Abstract

With a distance of only 750 kpc (2.5 million light years), the Andromeda galaxy (M31) is the nearest grand spiral galaxy. Its proximity allows us to reach spatial resolutions in the galaxy of less than a kiloparsec with single dish observations, which in other galaxies can only be achieved with interferometers.

It is thus no surprise that M31 was one of the first external spiral galaxies, from which polarized radio emission was detected. Most of the radio continuum emission is synchrotron emission, which originates from cosmic ray electrons that spiral around the interstellar magnetic field lines. Already early analysis of the polarized emission has shown, that the turbulent and large-scale magnetic field is concentrated in a ring-like structure at 10 kpc radius. This "ring" is a superposition of several spiral arms with small pitch angles, seen under a high inclination. Faraday rotation measures (RM) showed that the regular field of M31 is coherent, i.e. it preserves its direction around 360° in azimuth and across several kiloparsecs in radius.

The presence of a regular field over such long distances can be explained by galactic dynamo theory. However, the structure of the M31's large-scale magnetic field is unusually simple. An almost purely axisymmetric field is not known from any other spiral galaxy.

The aim of this work is to provide new clues to the understanding of M31's magnetic field structure, by utilizing new methods for data analysis, better resolutions and higher sensitivities than ever before, and by advancing into new wavelength regimes: Observations of the highest and lowest frequencies of any M31 radio continuum polarization survey are presented. The λ3.6 cm survey is still ongoing, but a preliminary map is shown.

At λ92 cm the first detection of polarization in a nearby galaxy at $\lambda > 22$ cm (factor 4 increase in wavelength) is shown. The results are consistent with current depolarization models.

A catalogue of the detected polarized background sources at 92 cm is given, and the analysis of these sources reveals that their internal structure is important. Classification and selection is needed for future observations with LOFAR in order to use a grid of polarized background sources to probe magnetic fields in the foreground.

The new RM Synthesis method (Brentjens & de Bruyn 2005) was employed for the analysis. It was developed with modern telescopes in mind, which provide a large bandwidth divided into hundreds of channels. I also show, how this method can also be applied to old existing data.

The extended 6 cm survey represents the deepest polarization map of an external

galaxy ever observed with the Effelsberg telescope. Weak polarized emission is detected far away from the disk, much further than what is known from previous surveys.
With the high resolution multi-frequency polarization study of M31's central region, it was possible to uncover the full three-dimensional structure of the innermost 0.7 kpc. The results are in good agreement with the model of a quadrupole axisymmetric spiral field by Braun et al. (2010). However, the direction of the magnetic field is opposite to the known field direction in the outer ring. The inner and outer fields are thus independent from each other, which was already predicted by Ruzmaikin & Shukurov (1981).
Full page colour representations of the Effelsberg maps and the full WSRT field as well as Faraday spectra of all polarized background sources detected at 92 cm can be found in the Appendix.