INFRARED EMISSION FROM FOUR Be STARS OPTICAL COUNTERPARTS OF GALACTIC X-RAY SOURCES

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ABSTRACT. Preliminary results of our infrared observations from 2.3 up to 10 and 20 microns of the Be-X-ray stars X Per, γ Cas and HDE 245770,indicate the presence of an ionized circumstellar disk with an electron density law of the type $n_e \propto r^{-3.5}$. X Per and γ Cas show besides,variable infrared excess at 10μ suggesting variability in the stellar wind. LS I+65°010 presents an anomalous infrared energy distribution for a Be star.

1. INTRODUCTION.

In the last years,many galactic X-ray sources have been identified with B-emission line stars (Bradt et al.1978). Maraschi et al.(1976) propose the Be stars as a new class of X-ray transient in which the sudden variations in mass-loss rate from the star in the presence of a compact companion,could produce transient X-ray emission.

High-dispersion IUE spectrograms of several Be stars show asymmetric or violet-shifted ultraviolet resonance lines,indicating the presence of moderately strong stellar wind with terminal velocities ranging from 700 to 1100 Km s^{-1} (Dachs,1980). The observed variabilities in different spectral regions (ultraviolet,optical and infrared) of some Be stars (Doazan et al.1980; Henrichs et al.1980; Slettebak et al. 1979;Ferrari-Toniolo et al.1978 and Elias et al.1978) suggests a variability in the characteristics of the stellar wind.

In order to determine the wind parameters of the Be stars,and to look at the infrared variability,four Be stars optical counterparts of galactic X-ray sources have been observed during 1978-1980. The

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infrared observations from 2.3 up to 10 and 20 microns were carried out at the 2.3 m infrared telescope of the University of Wyoming, using a Ge-bolometer. Table I reports the log of the IR observations and the optical and X-ray characteristics of the observed Be stars.

Table I : Log of IR observations

Star	X-Ray	S.P.	L_x/L_*	IR	N	Date
HDE 245770	A 0535+262	BO(II-V)e	$8\ 10^{-2}$	2.3-10μ	3	78Oct.-80Sept.
LS I+65010	2S0114+650	BO.5IIIe	$1.5\ 10^{-4}$	2.3-4.9μ	1	80Sept.
X Per	4U0352+309	BO(III-V)e	$2\ 10^{-5}$	2.3-10μ	9	78July-80Sept.
γ Cas	4U0053+604	BO.5IVe	$6\ 10^{-6}$	2.3-19.5μ	11	78Jun.-80Sept.

2. DISCUSSION.

During 1978-80, the Be stars γ Cas and X Per have been observed in different occasions. Infraed variability has been found especially at longer wavelengths. The IR light-curves of X Per seem to be correlated to the visual light-curve and will be discussed in a forthcoming paper. HDE 245770 has been observed during an X-ray quiescent phase and very close (Sept.25) to the recent X-ray flare-up of Oct.2 (Oda, 1980).

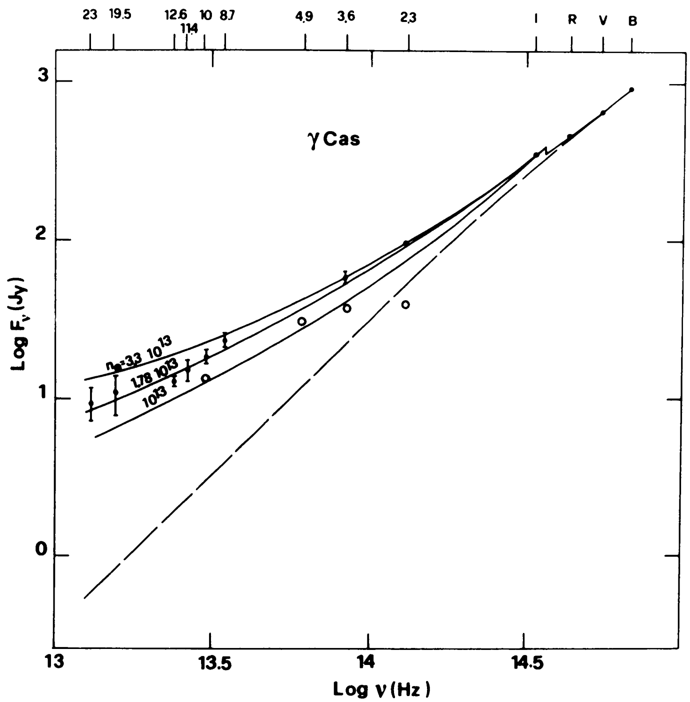

Figure 1. IR energy distribution of γ Cas.

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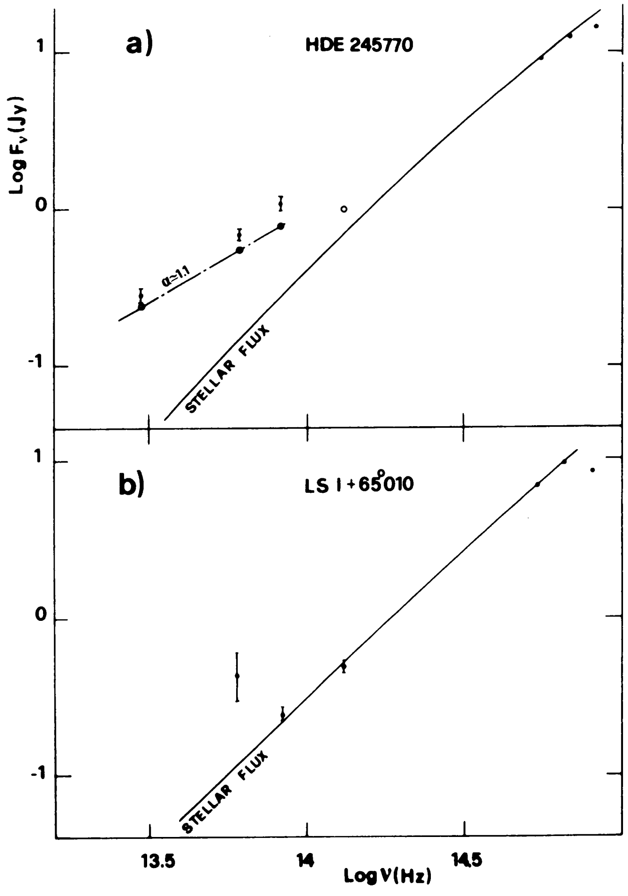

Figure 2a),b). IR energy distribution of HDE 245770 and LS I+65010.

No significative infrared variations has been found during these X-ray phases.

The IR energy distribution for our observed stars,were obtained correcting the measured magnitudes for the standard i.s. reddening law and the visual extintions reported in Table II. The continuum IR spectrum of γ Cas relative to the period 1980 Aug.-Sept.,was compared to the model described by Poeckert and Marlborough(1978).The best fit results for an electron density of the envelope $n_e(R*)=1.78\ 10^{13}cm^{-3}$. The IR excess (difference between the observed flux and the Kurucz model of the star) (open circle in the figures)shows a power spectrum law $S_\nu \propto \nu^\alpha$ between 5 and 10 microns with a spectral index $\alpha \sim 1.0$ for X Per, γ Cas and HDE 245770. This observed spectral index,different from a ff+bf spectrum with electron density $n_e \propto r^{-2}$ ($\alpha \sim 0.65$),indicates a steeper electron density law in the envelope surrounding our Be stars.

Using the spectral slope obtained by Hartmann (1978) for a thin isothermal disk, we derive $n_e \propto r^{-3.5}$ implying acceleration of the wind in the region where originates the 5 -10 microns radiation. From our measured IR excess at 10μ and using the spherical ff+bf models with a wind velocity law of the type $v(r) = v_\infty (0.01+0.99(1-R^*/r)^\beta)$ developed by Persi et al. (1980), we obtain a value of mass-loss rate for γCas, X Per and HDE 245770. These values of $\dot{M}$, reported in Table II, and obtained for an exponential velocity β =1-2, could be overestimated because of the spherical symmetry of the envelope here adopted.

Table II: Mass-Loss Rate.

Star	Log T* (K)	Log g	A_V	R* ($R_\odot$)	D (Kpc)	$S^{ff+bf}_{10\mu}$ (Jy)	V_∞ (Kms^{-1})	$\dot{M}$ ($M_\odot y^{-1}$) (10^{-7})
HDE 245770	4.48	3.5	2.31	10	1.80	0.24±0.03	300	29
γ Cas	4.40	3.5	0.31	11	0.25	15.6±2.0	860	76
X Per	4.48	4.0	1.08	5	0.35	0.34±0.06	650	4.9

The very reddened star LS I+65°010 (A_V=4.1) shows an anomalous infrared energy distribution with respect to other Be star (see Fig.2b). The flux at 5 micron could suggest the presence of dust surrounding the star. Further IR observations especially at longer wavelengths need to confirm the presence of dust in LS I +65°010.

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DISCUSSION

Poeckert: Your data tells you that there is an acceleration zone where the IR emission is produced, but you take the UV resonance lines as indicative of the absolute velocity. You can have an accelerating zone without having large velocities. Your $\dot{M}$ may be much lower.

Persi: This is a very important point. Our IR observations give us a correct value of the ratio $\dot{M}/v_\infty$, but I don't believe that our choice of the terminal velocity could strongly modify the values of $\dot{M}$.

Henrichs: The fact that your mass-loss rate value derived from the IR excess exceeds the value for UV measurements by a large factor does not surprise me. The reason is that the UV mass-loss rate value is obtained from the absorption column between the observer and the star, whereas from the IR emission you consider the projection of the whole (presumably) non-spheric envelope. Thus only in perfect spherical symmetry you would expect the same answer.

Editorial remark: See also discussion following the paper by Guarnieri et. al.

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