THE NATURE OF GQ MUS AS DEPICTED FROM PHOTOIONIZATION MODELS OF THE SHELL

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Consequences of a detailed photoionization model study of the shell ejected by Nova Mus 1983 (GQ Mus) are presented for the period from early 1983 to 1990 (Morisset & Péquignot 1996).

The drastic time variation of the emission line spectrum, including the transition from a nebular to a coronal stage in 1986, can be quantitatively understood in terms of a smooth evolution of both the expanding shell and the hot thermal source. This transition is due to a decrease of the shell density with time, and not to an increase of the source effective temperature.

The model shell comprises two components so that not all directions become optically thin to ionizing radiation simultaneously. The range of density and geometrical thickness of the *emitting* material is of the order of a factor 2.

If the *emitting* mass of the shell were conserved after 1984, the gas density would have to decrease much faster than t^{-3}, where t is the time since the explosion, implying a continuous *differential acceleration* of the material across a cloud and, according to models, a *steady* t^{-1} *decrease* of L_*, the luminosity of the central source. Alternatively, it is advocated that the rapid decline of Hβ with time after 1984 is due to an *evaporation* of the clouds in an intercloud medium heated by a fast wind from the source. Consistent with the existence of this wind, L_* is then found from photoionization models to remain nearly constant for at least five years.

Assuming blackbody emission, the central-source power $L_* = 1.75 \pm 0.2\,10^{38}\,\mathrm{erg\,s^{-1}}$ and the effective temperature $T_* = 2.7 \pm 0.2\,10^5\,\mathrm{K}$ are determined in 1984 without reference to either the distance to GQ Mus or the precise reddening correction. T_* is slightly smaller using stellar atmosphere models.

By the end of the radiation-bounded period (day 500), the mass of the shell is

$$\frac{M_{\rm shell}}{\rm M_\odot} = (7.3 \pm 1)\,10^{-5} \left(\frac{D}{3\,\rm kpc}\right)^2 10^{3.1(E_{\rm B-V}-0.5)},$$

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D being the distance to the nova and E_{B-V} the interstellar differential extinction. The shell is composed of $\sim 2\,10^4$ clouds filling altogether $\sim 1\%$ of the volume, the size of an individual cloud being comparable to the sound-crossing length at the temperature of the photoionized material. The expected fraction of clouds shielded from the source by other clouds is consistent with this fraction being identified with the thicker component of the model.

The post-nova shrank down to Roche lobe dimensions in less than two months. Three months after the explosion, T_* already exceeds $1.7\,10^5$ K. In a second outburst spanning days 110...170, the remnant swelled back to common-envelope dimensions. Following this event, the evolution of the source slowed down considerably.

The slow rise of T_* from the 6th month after outburst to turn off 10 yr later, is marginally consistent with hydrogen burning and no accretion for a white-dwarf mass $M_{WD} \sim 0.8\,M_\odot$. However both the luminosity derived from photoionization models of the 1984 data and the initial behaviour of the source indicate M_{WD} in excess of $1.10\,M_\odot$.

A large M_{WD} may in principle be reconciled with the evolution of T_* and H-burning if a continuous replenishment of the white-dwarf envelope from a hydrogen-rich companion is postulated. However the H-burning scenario would seem to require a pathologically large and fine-tuned accretion rate to account for observation. Accretion power itself is not able to sustain the luminosity.

Alternatively, it is speculated that the exceptionally long duration of the luminous phase may be due to a rare event, namely *post-outburst burning of helium*, perhaps through the reaction $^{12}C(\alpha, \gamma)^{16}O$ in a He-C-O layer built up as a result of elemental diffusion during many previous cycles of the nova. In this scenario, the second outburst spanning days 110...170 after explosion might be the consequence of a *helium flash*, developing soon after the first ebbing of the common envelope and soon before the normal end of H-burning.

References

Morisset C., Péquignot D., 1996, A&A, in press.