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# Observing Interstellar and Intergalactic Magnetic Fields

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A variety of approaches are used to investigate the interstellar and intergalactic magnetic fields. Some are based on magnetic effects on radiation processes, including Zeeman splitting of emission lines from clouds or clumps, polarized thermal emission from aligned dust grains in magnetized clouds, and diffuse radio synchrotron emission from relativistic electrons in magnetic fields in the diffuse medium. The others stem from magnetic effects on the propagation of radiation in the intervening medium, such as starlight polarization due to selective extinction by magnetically aligned dust grains, Zeeman splitting of absorption lines from foreground magnetized clouds, and Faraday rotation of linearly polarized emission in a magnetized medium.

Magnetic fields have been observed in extended diffuse Galactic interstellar objects, such as supernova remnants, HII regions and bubbles, and interstellar filaments. The field strengths and orientations can be partly derived from available observations, e.g., from starlight polarization, polarized thermal dust emission, polarized synchrotron emission, and Faraday rotation.

As best revealed by RMs of pulsars and background radio sources, magnetic fields in the Galactic disk of the Milky Way have a strength of a few $\mu$G. Coherent directions follow the spiral arms, but reverse directions go from arm to interarm regions although the transition longitudes are not yet well determined. The azimuthal fields in the Galactic halo reverse their directions above and below the Galactic plane, but the field scale-height and scale-radius are not known yet.

The orientation of magnetic fields in nearby spiral galaxies follows the spiral arms as shown by starlight polarization and polarized synchrotron emission. Faraday RMs give hints for possible magnetic field onfigurations in only a few galaxies.

Magnetic fields in the intracluster medium are revealed by radio halos and relics and RMs of background and embedded sources. The polarized relic emission indicates compressed anisotropic turbulent fields in the shock regions.

The existence of magnetic fields in the intergalactic medium and the cosmic web is indicated by radio synchrotron emission, though evidence is sparse.

Future observations should aim at the 3D tomography of the large-scale coherent magnetic fields in our Galaxy and nearby galaxies, a better description of intracluster field properties, and firm detections of intergalactic magnetic fields in the cosmic web.

**References**

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