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Polarised emission from aligned dust grains in nearby galaxies

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Non-spherical interstellar dust grains that are immersed in a magnetic field are expected to align with this field. The far-infrared (FIR) thermal emission of non-spherical grains is polarised along the longest axis of the grains. Combined, these two effects make polarised dust emission a powerful tool to study magnetic field configurations in environments where we expect a sufficiently strong alignment of the grains, like the interstellar medium in nearby galaxies. This was an important driver for the proposed B-BOP polarimeter that was part of the late SPICA mission design. In the absence of SPICA, FIR polarisation measurements can still be performed with a number of alternative instruments, including the HAWC+ polarimeter aboard SOFIA, albeit with a much reduced signal to noise ratio. To link FIR observations of nearby galaxies to theoretical predictions of galactic magnetic field configurations from magnetic dynamo theory, a forward modelling framework is required that converts a model prediction into a FIR polarisation image. We computed new optical emission coefficients for a mixture of spheroidal dust grains using our own Python module CosTuuM (Vandenbroucke, Baes & Camps, 2020) and added these to the radiative transfer code SKIRT (https://skirt.ugent.be/) to create such a framework. We applied our new framework to the Auriga galaxies (Grand et al., 2017), a set of Milky Way like galaxy simulations that include a treatment of the interstellar magnetic field. We constrained our dust model parameters by comparing all sky polarisation maps with the Planck 353 GHz observations of the Milky Way. Using the same model, we then generated synthetic images for nearby galaxies spanning a number of broad band ranges, including the HAWC+, SCUBA2, ALMA and B-BOP bands. We find a maximum observable linear polarisation fraction of 10% for face-on galaxies, which reduces to 3% for edge-on galaxies. The polarisation signal is strongest at wavelengths longer than 100 micron and correlates well with the underlying magnetic field structure. Probing the maximum linear polarisation fraction requires a minimum spatial resolution of 1 kpc.

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