# CIRCUMSTELLAR DUST AROUND FU ORIONIS STARS

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It is immediately apparent from IRAS and other far infrared data (figure 1) that all known FU Orionis stars, or fuors, are associated with substantial amounts of cool circumstellar dust.

The pre-outburst magnitudes for V1057 Cyg indicate that this star was immersed in circumstellar dust already before its flare-up in 1969-1970, and hence that this dust did not - as has been claimed - appear only after the outburst; regrettably there exist no far infrared data from that time. The colours also exclude the possibility that the star then was of the alleged spectral type K0, but point to it being of a rather early type and obscured by both interstellar, local, and circumstellar matter. For details, see Welin 1985.

A number of suspected pre-fuors also show considerable cool dust emission at far infrared wavelengths. These stars have been selected by the following criteria, based on what is known for the fuors:

a) advanced T Tau-type emission line spectra superposed on (nearly) featureless continua (for V380 Ori an early type);
b) moderate light variations (amplitudes less than about 1 m.);
c) the presence of arcuate reflection nebulae;
d) position in local dark nebulae.

Exact comparisons of the relative contributions to the total radiation from the underlying stars and from the circumstellar dust are unfortunately impossible until better knowledge has been obtained of truly interstellar reddenings and extinctions, and of the influence by local dust clouds (possibly with $R_V$ values well above 3, as seems likely in the local cloud around V1057 Cyg, judging from data for the nearby star LkHα 192 given by Haro 1972). Good polarimetric, photometric, and spectroscopic data also for neighbouring stars would be valuable in order to deduce interstellar reddenings, and might furthermore aid in determining local cloud properties.

If however, as an example, the flux from the dust associated with Bretz 4 is extrapolated beyond 100 μ by assuming blackbody radiation peaking at 100 μ, this object radiates about 35 times more energy at wavelengths longer than 100 μ than in optical-near infrared wavelengths (cf. Cohen and Kuhi 1979) - and to this must be added the still stronger radiation at shorter far infrared wavelengths. Since the circumstellar



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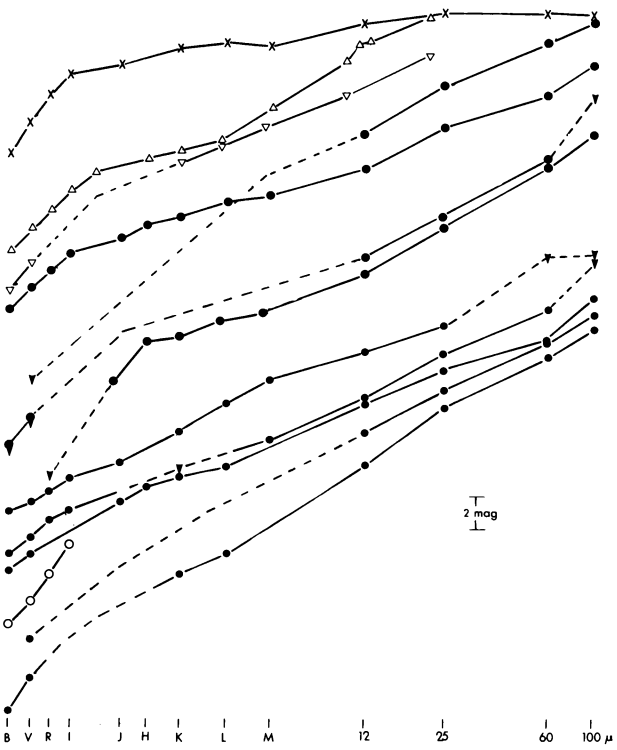


Figure 1. The distributions of optical and infrared magnitudes (from IRAS and various other sources) for: X α Ori (for comparison); V1057 Cyg Δ about 1 yr after its outburst, ∇ 11 yrs after, o before; ● other fuors, from top right downwards HH57IRS8, FU Ori, V1515 Cyg, V1735 Cyg; suggested pre-fuors V380 Ori, V1331 Cyg, V1121 Oph, RNO 33, Bretz 4. ▾ denotes uncertain magnitudes or IRAS upper limits.

dust presumably is heated by the underlying star, the total luminosity of the star must be quite high - as the distance is unknown, so is the luminosity, but Cohen's and Kuhi's data for the neighbouring star Mon R2-5a suggest a distance of about 2 kpc. This would give an optical-near infrared luminosity for Bretz 4 of 15 $L_\odot$, and a total luminosity of the order of $10^3$ $L_\odot$. The partial dispersal of circumstellar dust obscuring the star may thus give an increase in the optical brightness of the star of the same order as that observed in the known fuors.

Similarly, the existence of dust around pre-outburst V1057 Cyg, the amount of cool dust observed now, and inferences drawn from the proposed pre-fuors indicate that the luminosity of V1057 Cyg before the flare-up is likely to have been considerably higher than the often quoted 8 $L_\odot$ derived from optical data alone, and that changes in the circumstellar dust shell may have played a part in the 1969-1970 outburst.

REFERENCES

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