CENTRAL RADIO SOURCES IN GALAXIES

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From radio continuum observations it is known that the central regions of galaxies can be an important source of cosmic rays, in particular relativistic electrons. In order to get some insight in the properties of the central sources and their dependence on optical properties, especially morphological type, a large sample of galaxies ($\sim$ 400) was observed with the Westerbork Synthesis Radio Telescope at 1.4 GHz. The sample definitions, observations, reduction, survey characteristics and the analysis of the data are given in Hummel (1980, 1980a). Here we will concentrate on the results obtained for the central sources (< 20").

The observational results can be summarized as follows:

i) The distribution of the spectral index[1] for elliptical and lenticular galaxies has a median of $\alpha = -0.1$, indicating compact, nuclear sources. Central sources in spirals have a steeper spectrum ($\alpha \simeq -0.7$) and usually have rather complex structures.

ii) The central sources in ellipticals and early type spirals are at 1.4 GHz a factor 10 stronger than those in lenticulars. 10% of <u>all</u> the early type spirals, SO/a, Sa, Sab, have log P $\geqslant$ 21.6 WHz^{-1}.

iii) For the spiral galaxies there is <u>on average</u> a linear proportionality between the radio power of the central source and the <u>total</u> optical luminosity, but there is certainly no one to one correlation.

iv) The median radio power of the central sources in spirals decreases by a factor 10 from early type spirals (SO/a, Sa, Sab) to late type spirals (Scd, Sd, Sdm, Sm).

v) Central sources in barred spirals are on average a factor 2 stronger than those in non-barred spirals. About 10% of <u>all</u> barred spirals have log P $\geqslant$ 21.2 WHz^{-1}.

vi) The central sources in interacting spiral galaxies are on average a factor 2 to 3 stronger than those in isolated spiral galaxies. 10% of <u>all</u> interacting galaxies have log P $\geqslant$ 21.3 WHz^{-1}.

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[1] spectral index α defined by $S(:)\nu^{\alpha}$

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The higher radio power of the central sources in ellipticals compared to lenticulars suggests that the radio power of a compact, nuclear source is related to the mass and the rotation of the bulge component. This agrees with the fact that spirals in general do not have compact nuclear sources which are stronger than those in lenticulars (Hummel and Kotanyi, 1980). Also the change in radio power of the central sources in spirals with morphological type indicates that central sources are related to the mass distribution. Spirals which have the more centrally concentrated mass distribution (early type spirals, barred spirals), as inferred from studies of the dynamics of spirals (Roberts, 1978, Rubin et al. 1978) and from the light distribution, have on average stronger central sources.

Steep spectrum central sources are rarely detected in lenticular galaxies (Hummel and Kotanyi, 1980) but these sources are very common in spirals. The much lower gas content in lenticulars compared to spirals suggests that the gas content has some influence on the occurrence of these steep spectrum central sources. For spirals it is known that the gas content increases with morphological type (Roberts, 1975, Shostak, 1978) while the radio power of the central sources decreases. This suggests that there is a threshold in the gas content below which no central source can be maintained and above which there is hardly any dependence of the steep spectrum central sources on gas content.

The enhanced radio emission from the central sources in barred spirals might be (partly) related to non-circular motions of the gas in the region of the bar and the shocks induced by this. The kinematics of the gas may also be of importance to explain the enhanced emission in the interacting spiral galaxies. The stronger central sources in interacting galaxies can be explained by the gravitational interaction or by possible differences in initial conditions at the formation of double systems. Since there is a trend indicating that the central sources get stronger when the distance between the galaxies of a pair decreases (Hummel, 1980, Stocke, 1978) and since central sources in general are short lived phenomena we favour the gravitational interaction hypothesis. Several authors (cf. Condon and Dressel, 1978) have proposed that due to the interaction matter is falling toward the central region and this activates the central source. However, here the main question is whether the infalling matter can lose its angular momentum fast enough (cf. Gunn, 1979).

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