THE MAGNETIC FIELD OF M 51

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We present observations of the polarized emission and the derived magnetic field structure of the spiral galaxy M 51 at different wavelengths: 2.8 cm, 6.2 cm, 18 and 20.5 cm.

1. Polarized Emission

The λ 2.8 cm observation (a) shows a rather patchy structure. The main emission in the eastern and in the south–western parts is roughly confined to the optical size of the galaxy. The pattern changes to a four–armed spiral at the higher resolution of the λ 6.2 cm observation (b). At λ 20 cm only a smooth disk remains which extends beyond the optical disk (c).

A weak depression of the λ 2.8 cm map (a) between the inner and the outer eastern spiral arm coincides with the very abrupt boundary of the polarized emission observed at λ 6.2 cm (b) and also with the hole observed at λ 20.5 cm (c). (At λ 6.2 cm even the total emission shows an extended local minimum.) Its optical counterpart is the peculiar straight part of the arm in the eastern part of the galaxy. The whole region remains polarized at λ 2.8 cm; this means that the long–wavelength images are strongly affected by Faraday depolarization. The strong depolarization cannot be due to enhanced thermal gas density or field strength but indicates a bending of field lines out of the disk — an effect also observed in other galaxies like M 83 and NGC 6946.

In other parts of M 51 depolarization is weaker but still significant so that at long wavelengths only a part of the radio disk is visible in polarized intensity.

2. Magnetic Field Structure

Due to the low rotation measure and to the short wavelength the measured B–vectors at λ 2.8 cm (a) and λ 6.2 cm (b) represent the intrinsic magnetic field within a few degrees, whereas the vectors at longer wavelengths need to be corrected for Faraday rotation. Additionally, the different measurements do not have the same Faraday depth which must be kept in mind when comparing the images: (c) shows the field lines of a thin layer of the radio disk only. The Faraday depth is not constant, thus the thickness of this layer varies over the galactic disk. This causes the differences in the orientations of the field lines between Figs. (a)/(b) on the one hand and (c) on the other.

The correspondence between the optical picture (which refers to the spiral density wave in general together with local disturbances) and the intrinsic magnetic field pattern as seen at λ 2.8 cm is striking, even on small scales. This holds even better at the high resolution of the λ 6.2 cm observations. The orientation of the

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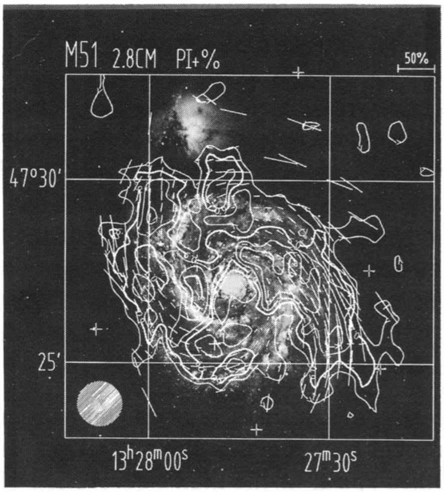

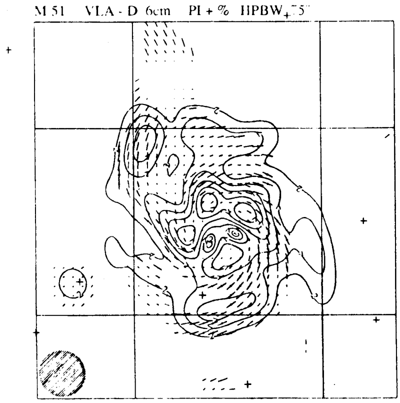

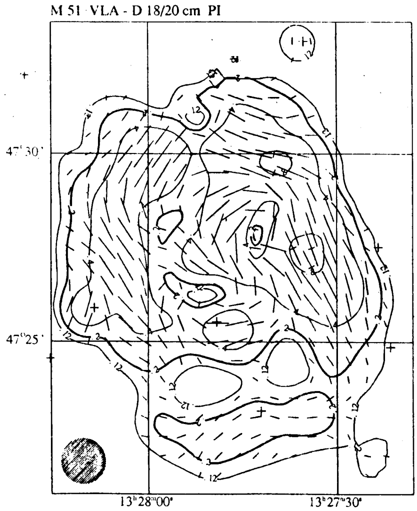

a) Polarized Intensity at λ 2.8 cm. The vectors (obtained by rotating the **E**–vectors by 90°) indicate the orientation of the **B**–field within a few degrees, the length being proportional to the degree of polarization.
b) Polarized Intensity at λ 6.2 cm shown in the same way as above.
c) Polarized Intensity at λ 20.5 cm. The vectors indicate the orientation of the **B**–field as derived from measurements at $\lambda\lambda$ 18.0 cm and 20.5 cm, the length being proportional to the polarized intensity. Note the angle differences between Figs. a/b and c which indicate the varying Faraday depth.

magnetic field also follows peculiar structures of the spiral arms such as straight parts, bifurcations and kinks. Note that the spiral structure of the magnetic field can be traced into the very center. A close examination shows a good coincidence between the field orientation in the center of M 51 and the orientation of the central molecular bar. This resembles the behaviour of the magnetic field in the barred galaxy M 83. Thus, the non–axisymmetric structure of the magnetic field in the center is just the "synchrotron counterpart" to the optical structure.

References

Horellou, C., Beck, R., Berkhuijsen, E.M., Krause, M., Klein, U.: 1992, *A & A* **265**, 417
Neininger, N.: 1992, *A & A* **263**, 30

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