Accretion efficiency and mass transfer in two binary star systems

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COOL STARS 20.5 ... virtually cool

INTRODUCTION

We analyze the accretion properties of two binary star systems: the BY Draconis type variable V1803 Cyg, which is an A component of the binary system 61Cyg and the semi-regular (SR) symbiotic variable NQ Gem.
In this aim, we estimate an accretion efficiency in these binaries, based on the relation between luminosity and rate of accretion.
We give an appraisal on the currently active mass transfer mechanism between the components in the binaries. This could be relevant to the type of accretion, wind or disc is dominant for each of the objects.
A feasible contribution of the accretion rate to the objects' activity states, as an effect on the luminosity variations is considered.
We compare the results for both objects, according to the features of their different stellar types.

Accretion efficiency (η_{acc}):
η_{acc} - expresses the amount of energy gained from matter with mass M, in units of its mass energy. A useful measure that illustrates the power of accretion as an energy generator [6].

$$\eta_{acc} = \frac{GM}{R_1 c^2}$$

Accretion rate ($\dot{M}_{acc}$) [2]:

$$\dot{M} = 2\pi R_{R1} \Sigma(-V_R)$$

Mass transfer ($\dot{M}_{tr}$):
- Stellar wind
- Roche lobe overflow

OBJECTS' DETAILS

V1803 Cyg (61Cyg A)

BY Draconis-type variable;
Spectral type: K5V;
Rotational period: 35.7 days [8]
Very long orbital period of the binary 61Cyg ≈ **650 yrs [5];**

NQ Gem

Symbiotic variable;
Semi-regular variable;
A bright carbon star with hydrogen emission;
The light curves show pulsations with period
P_{pls} ≈ 58 days [3];

RESULTS

❑ Stellar parameters and the accretion efficiency estimation

Table. Objects parameters - used, obtained and estimated in the calculations:
M1 - mass of the primary star; **M2** – mass of the secondary star; **R1** – radius of the primary star; **R2**– radius of the secondary star; **RM** - the distance from the central object at which the accretion rate reaches its maximum value; **Vr** - Radial velocity**; L[L⊙] -** Mean values of luminosity; **Lx** – X-ray luminosity; **Teff** - Effective temperature**; Tshw** – the shock wave temperature, in the place with maximum accretion rate at **RM**; $\dot{M}_{acc}$ - accretion rate; η_{accr} - accretion efficiency;
- **Σcln ≈ 10^{23} cm^{-2}** - column surface density [7]; **Ω** ≈ 17 km/s – angular velocity [current paper estimation];
- **Note:** References in brackets []; **CPE** – current paper estimations;

Object / Parameter	V1803 Cyg	NQ Gem
M_1 [$M_\odot$]	**0.690** [5]	**0.6** [7]
M_2 [$M_\odot$]	**0.605** [5]	[TBC]
R_1 [$R_\odot$]	**0.665** [5]	**RM = 0.03 (±0.0004)** [CPE]
R_2 [$R_\odot$]	**0.590** [5, 8]	[TBC]
Vr [km/s]	**-65.82** [4]	**45.71**
L_1 [$L_\odot$]	**0.15** [5, 8]	**0.20 (=Lx)** [7]
T_{eff} [K]	**4450** [5, 8]	**Tshw ≈ 7.2 (± 0.05) x 10^4** [CPE]
$\dot{M}_{acc}$ [$M_\odot$/yr]	**1.6 (±0.01) x 10^{-9}** [CPE]	**1.02 x 10^{-8}** [7]
η_{accr} [%]	**2.4 (±0.01) x 10^{-4}** [CPE]	**1.28 (±0.12) x 10^{-4}** [CPE]

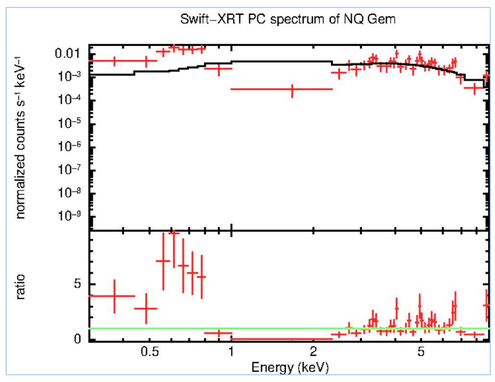

Figure. Time-averaged XRT energy spectrum of NQ Gem, in PC mode. (by Swift-XRT generator, (Evans et al. 2009, MNRAS, 397, 1177)).

❑ Remarks and Conclusions from the results

- The angular velocity of V1803Cyg is high enough, ~ 1/3 of **Vr**, The formation of accretion ring is very probable.
- It is possible of mass losing and matter scattering: the approximately high accretion rate, but not very high accretion efficiency on the surface.
- Unstable accretion structure. An "**A**" component wind is possible.
- Most likely a double feeding mass transfer: via wind and RLOF.

- An X-ray variability of NQ Gem in the range of 0.3 – 10keV, with a maximum count rates activity mostly in the hard band part of the energy spectrum, is detected, see Figure (see also [1], [7]).
- The NQ Gem X-ray luminosity could be contributed by the mass transfer via stellar wind.
- The approximately high accretion rate → not very high accretion efficiency

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