Toy model attempt for LOFAR depolarisation canals

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Abstract

MHD turbulence simulations (Richard et al. 2022) show distinct dissipation sheets where the magnetic field changes orientation abruptly. We started to investigate what signature these sheets could have in LOFAR observations by implementing an oversimplistic model. We assume that the density of thermal and relativistic electrons is uniform and prescribe a magnetic field configuration where field lines spiral around a given axis. The direction of the magnetic field changes sign abruptly on a cylindrical surface, to mimic a current sheet which would be curved in one direction. We then observe this scene at an angle with respect the axis of this cylinder. Finally, we synthethise the polarised emission as seen from LOFAR as a function of the distance to the cylinder axis. We take into account synchrotron emission and its Faraday rotation.

For well defined values for the angle of observation and for the spiraling angle of the field lines, we find that there can be a dip in the maximum polarised emission received by LOFAR, at a location close the edge of the cylinder which would hence be seen as a depolarisation canal. We analyse in details how such a dip can be produced, and we propose that other curved structures such as magnetised shocks or rotational discontinuities may also in some cases be responsible for local polarisation deficits. The straightness of the canals and the homogeneity of the canals alongt their length would however be hard to explain unless MHD turbulence favours nearly cylindrical dissipation structures.

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