Grain alignment with fast, numerically exact methods in 3D radiative transfer

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We have developed a 3D radiative transfer code, which will calculate the full Stokes vector of the scattered light, not just the intensity. In addition, we will be able to have grains aligned in the magnetic field, using fast and numerically exact methods of solving the alignment of non-spherical grains. This allow the calculation of their effect on the arising polarization of the scattered light.

Polarized scattered light has been observed in cometary comae [1] and in circumstellar disks [2]. Polarized scattered light carries information about the grains from which the light scattered. However, modelling polarized scattered light is a complicated problem. So far, most scattering codes consider either optically thin cases, where radiative transfer is not necessary, or only do one-dimensional (1D) radiative transfer. Three-dimensional (3D) radiative transfer is mainly focused on unpolarized radiation, which is easier to calculate.

Interstellar dust grains are aligned with magnetic fields. However, in many scattering codes, the grains are assumed to be randomly aligned, allowing for a simplification of the problem. In this work, we utilize a new 3D Monte Carlo radiative transfer code which incorporates the full Stokes vector for both the incoming radiation and the radiation scattered by aligned dust grains.

The dust model can include different populations of dust, differing in composition, size distribution, shapes, and orientation. Based on the dust populations and the fraction of alignment, we calculate the average scattering matrix as well as the extinction matrix in each computational cell. Due to the limits of memory, this calculation is done on the fly, based on pre-calculated critical aligned size, scattering and extinction matrices per dust population.

In recent works [3,4], we have presented a full solution to the scattering problem of non-spherical grains and the corresponding dynamical problem in a numerically exact manner. The solution provides a means of studying how cosmic dust grains spin under radiative torques. In this work, we apply the previously developed scattering dynamics framework to obtain the pre-calculation scattering and extinction matrices of gradually aligning dust populations.

References

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