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RADIO CONTINUUM, FAR INFRARED AND STAR FORMATION

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A very tight correlation has been found between the radio emission and the far infrared emission from galaxies. This has been found for various samples of galaxies (de Jong et al., 1985: Helou et al., 1985) and is explained in terms of recent star formation. The tight correlation would imply that the total radio emission (the sum of thermal and synchrotron emission) is a good tracer of star formation.

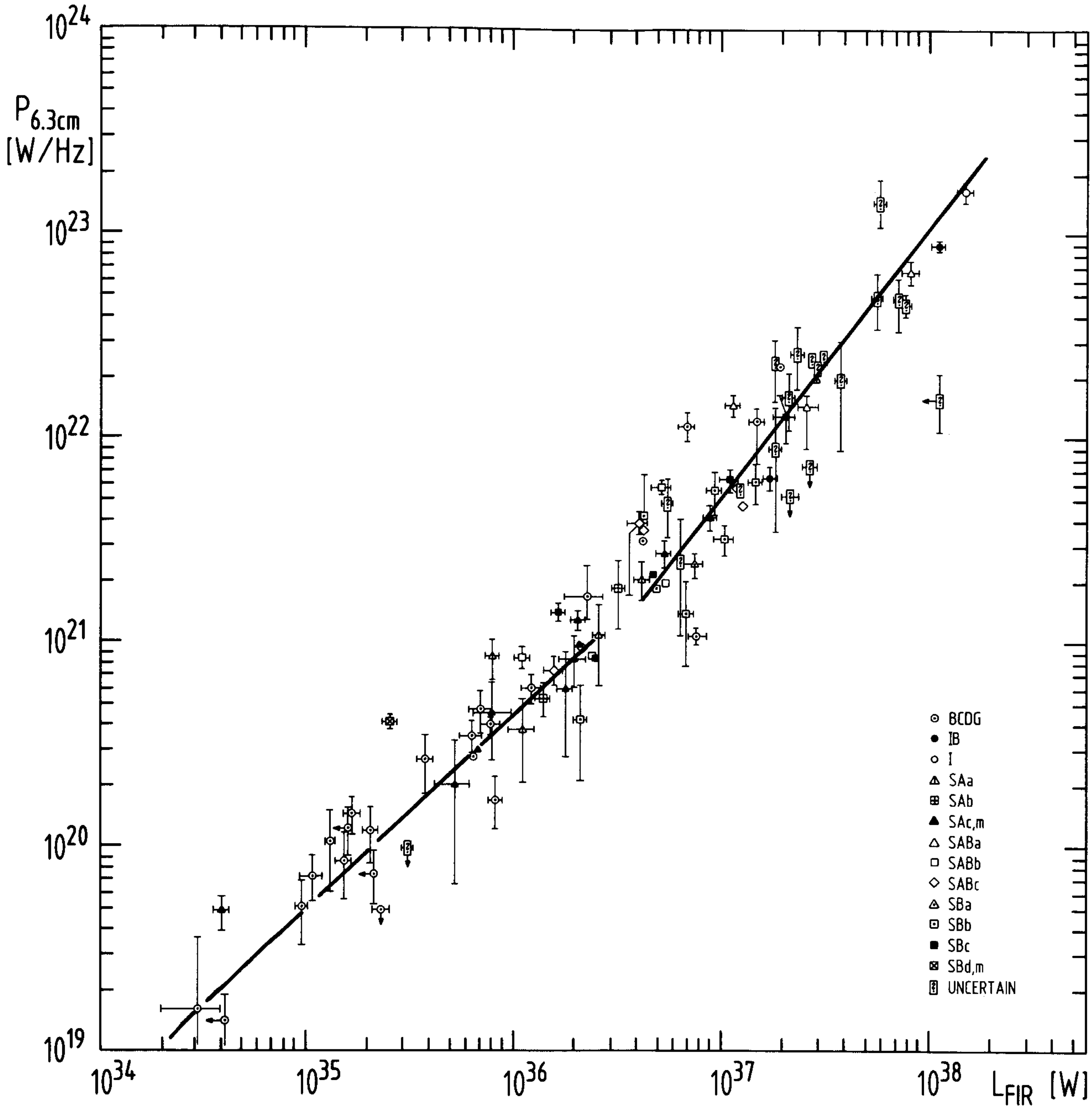
In Figure 1 we show the correlation between the radio power at 5 GHz and the far infrared luminosity. The galaxies are of various morphological types and were selected from the various IRAS circulars, hence the sample is an infrared selected sample. Noticeable is that we corrected the far infrared luminosities for the dust temperature. This turned out to be significant because it decreased the dispersion in the correlation.

As can be seen the correlation is very tight over 4 decades! There is strong evidence that the slope of the linear regression changes, in the sense that it is steeper at higher infrared luminosities ($L_{ir} > 5 \times 10^{36}$W). It could also be that the objects of the minisurvey, which preferentially occupy this region of the diagram, have a slight excess of radio emission.

The global correlation between radio power and far infrared emission is also seen in individual galaxies. Figures 2 and 3 show the distributions of the radio emission at 1.4 GHz (Haynes et al., 1986) and of the 100μm emission as observed with IRAS. This shows (as in a number of other galaxies studied in detail) an almost exact coincidence of the two kinds of emission. Note however that most of the radio background sources are not visible at 100μm.

It turned out that the brightest regions in the radio continuum and at 100μm are related to HII regions. There the radio emission is dominated by thermal emission as is indicated by the flat radio spectra. In the far infrared these regions show the highest temperature ($T_\alpha \sim 40°$). The more extended component is dominated by radio emission due to the synchrotron mechanism and by far infrared emission from cooler dust ($T_\alpha \sim 20°$). The heating mechanism for this hot dust and cooler dust is probably different. The hot dust is heated by the radiation from hot, young stars, while the cooler dust can be heated by the interstellar radiation field (Cox et al., 1986). These different heating mechanisms have to be considered when relating the radio continuum emission (in particular the nonthermal component) to star formation.

The separation between the nonthermal component and the thermal component, which is possible locally for individual galaxies, is in principle also possible for the integrated radio emission from galaxies. Assuming a nonthermal spectral


10^{24}
$P_{6.3cm}$ [W/Hz]
10^{23}
10^{22}
10^{21}
10^{20}
10^{19}
10^{34}
10^{35}
10^{36}
10^{37}
10^{38}
L_{FIR} [W]
BCDG
IB
I
SAa
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SAc,m
SABa
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SBa
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Figure 1

Figure 2

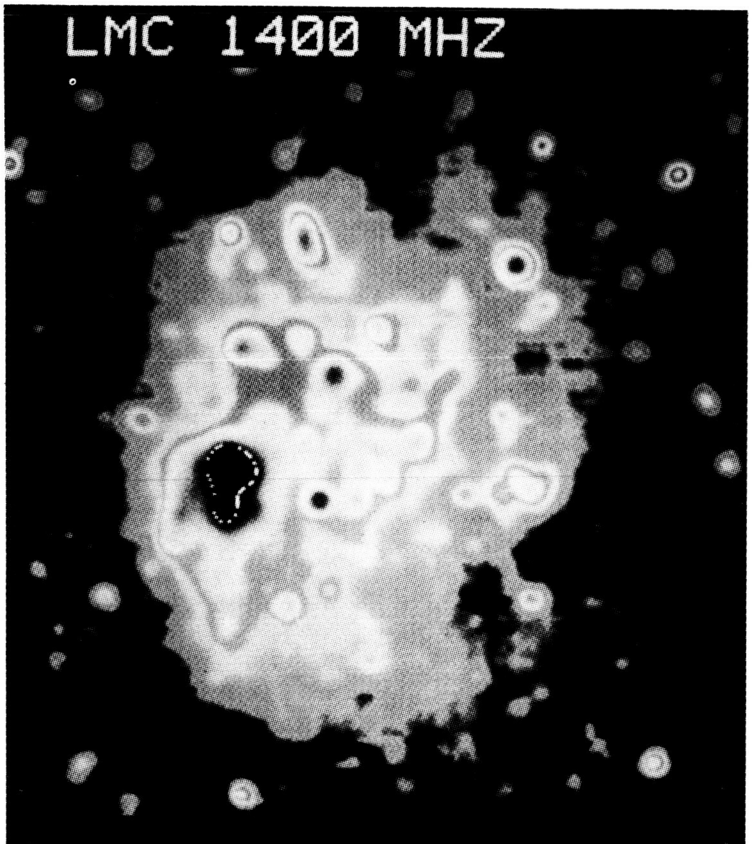
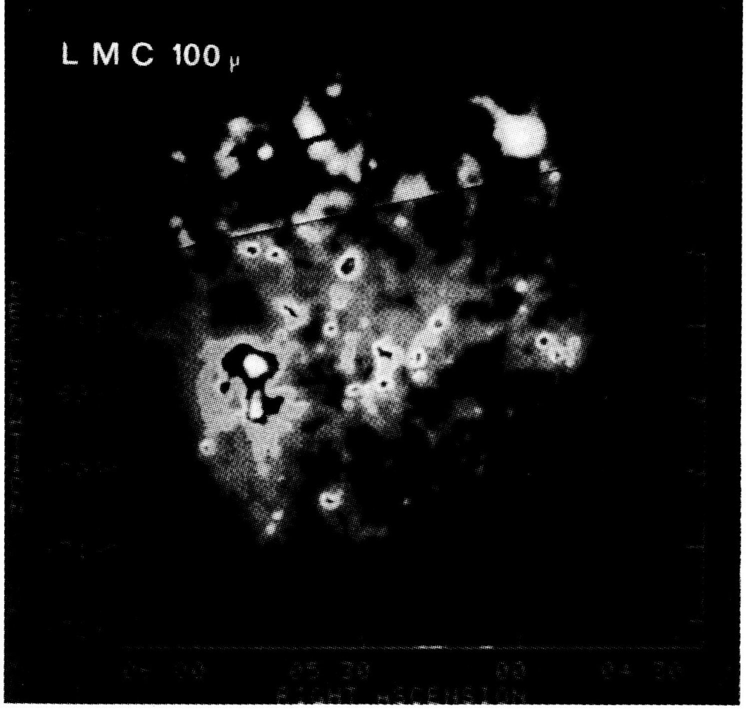
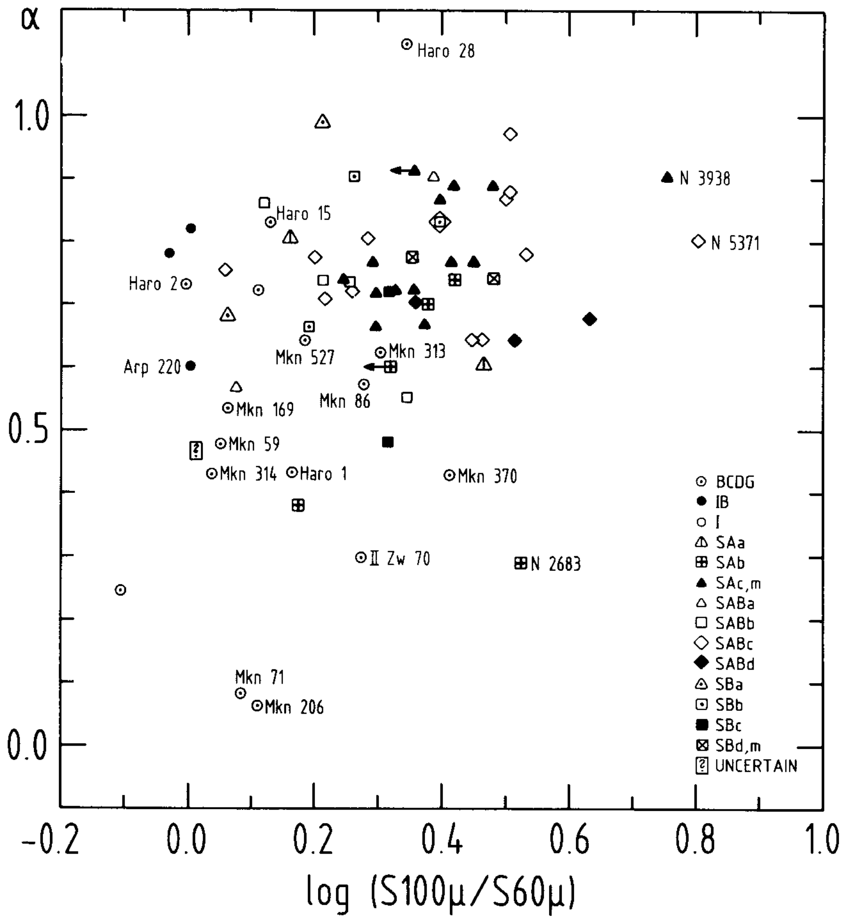


Figure 3



index, the observed spectral index could be a measure of the thermal fraction. As seen before, the thermal fraction is expected to correlate with hot dust. In this simplistic view one would expect a correlation between the observed radio spectral index (α) and the far infrared spectral index ($\log(S_{100\mu m}/S_{60\mu m})$), which is a measure of the dust temperature.



In Figure 4 we show this diagram for the far infrared selected sample. There is no obvious correlation. This can have several causes:

- Up to frequencies of 5 GHz the thermal fraction is in general still not dominating the total radio emission from spiral galaxies.
- The spectral index for the nonthermal component is not known exactly and can in fact, in particular for galaxies in an active star-forming phase, vary from galaxy to galaxy. Note that SNR usually have a relatively flat spectrum ($\alpha \cong 0.5$) compared to the spectra of galaxies. Low frequency ($\nu <$ 1.5 GHz) and high frequency ($\nu >$ 10 GHz) measurements are needed to accurately determine the thermal fraction.

We conclude:

i) The thermal radio component is a good tracer of star formation. It is related to the hot dust component.

ii) The coupling between star formation and the nonthermal component is less direct, perhaps mainly due to the relatively long confinement time of cosmic rays and to diffusion of cosmic rays.

iii) The nonthermal component probably contains information on the star forming history of galaxies over a time scale of $\sim 10^8$ yr (see Hummel, 1986: poster by Klein and Wunderlich).

iv) A correlation between the thermal fraction of the radio emission and the dust temperature is expected but not yet visible here because the spectral index is not an accurate enough measure of the thermal fraction.

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