A new class of X-ray emitters: the gCas-like sources

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$gamma$ Cassiopeiae (B0.5 Ve; $gamma$ Cas) has long stood out as having unique X-ray properties among massive stars and Be/X-ray systems. Their properties include hard-thermal X-ray emission (kT sim 12 keV) of moderate luminosity (sim 10$^{32-33}$ erg,s^{-1}, at 0.2--12 keV) and a light curve that displays marked variability on long and short time scales. In contrast, ``normal'' O-B-Be stars are usually soft (kT sim 0.5 keV) and modest X-ray emitters, while all well-known Be/X-ray systems (all of them are Be + neutron star binaries) are non-thermal and more intense X-ray emitters. In spite of several multi-wavelength observing campaigns, since its discovery as prototype of Be stars in the end of 19 century, the true nature of the X-ray emission of $gamma$ Cas remains elusive. Two exciting interpretations have been proposed in the recent literature and raise a number of interesting astrophysical issues, and these are that the X-rays are emitted from: (i) the interaction between a single-Be star with unusually strong magnetic activity and its decretion disk; and (ii) a binary system with an accreting white dwarf. In the first case, $gamma$ Cas would be a progenitor to the magnetars, while the Be + WD binary case would be predicted by evolutionary models of massive binary systems, though they are still not identified as such. One of the obstacles in advancing the understanding of the X-rays of $gamma$ Cas is the fact that the proposed models are restricted to one only object: $gamma$ Cas itself. This work intends to fill such gap.

Our efforts were concentrated on two pillars of inquiry: the investigation of the X-rays of $gamma$ Cas itself, and the search for and study of new $gamma$ Cas analogs. We confirm the main properties already known in the literature of $gamma$ Cas, but a number of peculiarities were also observed for the first time. For example, the local photoelectric absorption of $gamma$ Cas is variable and apparently non-correlated with the intensity of the Fe fluorescence line at 6.4 keV. Also, we detect strong and recurrent variations in its energy distribution in the form of flare-like events in the X-ray colours. On the other hand, we present 6 B0.5e-B1e stars with common X-ray and optical properties quite similar to those of the so far unique star $gamma$ Cas and we point out the emergence of a new class of X-ray emitters: the $gamma$ Cas-like sources. Apart the fact that all stars occupy a narrow band of spectral type, all of them have large or dense circumstellar disks. Other members of the class are: HD 161103, SAO 49725, SS 397, HD 119682, HD 110432 and USNO 0750-13549725. The last three stars are blue stragglers in open clusters of sim 45--60 millions of years (NGC 5281, NGC 4609 and NGC 6649, respectively). Therefore, an evolved status may be a prerequisite to the source being a peculiar X-ray emitter like $gamma$ Cas. Other 41 candidates to members of this class were identified from an extensive investigation of the 2XMMp catalogue.

The massive stars in five young open clusters (sim 10--25 millions of years) especially rich in Be stars ($>$ 135) and in two other old open clusters (sim 95 and 300 millions of years) containing $>$ 11 Be stars were investigated. We paid particular attention to the massive stars, with the aim of constraining evolutionary processes that might lead to the Be phenomenon and to search for low X-ray luminosity massive accreting binaries and $gamma$ Cas-like systems. There is no clear evidence of the presence of these systems in following clusters we have examined so far: NGC 7419, NGC 3766, NGC 663, NGC 884, NGC 869, NGC 3114 and IC 4725. The only exceptions are the well-known Be/X RX,J0146.9+6121 in NGC 663, and perhaps for MWC 39 in NGC 884, which is most likely a neutron star accreting wind matter originating from its main sequence B star companion.

The nature of the X-ray emission of the new class of $gamma$ Cas-like objects is discussed in light of the models proposed for $gamma$ Cas, on the basis of the derived properties and frequency of these objects in open clusters. Finally, we discuss the implications of the results in the context of the Be phenomenom.

(This work was based on X-ray observations carried out by XMM-{it Newton} satelite and available informations in the literature, and for some targets also on optical and infrared spectroscopy from several Earth-based telescopes.)

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