IRAS OBSERVATIONS of the ISM in the γ CAS REFLECTION NEBULA

Richard H. Buss Jr. Michael W. Werner

NASA Ames Research Center, Moffett Field, CA

1 Introduction

Mid-infrared emission from other galaxies originates both from interstellar grains heated by diffuse starlight and local excitation of grains by hot OB stars. Thus, a detailed examination of the *IRAS* data from a B star interacting with the interstellar medium (ISM) could provide insight into infrared (IR) emission processes in external galaxies. We have therefore used *IRAS* data to study the B0 IVe star γ Cas and its surroundings, which we find to exhibit evidence of grain heating, destruction, and possible star formation.

2 Background

γ Cas lies at a Galactic $b = -2°$ and is associated with the visual reflection/emission nebulae, IC 59 and IC 63 (Witt *et al.* 1989), and an H II region (S185) 120′ in extent. γ Cas lies (d=200 pc) at the edge of the local interstellar cavity, with little intervening dense molecular or atomic material (Paresce 1984; Jenkins, Savage, and Spitzer 1986). Recently, Witt *et al.* have detected H_2 emission in the ultraviolet and "extended red emission [ERE]" at 8000 Å from IC 63 but not from IC 59. They attribute both phenomena to ISM fluorescence excited by γ Cas.

Like other stars of its spectral type, γ Cas is known to have a strong stellar wind (Grady, Bjorkman, and Snow 1987). Moreover, γ Cas has a neutron star companion (Frontera *et al.* 1987), implying that a supernova occurred less than 10^6 years ago. Adopting a luminosity of $8 \times 10^4 L_\odot$ for γ Cas, the effective energy density of its radiation will equal that of the interstellar radiation field (8×10^{-13} ergs cm^{-3}) at a distance of 11 pc from the star, corresponding to 3 degrees at 200 pc. Thus, γ Cas should be the dominant heat source over the 2.25° ×2.25° *IRAS* image that we have studied.

3 *IRAS* Data

We have examined 2.25 × 2.25 square degree co-adds centered near γ Cas in all 4 *IRAS* wavelength bands (*e. g.* Figures 1, 2). The principal features of the data are: 1) A promi-

nent 12 and 25 μm point source at the position of γ Cas; 2) Extended emission which shows positional associations with γ Cas, IC 59, and IC 63, yet which is very bright elsewhere in the field; 3) A second point source, which lies halfway between IC 59 and IC 63, and which is extremely bright, increasing in intensity from 12 to 100 μm.

The *IRAS* energy distribution and LRS spectrum of γ Cas (*cf.* Schaeffer 1986; Coe 1986) resemble those of other Be stars and appear to be due to the combination of blackbody emission from the stellar photosphere and free-free emission from the circumstellar wind.

The extended IR emission associated with IC 59 and IC 63 shows a color temperature T(60μm/100μm) decreasing with increasing distance from γ Cas, as would be expected if it is primarily responsible for heating the radiating dust in these clouds. The energy distributions of the two nebulae, however, show slight differences that could be associated with the differing amounts of fluorescent emission found by Witt *et al.* Both show strong emission at 12 μm due to nonequilibrium radiation from tiny grains, yet the large grains radiating at longer wavelengths have T(60μm/100μm) = 55 K for IC 63 vs. T(60μm/100μm) = 45 K for IC 59. In the visible (Witt *et al.*) and the IR (Figs. 1 and 2), the two nebulae show sharp edges on the sides facing γ Cas; on other sides, the emission is diffuse (Figs. 1 and 2). This morphology suggests the nebulae are shaped by radiation pressure from γ Cas. At 60 μm (Figure 2), a bright emission region extends 10′ from γ Cas toward IC 59 and IC 63. Because T(60μm/100μm) = 60 K in this extension indicates that γ Cas is heating the large, nearby interstellar grains, the weakness of *IRAS* 12 μm (Figure 1) emission from this region adjacent to γ Cas suggests that small grains have been destroyed in — or swept out of — a 10-15′ (0.6 pc) radius region around γ Cas.

An extremely bright source (F_{60} = 108 Jy), cataloged as *IRAS* 00556+6048, appears between IC 59 and IC 63. *IRAS* 00556+6048 is not associated with any known PN, H II region, strong radio source, or near-IR bright star. Its IR colors [and possibly most of its spectrum (*cf.* Volk and Cohen 1989)] resemble those of a "red-reflection nebula" or a Herbig-Haro central star (Walker *et al.* 1989). The *IRAS* LRS (Olnon and Raimond; Beichman 1987) database spectrum for this object shows IR emission lines at 7.7, 8.6, and 11.3 μm attributed to macromolecules, as well as a Ne II 12.8 μm line on a red continuum. The spectrum resembles those of diffuse nebulae with spectra unlike those of H II regions or planetary nebulae (class 21:γ03; Cheeseman *et al.* 1989). The Palomar Sky Survey R and B prints (*cf.* Witt *et al.* 1988) show faint nebulosity within 2′ of the *IRAS* position. The nebula appears roughly elliptical on the red plate, the semimajor axis oriented east-west. We are currently investigating the nature of this object and its association (if any) with IC 59, IC 63, and γ Cas. Perhaps it is a compact, dust-embedded protostar or young stellar object induced to collapse by either the putative supernova or by the radiation pressure from Gamma Cas. In this case, ionization and excitation by γ Cas of the remnant outer fringes of the collapsing cloud might have produced the visible and ionized nebula.

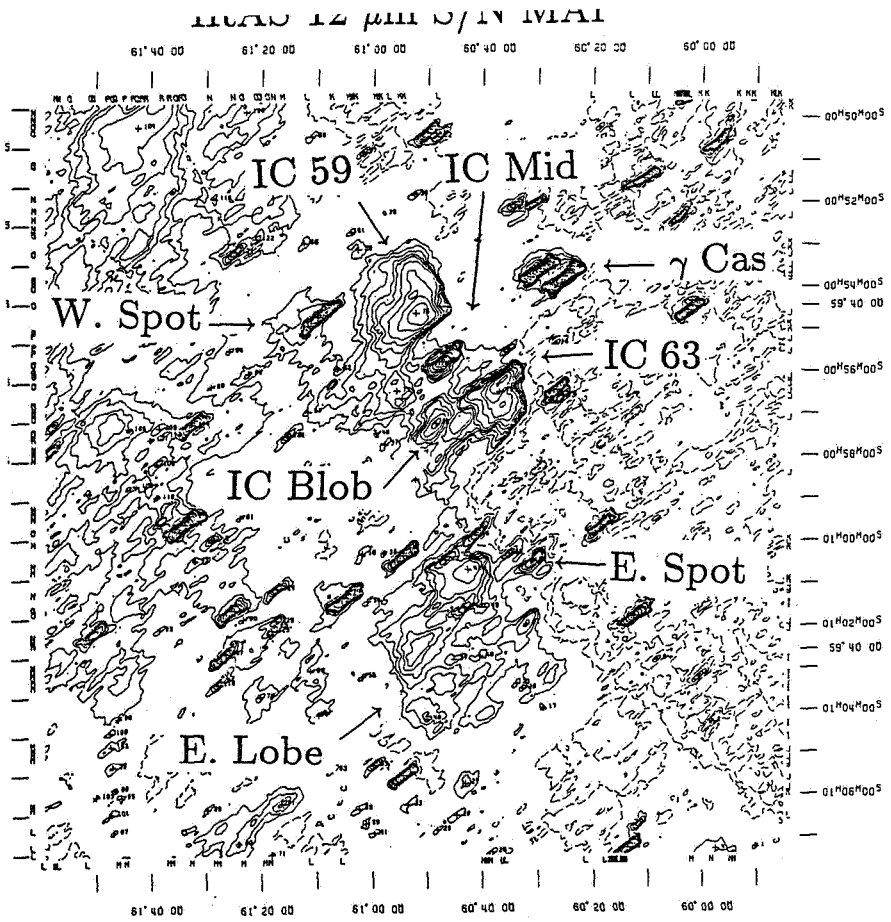

Figure 1 – The emission from IC 59 and IC 63 likely originates from intermittent photoexcitation of tiny interstellar grains by γ Cas. Note the hole of emission near γ Cas itself, showing that tiny grains have been destroyed (Maximum contour for IC 63 is 113.)

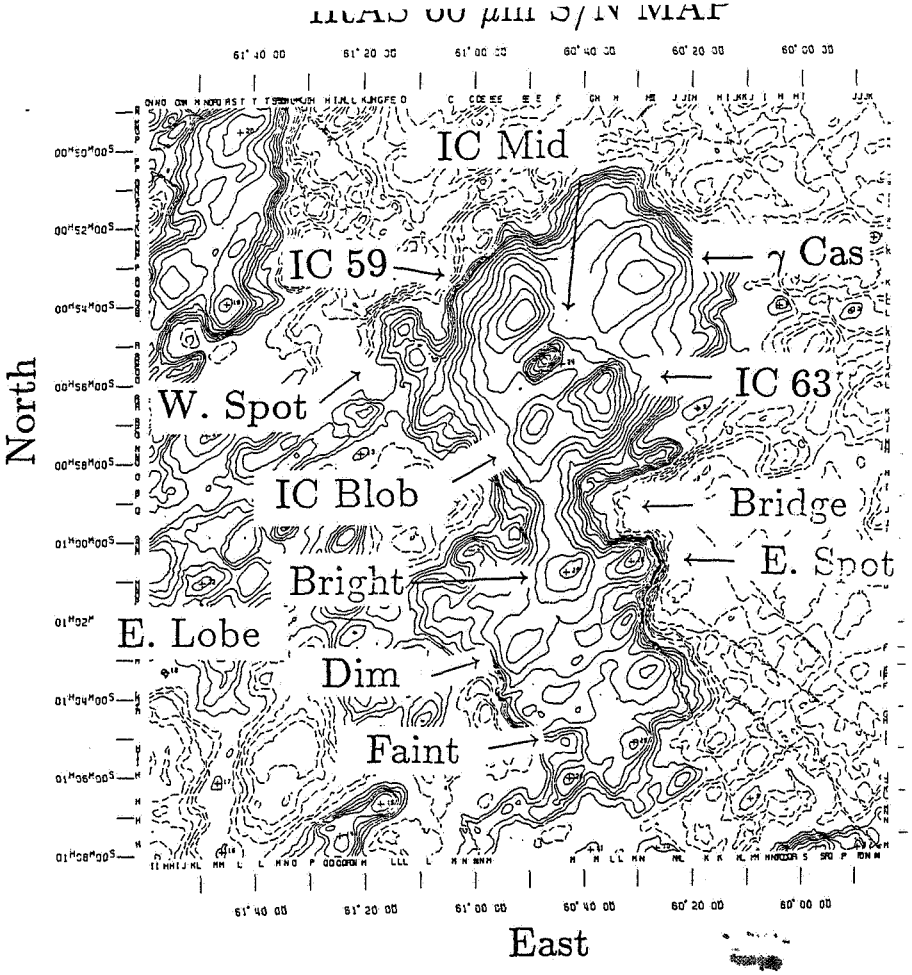

Figure 2 – The emission is highly extended, showing that an interstellar cloud is present. The mystery source, ("IC MID"), IRAS 00556+6048, is perhaps a protostar induced to collapse by γ Cas, as it lies between the IC nebulae. (Maximum contour for IC 63 is 640.)