. N., Starrfield S., Krautter J., 1996, IAUC 6295

Kenyon S. J., Gallagher J. S., 1983, AJ, 88, 666

Kolotilov E. A., Tatarnikov A. M., Shenavrin V. I., Yudin B. F., 1996, Astron. Lett, 22, 729

Mason C. G., Gehrz R. D., Woodward C. E., Smilowitz J. B., Greenhouse M. A., Hayward T. L., Houck J. R., 1996, ApJ, 470, 577

Munari U., Goranskij V. P., Popova A. A., Shugarov S. Yu., Tatarnikov A. M., Yudin B. F., Karitskaya E. A., Kusakin A. V., Zwitter T. Z., Lepardo A., Passuello R., Sostero G., Metiova N. V., Shenavrin V. I., 1996, A&A, 315, 166

Ohsima O., Akazawa H., Ohkura N., 1996, IBVS 4295

Zakarov G. P., 1951, Peremn. Zved., 8, 369