A SURVEY OF NOVA REMNANTS*

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ABSTRACT. Exnovae and nova shells are generally faint and difficult to observe. Only a few have been studied, and even less of them in sufficient detail. We give a progress report on our survey of exnovae and nova shells, especially on the results of a spectral survey of novae in the southern Milky Way. The three-dimensional structure in the light of Hα derived for the nebula of GK Per is displayed.

1. Motivation

Nova remnants, both nebular and stellar, constitute valuable sources for the derivation of outburst geometry and physics. Observational material, however, has been sampled on only a few spectacular objects, and for those, three-dimensional (topokinematic) images of nebulae, and studies of structural differences in the light of different ions are largely lacking. The central stars of a large majority of the nearly 250 novae discovered during outburst has never been looked at during minimum. This is not surprising in view of the faintness of the remnants and the lack of proper identifications.

The Catalogue and Atlas of Galactic Novae (Duerbeck 1986), containing accurate positions and finding charts, has been used to obtain spectra of faint novae (about 100 objects) and direct images in search of nova shells (about 40 objects).

Based on observations obtained at the European Southern Observatory, La Silla, Chile, and at the Centro Astronomico Hispano-Aleman Calar Alto, Spain, operated by the Max-Planck-Institut für Astronomie, Heidelberg.

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2. A Spectroscopic Survey of Novae

The Cassegrain spectrograph of the Calar Alto 2.2 m telescope, equipped with an image tube was used in 1983 and 1984 for northern objects, and the Cassegrain spectrograph of the ESO 1.5 m telescope equipped with an image dissector scanner was used in 1986 and is scheduled in 1987 for southern objects. Three exnovae were observed with the IDS at the ESO 3.6 m telescope. Since the IDS spectra require less reduction work, most of the quantitative data available so far are for the southern objects between RA 11 - 23 h. The preliminary results are summarized in the following. The continuum magnitudes, derived from the IDS spectra, are accurate to about 0.5 in V (due to light losses at the rim of the aperture), and 0.1 in the B-V and V-R colours.

Table 1. Description of Spectra (Wavelength Range 3900 - 7100 Å)

Remarks:	Lines connected by + are blends. He II + C III refers to Her II 4686 + C III 4650. The contributions to the hydrogen lines by the star and the shell cannot be separated.
DO Aql:	V = 18.55, B-V = 0.20, V-R = 0.50; weak, flat continuum (noisy);stellar and nebular emission lines: Hα + [N II], [O III], He II + C III. (Fig. 1).
V356 Aql:	V = 18.00, B-V = 0.25, V-R = 0.00; blue continuum; emission lines:Strong Hα, weak Hβ, strong He II + C III.
V368 Aql:	V = 17.25, B-V = 0.70, V-R = 0.60; flat continuum; emission lines: Strong Hα, Hβ, He II + C III; He I 4471?
V603 Aql:	V = 11.80, B-V = 0.00, V-R = 0.15; blue continuum; emission lines: Hα - Hε, strong He II + C III; very broad continuum feature centered on He II 5412; He I 5876, 4471,4026, 7065, 4713, 6678, 4922, 4388, 4144, 4169, 5016, also C III 4187, C II 4267, N III 4379, O II 4071.
OY Ara:	V = 18.55, B-V = -0.15; blue continuum (noisy); emission lines: Strong Hα; Hβ, Hγ, He I 6678?, He I 4471 in absorption?
AR Cir:	V = 14.10, B-V = 1.15; G type star; superimposed on exnova?
V655 CrA:	Blend of two stars, faint; red, noisy continuum; Hα emission?
HR Del:	V = 12.70, B-V = 0.30, V-R = 0.15; blue continuum; nebular and stellar emission lines:[O III], Hα + [N II], strong He II + C III; Hβ; Hγ in absorption ?; very broad feature centered on He II 5412, broad C II 4267?, N III 4379 (contribution of [O III] 4364?)

GW Lib: V = 16.60, B-V = 0.00, V-R = -0.15; blue continuum; emission lines: narrow lines of Hα - Hδ; all (except Hα) centered on broad absorption troughs; broad emission of He I 5876, Fe II 5169, 5018, 4924, narrow He I 4471 (+ broad absorption trough?) (Fig. 2).

BT Mon: V = 16.60, B-V = 0.25, V-R = 0.30; blue continuum; emission lines: strong Hα - Hδ, He II + C III, NIII; moderately strong He II 5412; fairly weak He I 5876, 4471, 4026, 7065, 6678, 4922; moderately strong C II 4267, C III 4187.

GQ Mus: V = 16.55, B-V = 0.15, V-R = -0.05; in nebular phase; pronounced emission line spectrum; major lines according to decreasing strength: Hα, He II 4686, [Fe VII] 4942, Hβ, [Fe VII] 6090, [Fe XIV] 5302?, [A V] 4610?, [Fe VII] 5721.

IL Nor: Faint; blue continuum (noisy); emission lines: Hα, Hβ.

RS Oph: V = 10.90, B-V = 0.96, V-R = 1.00; red continuum; emission lines: Hα - Hδ (strong decrement), He I 5876, 7065, 6678, 5016; numerous Fe II, some [Fe II] and [Fe III] lines.

V841 Oph: V = 13.60, B-V = 0.30, V-R = 0.30; blue continuum; emission lines: weak Hα, Hβ (with absorption troughs?), relatively strong He II + C III, N III, He II 5412; weak He I 5876, 4471?, 7065, 6678, 5048, 5016.

V849 Oph: V = 18.60, B-V = 0.15, V-R = 0.05; blue continuum (noisy); emission lines: Hα (strong) - Hγ, He II (+ C III?), He I 5876, C II 4267?

V972 Oph: V = 16.55, B-V = 0.95, V-R = 0.75; reddened continuum; emission lines: Weak Hα, strong He II + C III; no He I visible.

RR Pic: Fairly blue continuum; emission lines: relatively strong Hα- Hε, ; very strong He II + C III; He II 5412, 4542.

CP Pup: V = 15.30, B-V = 0.05, V-R = 0.10; blue continuum; emission lines: strong Hα - Hε, strong He II + C III, fairly strong He II 5412, 4542, weak He I 7065, 5876, 4471, 6678, 4922.

T Pyx: V = 14.80, B-V = 0.30, V-R = 0.40; blue continuum; emission lines: Hα - Hε, strong He II + C III, relatively strong He II 5412, 4542; strong He I 5876, 7065, 6678, 4922, 5048, 5016.

SS Sge: V = 17.90, B-V = 0.75, V-R = 0.65; red continuum, featureless, except emission lines of He II + C III?

BS Sgr: V = 15.45, B-V = 1.10, V-R = 0.70; red continuum, featureless, except emission lines of He II + C III, C II 4267?

GR Sgr: V = 16.50, B-V = 0.50, V-R = 0.30; flat continuum; emission lines: Weak Hα; He II 4686?

V999 Sgr: V = 16.60, B-V = 0.75, V-R = 0.60; blue continuum; emission lines: Weak Hα.

V1017 Sgr: V = 13.70, B-V = 1.05, V-R = 0.35; red continuum; emission lines: Hα - Hδ; Hγ, Hδ? with P Cyg profiles; relatively weak He I 5876, 4471, 4026, 7065, 6678, 4922, 4144, 4169; absorption lines, clearly due to the secondary: Ca II 3934, 3968, Mg I 5184, 5173, 5167; Na I 5890, 5896.

V1059 Sgr: V = 17.40, B-V = 0.75, V-R = 0.30; flat continuum (noisy); emission lines: Hα - Hγ, He II (+ C III?).

N Sco 85: V = 15.80, B-V = 0.70, V-R = 0.90; in nebular phase, pronounced emission line spectrum; major lines according to decreasing strength: Hα, He I 7065, Hβ, [N II] 5755, He I 5876, [O III] 5007, He II 4686, He I 6678, N III 4641, Hγ + [O III] 4340-63.

X Ser: V = 15.30, B-V = 0.20, V-R = 0.15; blue continuum; emission lines: Hα - Hγ; strong He II; He I 5016; He I 5876 noticeably missing. [O I] 5577, 6300, 6364 (atmospheric?)

FH Ser: V = 16.45, B-V = 0.50, V-R = 0.55; flat continuum; nebular and stellar lines: Strong Hα + [N II], [O III]; Hβ, Hγ, strong He I 5876, 7065; probably He II + C III.

3. The Three-dimensional Shell of GK Per

Fig. 2 gives a schematic three-dimensional view of the present state of the shell around GK Per, seen in the light of Hα, rotated 45° from the west towards the observer. The most important features are:

The general shape of the shell is a prolate ellipsoid and thus corresponds to the basic structure found in all well-studied shells. The peculiar features of the shell, which - until now - was considered to be irregular, is the missing south-polar cap and the absence of the quarter of the ellipsoid extending from the near center to the west.

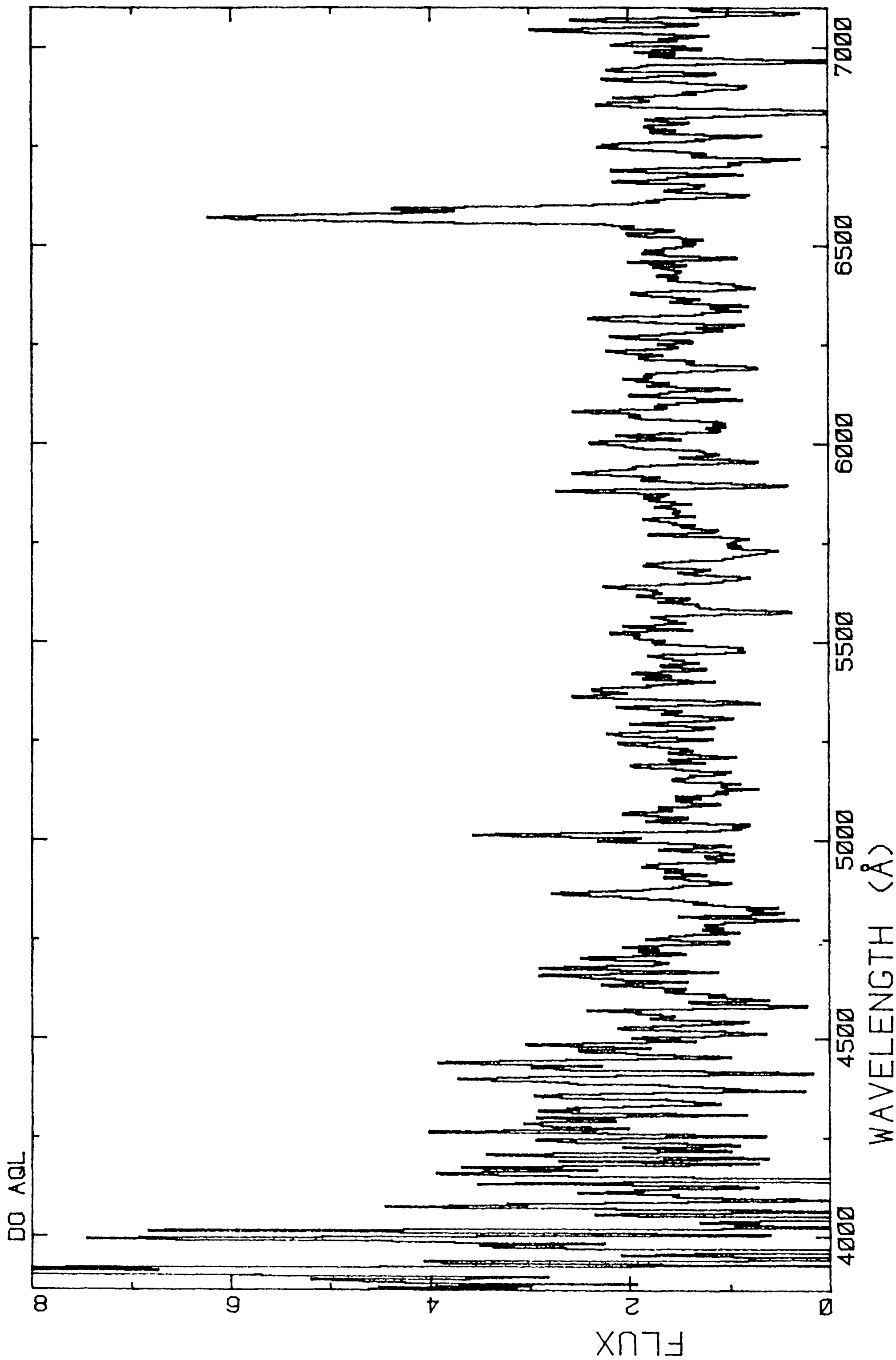

Fig.1. The spectrum of DO Aql (N Aql 1925), observed with the IDS at the ESO 1.5 m telescope. This very slow nova shows a resolvable shell and nebular lines of [N II] and [O III].

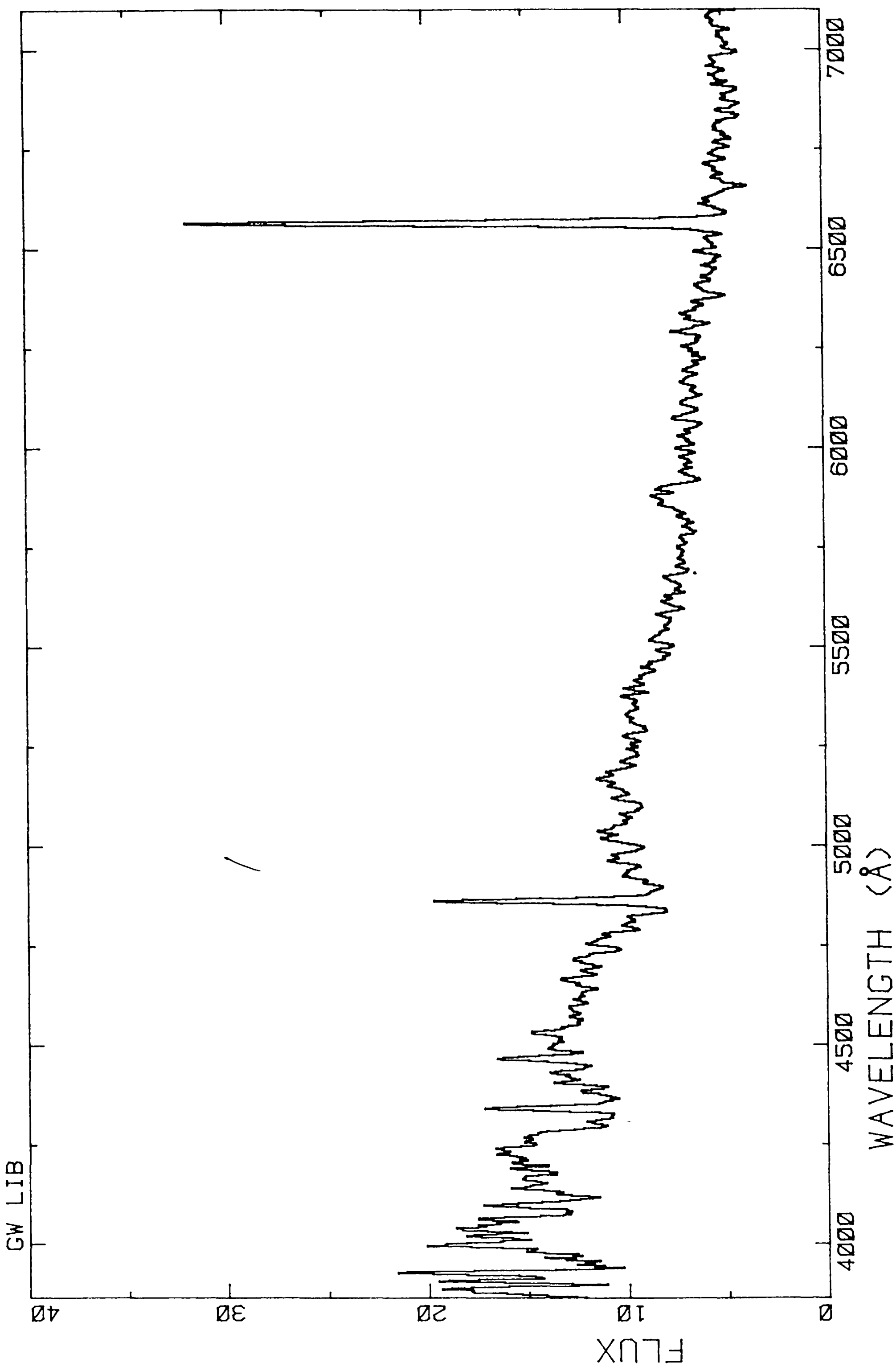

Fig. 2. The spectrum of GW Lib (N Lib 1983), as observed with the IDS at the ESO 1.5 m telescope. The spectral appearance is not unlikely that of a dwarf nova. Since GW Lib was not observed spectroscopically during outburst, additional information is needed to decide whether it is is a nova or a dwarf nova with long cycle length.

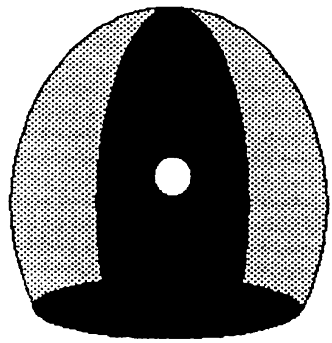

Fig.3. Three-dimensional schematic view of the shell around GK Per in the light of Hα.

4. Future Work

As soon as the spectra for sufficiently many exnovae are reduced, possible correlations between the physical state at a given time after outburst, as indicated by the spectral appearance of the system and outburst parameters will be investigated.

The three-dimensional structure of GK Per in the light of [O III] will soon be completed. Topokinematic studies of DQ Her, RR Pic and CP Pup are in progress.

Reference:

Duerbeck, H.W. 1986, Space Sci. Rev. (submitted).