N87-24299

IRAS Observations of Irregular Galaxies*

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Abstract

Normal irregular galaxies seem to be unusual in having vigorous star formation yet lacking the many dark nebulae typical of spirals. IRAS observations of a large sample of irregulars are used to explore the dust contents of these galaxies. Compared to normal spirals, the irregulars generally have higher L_{IR}/L_B ratios, warmer f(100)/f(60) dust color temperatures, and lower globally-averaged dust/gas ratios. The relationship between the infrared data and various global optical properties of the galaxies is discussed.

In spiral galaxies dust seems to be intimately connected with star-forming regions. In normal irregular galaxies, however, there appears to be a dearth of dark nebulae and reddenings are low relative to spirals. This is in spite of the vigorous, apparently normal, star formation often found in irregular galaxies. We present preliminary results from an investigation of the dust content of a large sample of irregulars based on IRAS (co-added survey) infrared observations at 12, 25, 60, and 100 μm (see also Hunter et al. 1986).

The irregular galaxies are divided into four groups: 1) "Dwarf"-- low surface brightness Magellanic-type irregulars, 2) "Giant"-- high surface brightness Magellanic-types, 3) "Amorphous"-- noted for their smoothness and lack of resolution into stars and clusters, and 4) "Distant"-- distant, clumpy irregulars. Systems in the first three grouups are primarily nearby, non-interacting galaxies. The distant irregulars, however, are at such large distances that morphological distinctions are more difficult and many of the systems have been found to be interacting. The galaxies in these four groups have many similar optical properties which are summarized and compared by Hunter and Gallagher (1986). For comparison with spiral galaxies we have chosen systems from Kennicutt's (1983) list of Hα observations and taken infrared data from the Cataloged Galaxies and Quasars Observed in the IRAS Survey.

In comparing the different groups of irregular galaxies, we find that the distant irregulars tend to have higher ratios of $L_{IR}/L_{H\alpha}$ and L_{IR}/L_B and somewhat warmer f(100)/f(60) dust color temperatures. However, differences in the infrared properties could be due to the fact that many of these systems are

* See erratum, page 257.

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interacting. The dwarf irregulars tend to have somewhat lower L_{IR}/L_B ratios, but otherwise the groups have fairly similar infrared properties.

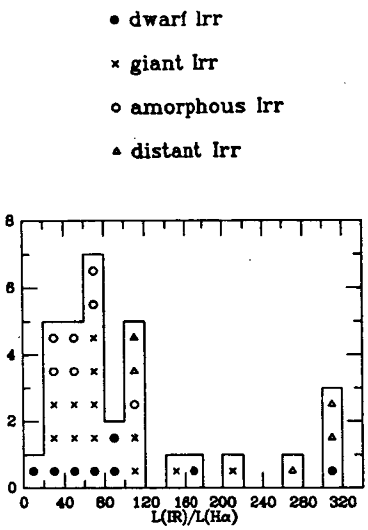


Fig. 1-Ratio of infrared to Hα luminosity of the irregulars.

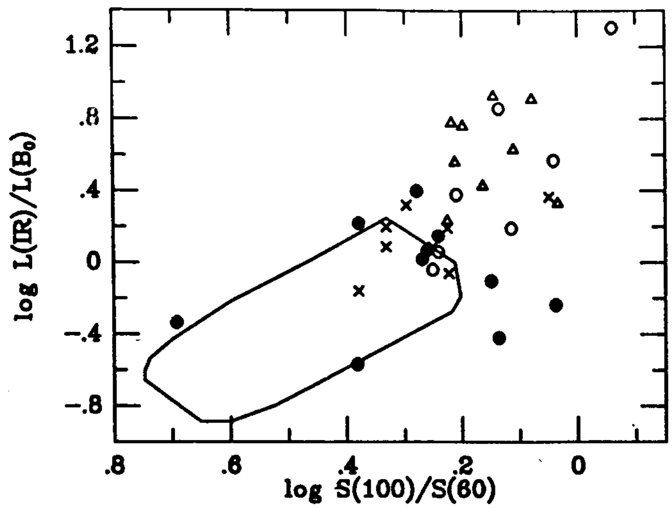


Fig. 2-The outlined region shows the area occupied by normal spiral galaxies (de Jong et al. 1984).

In a comparison of irregulars with spiral galaxies, on the other hand, there are some general differences. When irregulars are put on the plot of log L_{IR}/L_B vs. log f(100)/f(60) of de Jong et al. (1984), one finds that on average the irregulars have warmer f(100)/f(60) dust color temperatures and somewhat higher L_{IR}/L_B ratios than the spirals. However, in terms of the f(25)/f(12) dust color temperature, the spirals are on average somewhat warmer. Also, spirals generally have higher $L_{IR}/L_{H\alpha}$ ratios.

Because dust at a range of temperatures contributes to the global IRAS fluxes, the ratio f(100)/f(60) does not refer to a single temperature of the dust. However, the ratio does give an idea of the average temperature of the dust contributing to those passbands. One can then ask why this temperature-sensitive ratio varies and why irregulars are warmer in general than many spirals. One factor affecting the dust color temperature is the composition of the dust grains. One might expect that, if composition of the grains is the dominant factor affecting the overall temperature variation in the dust between galaxies, that the temperature ratio f(100)/f(60) would be correlated with the metallicity of the galaxies. Irregulars are in general more metal poor than spirals. However, a plot of f(100)/f(60) against the oxygen abundance shows that the average temperature of the dust does not depend on the metal abundance of the irregular in any simple fashion.

Dust masses have also been estimated using f(60) and a silicate model. It is important to note that the dust and gas masses are global measurements rather than measurements of individual star-forming regions; and the gas beyond the optical galaxy is not expected to contain dust that contributes to the IRAS infrared flux. Keeping this in mind, one finds that irregulars generally have lower global dust/gas ratios than spirals. Studies (Werner et al. 1978; Viallefond, Goss, and Allen 1982; Viallefond, Donas, and Goss 1983; references

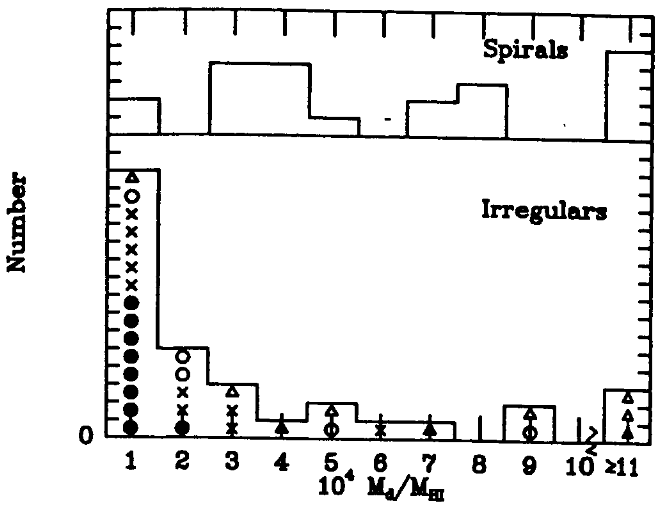


Fig. 3-The dust/hydrogen gas ratio. Dust masses have been estimated using f(60) and a silicate model. These are globally-averaged values.

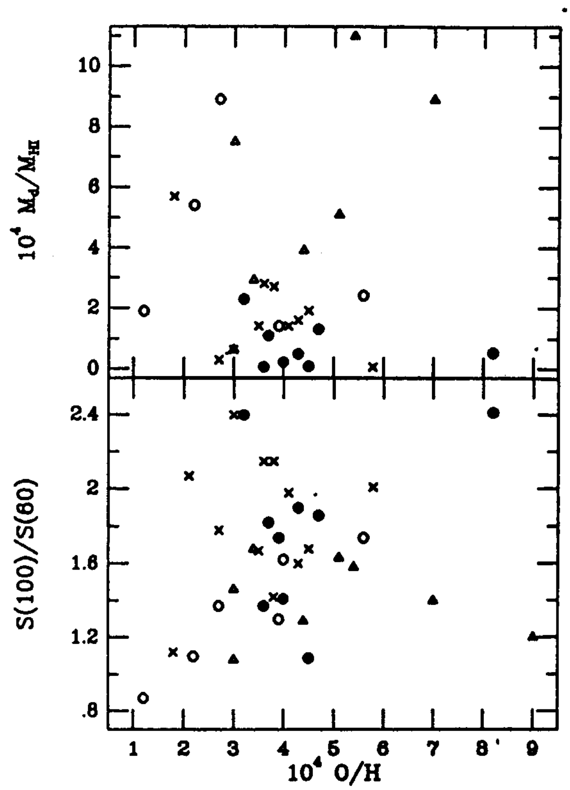
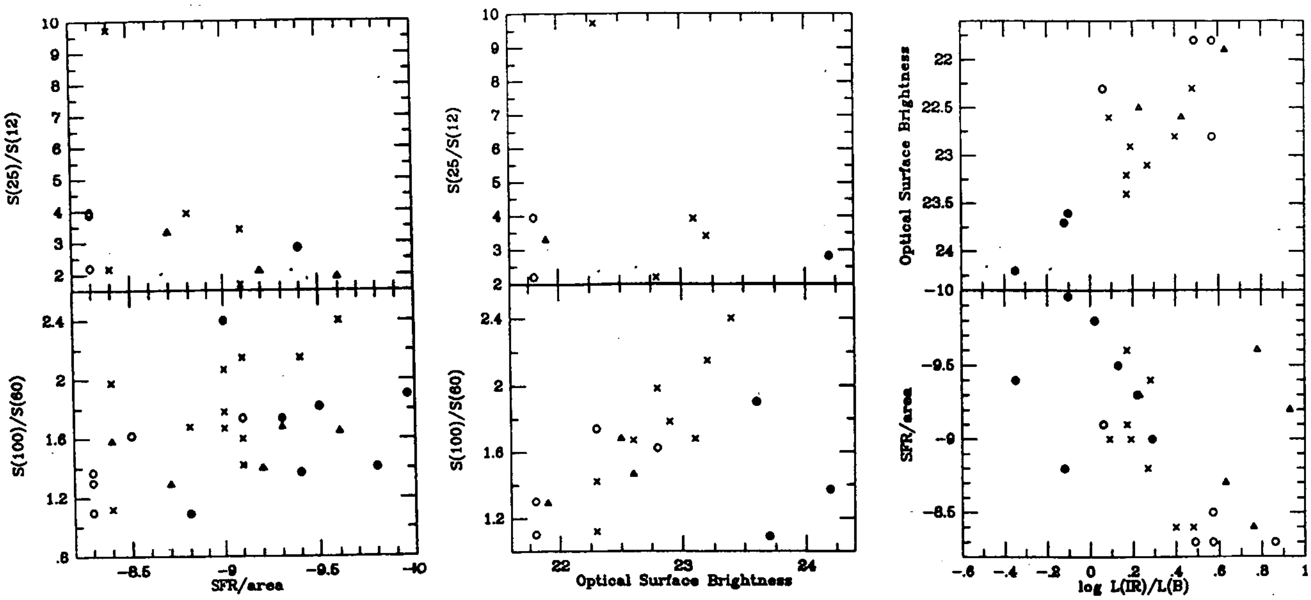


Fig. 4-Dust color temperatures and global dust/hydrogen gas ratios vs. oxygen abundance of the irregular.

in Koornneef 1984) of a few individual star-forming regions in the LMC suggest that local dust/gas ratios are also lower than regions in spirals although large optical depths due to dust can occur (Gatley et al. 1981). There is no correlation of the dust/gas ratio with the metallicity of the irregular.

Traditionally people have thought that radiation from stars in star-forming regions is responsible for heating the dust (cf. Wynn-Williams and Becklin 1974). But, with IRAS people have found that "cirrus" (Low et al. 1984) can also contribute to a galaxy's total far-IR flux. It is possible then that part of the far-IR flux of a galaxy comes from stars not connected with the current star-forming activity (see also Helou 1986; Persson and Helou, 1986). The problem in dealing with integrated fluxes of galaxies is in determining the relative contributions of these two sources.

The SFR (star formation rate)/area is a measure of the star-formation related radiation field in the galaxy, and the optical surface brightness is more a measure of the general stellar radiation field. There is no correlation between the temperature-indicators, f(25)/f(12) and f(100)/f(60), and the SFR/area although there may be a trend between f(100)/f(60) and surface brightness. There are also hints of trends of both SFR/area and surface brightness vs. L_{IR}/L_B, but they are far from clean. When spirals are added to these plots, they increase the scatter. Part of the difficulty in using these



Figs. 5,6,7-The star formation rate per unit area and the blue optical surface brightness vs. infrared properties of the galaxies.

parameters is that we are looking at local processes through global averages. In addition the irregular galaxies have formed stars at approximately constant rates, so the stellar radiation field is not independent of the current SFR and it is difficult to separate the two. (See Gallagher and Hunter, these proceedings, for a discussion of star-formation rates and histories).

We are grateful to all of the people involved in the IRAS project for an excellent infrared data base and to the people at IPAC for their assistance in extracting the data. This work is supported in part by a grant from NASA as part of the IRAS General Investigator program.

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