THE MAGNETIC-FIELD STRUCTURE AND DYNAMICS OF NGC 253

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ABSTRACT

Total-power and polarization observations of NGC 253 at 10.7 GHz have been performed with the 100-m MPIfR radio telescope. The observed arm/interarm polarization contrasts are discussed in the context of possible field configurations in spiral arms.

1. THE OBSERVATIONAL DATA

The nearly edge-on SABc galaxy NGC 253 was studied at 10.7 GHz with the 100-m MPIfR radio telescope. High-sensitivity total-power and polarization maps with a resolution of 1.2 arcmin have been obtained. Three components of the radio-continuum emission have been observed: the completely unpolarized, barely resolved central source, the high-brightness plateau associated with the brightest parts of the spiral structure, and the weak outer disk. Although the high inclination of $78^{\circ}\!.5$ made some details of the plateau difficult to resolve with our beam, the existence of a bright, weakly polarized radio bar seems unquestionable. Extensions along the inner spiral arms producing most of the polarized flux are also clearly visible.

The highest polarization, reaching 50 percent after correction for the thermal flux, has been observed close to tracers of a spiral shock in the NW arm. The integrated nonthermal emission from the disk of NGC 253 is however only 14 percent polarized. An even lower degree of polarization is expected in the interarm region and in the outer disk.

2. IMPLICATIONS FOR THE FIELD STRUCTURE

Depolarization effects at 10.7 GHz were found to be small. It is thus likely that the observed polarization contrast between the spiral

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arms and the remaining part of the disk represents true changes in the field structure. Due to the high inclination of NGC 253 that contrast would imply differences in the relative strength of the vertical component of the random magnetic field. The ratio of the vertical component to the total field, $\langle B_z\rangle/\langle B_t\rangle$, in a fully isotropic three-dimensional field is about 0.57. Computer simulations of the radiation from random fields showed that a value $\langle B_z\rangle/\langle B_t\rangle = 0.5$ is needed to account for a polarization as low as 14 percent. This ratio is likely to be even higher in the interarm region. The B_z component seems to be significantly suppressed in spiral arms where $\langle B_z\rangle/\langle B_t\rangle$ drops to about 0.2.

The formation of a rather flat arm field from the nearly isotropic interarm field is difficult to explain within the framework of pure hydrodynamic shocks allowing no significant compression along the z-axis (Tubbs, 1980; Soukup and Yuan, 1981). Models involving the development of pure Parker instabilities (Parker, 1966; Mouschovias et al., 1974) poorly explain the dramatic polarization increase in the spiral arms, unless we assume a significant change of properties of the instability in compressed regions. The upward migration of cosmic-ray electrons as needed for the formation of a "thick disk", perhaps efficient in weakly polarized interarm regions, must be in some way inhibited in spiral shocks. Such a condition is necessary to avoid too intense emission from highly inclined parts of the field structure, which would give too high an observed B_z in the spiral arms. A significant change in the nature of the instability itself in shocked regions cannot be excluded either (Elmegreen, 1982). Detailed models of radio emission from various types of curved Parker-type structures are now in preparation.

REFERENCES

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DISCUSSION

G.D. van Albada: What is the reason to include B_z? You can probably depolarize the radiation by just having a random field in the plane?

Urbanik: Not for that inclination angle of 78°5! Because for a completely random field in the plane you would still have 65% polarization everywhere. And depolarization by Faraday effect is completely insignificant: the maximum depolarization we could get for very extreme assumptions is of order 0.7.