Polarisation in Radio Astronomy: techniques of measurement, history and present status **Richard Wielebinski** Max-Planck-Institut für Radioastronomie, Bonn

Maxwell's equations imply polarisation of electromagnetic waves



first transmitter and receiver

Heinrich Hertz

Showed the importance of

POLARISATION

in his experiments

Dipoles have to be aligned!



Radio emission at m and cm wavelengths comes from synchrotron process Synchrotron emission is polarised We see vectors normal to the magnetic field

Solar radio polarisation was discovered in 1946 already **Polarisation of Jupiter followed** in late 1950s Radio polarisation of Crab nebula was found in 1957 Polarisation of radio galaxies and the Milky Way followed in 1962

How do we measure polarisation?

Dipoles are at the heart of measurement Crossed dipoles give us V⁰ and V⁹⁰ At higher frequencies waveguides are used as feeds TE₁₁ mode is basic Careful design of feed is essential Multimode feeds can be optimized for polarisation

The 408 MHz +11cm prime focus feed



Crossed dipole feed for 21cm horn



Secondary focus feed

PRESEL

Prime focus feed

MP/17

Receivers circuits











Analogue polarimeter circuits

IF polarimeter





8 channel polarimeter

Polarimeters (analogue)

8 channel polarimeter

Polarimeter 2 GHz bandwidth







Digital polarimeters





Digital polarimeter (Wolleben et al. 2010)





Supernova remnants are polarised





Young SNRs show in general radial magnetic Field, old SNRs have Tangential field



Polarisation of radio galaxies first detection in 1962 (delay due to Faraday depolarisation)





Cygnus A Baker et al. 1975

Centaurus A Cooper et al. 1967



Ionospheric Faraday rotation Wielebinski & Shakeshaft 1962





Galactic Faraday rotation Muller et al. 1963 \rightarrow



Fig. 2. Intensities and position angles of the polarized radiation at both 610 Mc/s and 408 Me/s





g, a

Spoelstra 1984 derives RM





Predicted in radio by Bolton & Wild 1957

Finally discovered in radio by Verschuur,1968





Radio polarisation observations of galaxies 1970s



Mathewson et al.1972

Beck, Berkhuijsen, Wielebinski, 1978

Pulsar polarisation

Pulsars were discovered in Cambridge in 1968 by Hewish et al.

Soon after discovery it was shown that pulsars were highly polarised, especially at low radio frequencies



Lyne & Smith, 1968



Manchester, 1971

Polarisation is a very important parameter, so far underestimated, mainly because of technical difficulties

There has been great progress in recent years!!

All sky catalogue of source RM Simard-Normandin & Kronberg 1980





SP: b=-90°

RM northern sky, Taylor et al. 2011

RM of pulsars and EGRS in the direction of the Galactic centre Brown et al. 2007

The magnitude of the RM and the direction agree – this must mean that RM is local!

1.4 GHz Polarization Survey

Wolleben, Reich, W.& P., Landecker, Testori, Wielebinski 2006

Uyaniker et al. 1999 begin the Effelsberg Medium Latitude Survey at 21cm

Wieringa et al. 1993 show that there is fine structure in polarisation

<u>Sino – German 6cm survey; Han, Reich et al.</u>

The DRAO – Effelsberg 21 cm survey; Landecker et al. 2010

<u>Multifrequency polarisation of pulsars</u> Karastergiou et al.

Radio polarisation of galaxies

M31 6cm Total Intensity + Magnetic Field (Effelsberg)

Copyright: MPIfR Bonn (R.Beck, E.M.Berkhuijsen & P.Hoernes)

Copyright: MPIfR Bonn (M.Krause & M.Dumke)

6cm Total Int. + B-Vectors (VLA+Effelsberg)

Copyright: MPIfR Bonn (R.Beck, C.Horellou & N.Neininger)

A combination of Effelsberg and VLA Gives the best Results at present

Fletcher, Beck, et al.

Fornax A

Cyg A

Polarisation of Radio galaxies

Courtesy of NRAO

The next generation of telescopes: ALMA, Lofar, SKA should give great opportunities to extend polarisation studies But polarimeters must be implemented!

Thank you!!!

Optical polarisation

At first optical astronomers interpreted polarisation as a scattering effect

Only later it was accepted that dust aligned in magnetic field is the cause of polarisation

Optical polarization observations Milky Way 1949 ; galaxies in 1958

Hiltner, (1951)

Hiltner, (1958)

Mathewson & Ford, 1970

