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# Nanoquasars? From Symbiotic Stars to Quasars

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**Abstract.** We report an analogy between two symbiotic stars with jets (CH Cyg and MWC 560) and powerful quasars. The spectral similarity gives us the unique possibility to consider quasar spectral relationships using objects less massive by a factor of millions. Our results reinforce the interpretation of the optical Eigenvector 1 diagram (a possible Hertzsprung–Russell diagram found for low redshift quasars) as driven mainly by the luminosity-to-mass ($L/M$) ratio. The accreting white dwarfs CH Cyg and MWC 560, their jets, and emission lines, may well represent the low energy, non-relativistic end of accretion phenomena, which encompass the most powerful quasars and the microquasars. The remarkable similarities suggest that they deserve the name "nanoquasars" ($\nu\alpha\nu o\varsigma$ = dwarf).

## 1. Emission Line Similarities

Stellar and quasar accretion processes have a lot of similarities in spite of the differences in the type and the mass of the accreting object. Here we show some striking similarities between the emission line spectra of a few accreting white dwarfs and quasars. In spite of the enormous ($\sim 10^7$ times) difference in the central object mass, the optical and UV emission lines of the symbiotic stars CH Cyg and MWC 560 are strikingly similar to those of the low redshift quasar I Zw 1 (widely used as template for almost all quasars).

## 2. Eigenvector 1

During the last decade, several investigations of AGN emission lines have emphasized the importance of a set of correlations conventionally called "Eigenvector 1 " (see Sulentic et al. 2001). The physical drivers of these correlations could be the accretion rate, the orientation, and the black hole mass (Marziani et al. 2001; Boroson 2002). We want to use the emission line similarity between quasars and symbiotic stars to understand better this correlation space. The investigations of Kaspi et al. (2000) and Marziani et al. (2001) give us the possibility to create a theoretical grid over the optical Eigenvector 1 diagram (see Figure 1 [*right*]). As can be seen, the positions of MWC 560 and CH Cyg are very close to those predicted from the extrapolation of the assumed quasar relationships. The quasar relations used correctly predict that the luminosity of these two objects should be considerably less than the Eddington luminosity for a white dwarf. In reality, the total luminosity of the white dwarf of CH Cyg in 1984 May is estimated to be $L \leq 1600\ L_{\odot}$ (Mikołajewska et al. 1988) and that of MWC 560 is $L \approx 1000\ L_{\odot}$ (in 1998 November–December, Schmid et al. 2001).

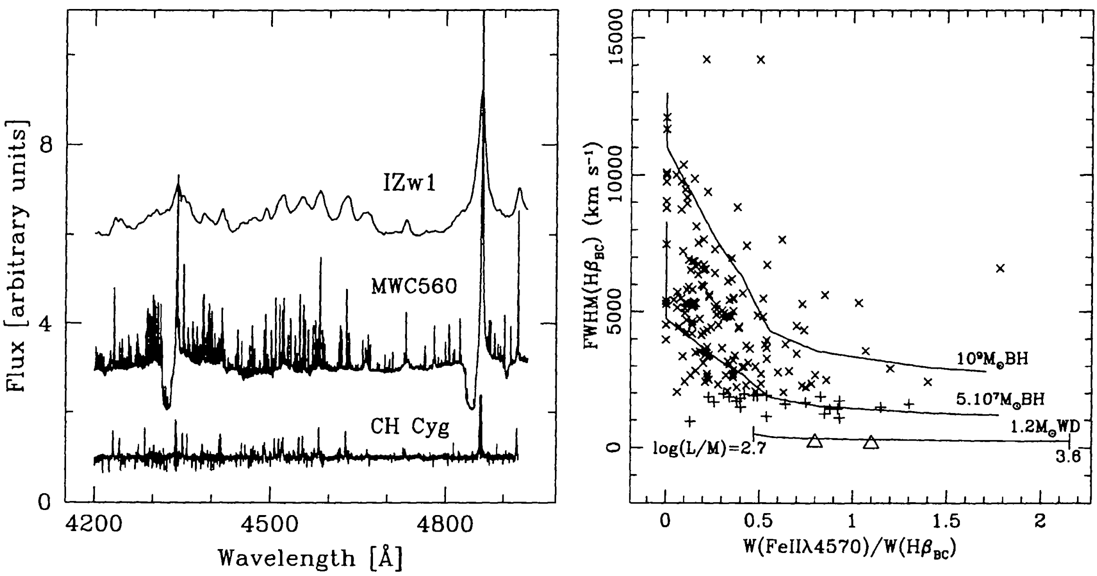


Figure 1. *Left:* A comparison between the optical spectra in the H$\gamma$–H$\beta$ region of the interacting binaries CH Cyg, MWC 560, and the low redshift quasar I Zw 1. A clear similarity between the emission lines is visible. *Right:* The optical Eigenvector 1 diagram. The plus signs represent our quasar sample; the triangles, the two symbiotic stars with quasar-like spectra. The theoretical lines are plotted for black hole mass $10^9$ and $5 \times 10^7$ $M_\odot$, and white dwarf mass 1.2 $M_\odot$.

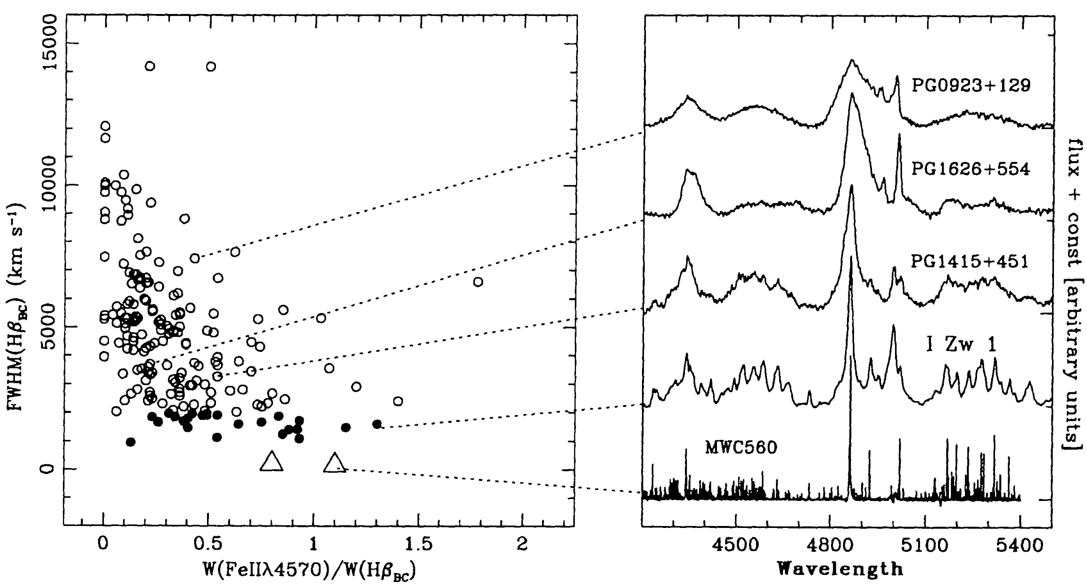


Figure 2. A few spectra demonstrating the spectral similarity and the changes along the optical Eigenvector 1 diagram. The quasar spectra are deredshifted. For MWC 560 only the emission line spectrum is subtracted and plotted.

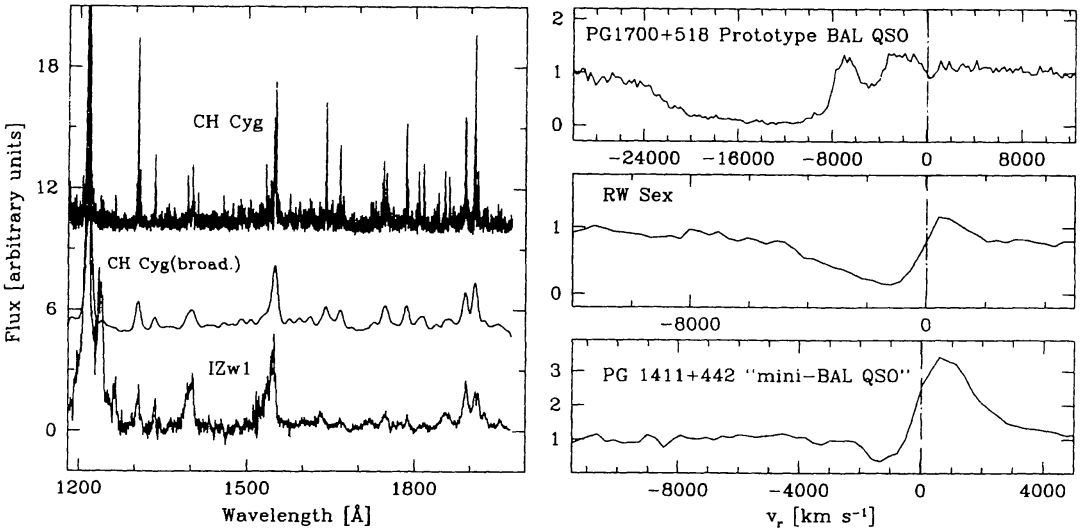


Figure 3. *Left:* Comparison between the UV spectra of CH Cyg and I Zw 1. For CH Cyg the original *IUE* spectrum and a broadened and scaled one are plotted. *Right:* Similarity of the C IV λ1549 profile of the nova-like variable RW Sex, with those of broad absorption line quasars.

Assuming a typical white dwarf mass in symbiotic stars of $M_{WD} = 1.0–1.4\ M_\odot$, we obtain $(L/M) \approx 10^3$ in solar units, in agreement with parameters used to plot the lowest line in Figure 1 (*right*). (This line is plotted for $T_{\rm eff} = 8000$ K and $\log(L/M)$ running from 2.7 to 3.6; more details can be found in Zamanov & Marziani 2002.) In this way the position of MWC 560 and CH Cyg reinforces the interpretation of the Eigenvector 1 correlation space as mainly driven by the $L/M$ ratio.

## 3. The Energy Source of Jets

The luminosity of MWC 560 and CH Cyg is considerably less than the Eddington luminosity. It indicates a mass accretion rate of about $\dot{M}_{\rm acc} \leq 0.05 \dot{M}_{\rm Edd}$. At such mass accretion rates the most probable jet energy source is the extraction of rotational energy from the compact object that is probably going on via the propeller action of a magnetic white dwarf (Mikołajewski et al. 1996). The most probable source of jet formation in quasars and stellar-mass black holes is the extraction of energy and angular momentum via the Blandford & Znajek (1977) mechanism. In this sense, the jets in "nanoquasars" probably represent a low energy (non-relativistic) analogue of the jets of quasars and microquasars, having a similar energy source—the extraction of rotational energy from the central compact object.

## 4. Other Possible Analogies

The FWHM in quasars is probably connected with the orientation. In MWC 560 (visible pole on) FWHM(H$\beta$)=110 km s$^{-1}$, and in CH Cyg (visible edge on) FWHM(H$\beta$)=200 km s$^{-1}$. This is in quantitative agreement with the expectations for quasars, that a face-on object must have 2 times lower FWHM (Marziani et al. 2001).

CH Cyg, after its drop in brightness during 1984, showed broad wings in the Balmer lines (Tomov 1984). Maybe we can connect this with the very broad line region in quasars visible in objects with FWHM > 4000 km $s^{-1}$. Following the theoretical lines (Figure 1 [*right*]) these quasars seem to have lower $L/M$ ratios.

Panferov et al. (1997) stressed that the structure of the emission–absorption Balmer lines of MWC 560 is similar to the line profiles of broad absorption line quasars, such as PG 1700+518. In addition, several cataclysmic variables (e.g., TW Vir and RW Sex) show C IV P Cygni profiles that somewhat resemble the profiles of so-called mini-BAL QSOs (see Figure 3), probably indicating a similar geometry or/and mechanisms.

## 5. Open Questions

1) How many symbiotic stars (and other interacting binaries) have spectra similar to those of quasars? 2) The analogy proposed here is based on low ionization emission lines (Eigenvector 1). Can we extend this using high ionization lines visible in high ionization symbiotics? 3) The extraction of rotational energy from the central compact object seems to be the (most likely) energy source for the jets. How many objects with jets have the same energy source? 4) It will be extremely interesting to find a black hole accreting from the wind of a red giant. It probably would represent very good imitation of quasar.

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## Discussion

*Nussbaumer:* Michael Penston will—either from Heaven or Hell—send us a very pleased smile. He had already suggested twenty years ago that QSOs could be thought of as an assembly of symbiotics. In the talk, similarities between the jets in symbiotics and QSOs have been pointed out. It is now time to do proper model calculations relating accretion and jets. Symbiotics like MWC 560 are ideal for that, and in his review Schmid will probably mention such work (see also the poster by Stute, Camenzind, & Scmid [this volume, p 498]).

*Zamanov:* OK, I fully agree with this "smiling" comment.

*Mikołajewska:* The $L/M$ ratio in CH Cyg was $\sim$10÷20 at the onset of the jet activity (mid-1984), and $\sim$100 during the most prominent maximum in 1981–mid-1984. These values are much lower than $L/M \sim 4000$ ($\log[L/M] \sim 3.5$!) adopted in your analysis, which, in my opinion, makes your final conclusion problematic.

*Zamanov:* Bearing in mind the huge extrapolation ($10^7$ times in the mass of the accreting object and $\sim 10^2$–$10^3$ in the efficiency of accretion), as well as the limited ranges of mass and luminosity, that the correlations of Kaspi et al. (2000) and Marziani et al. (2001) are derived from, we consider that differences up to 1 order of magnitude are not bad. But if the discrepancy is higher, we need to go to a more careful analysis of the ionizing parameter on an object-by-object basis, as well as include the influence of other parameters (efficiency of accretion, orientation, chemical abundances, etc.).