NEW RESULTS IN THE THEORY OF DUST GRAIN ALIGNMENT

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Two complementary approaches are used in an attempt to propose an unique appropriate formulation of the solution to the problem of magnetic alignment of grains in the diffuse and/or the more denser clouds, whatever the mechanism of rotational excitation (thermal of suprathermal) can be. The interest of such an unified formulation is mainly that the same theoretical expression for polarization can be used everywhere, allowing for easier comparisons between regions where the physical conditions (temperature, densities, magnetic field, grain size) are highly different.

The first consists in applying a Monte-Carlo method (Purcell and Spitzer, 1971; Cugnon, 1985) to a limited number of representative cases, for which all the torques acting on the grain are taken into account : impulsive random torques due to direct collisions with gas atoms, to evaporations of atoms from the surface, and to exo-energetic recombinations forming hydrogen molecules, followed by violent ejections from peculiar sites; magnetic torques. Three characteristic times are associated with these torques :
- the collisional damping time, related to atomic collisions,
- the time necessary to change completely the actual sites configuration (re-surfacing time) narrowly bound to the correlation time of the suprathermal torque, as defined by Purcell (1979),
- the magnetic damping time.
Also, three temperatures can be defined, which are :
- the rotational temperature of the grain, equal to a weighted mean between the gas temperature, the grain temperature, and the temperature associated with molecular ejection, when this process is random,
- the internal temperature of the grain,
- the "pseudo-temperature" associated to the suprathermal excitation due to molecular ejections from a limited number of peculiar sites.

The Monte-Carlo method implies the random generation of the collisional parameters, among which the time interval between two collisions (or evaporations), the incoming velo-

city of the gas atom, the evaporation and ejection velocities, with the constraint of a maxwellian distribution, and, as a working hypothesis, the rotational and precessional angles, because of the symmetry of the problem and of their fast variations with respect to the other position angles. In order to reduce appreciably the computer running time, it was necessary to increase the mass of the colliding atoms by a factor 10000, and to modify correspondingly the magnetic damping time. For simplicity, also, the surface of the spheroid was divided into 10000 elements, among which the peculiar ejection sites were chosen.

During the time interval separating two impulsive events, the position angles and the angular momentum are incremented by the necessary amount (including a fluctuating part governed by the grain temperature) due to magnetic torques.

The second approach starts from an heuristic (and somewhat speculative) point of view. It consists in a generalization of the author's results (Cugnon, 1983; see also Purcell and Spitzer, 1971; Greenberg, 1978) obtained for thermal alignment to the suprathermal case. It appears indeed that in the two extreme cases, i. e. when the correlation time of the suprathermal torque is very long (short) compared with the collisional and magnetic damping times, the thermal formulation may be used after redefinition of the involved times and temperatures. For example, in the first situation, using the pseudo-temperature quoted above, which is very high, as rotational temperature, and a time characteristic of the changes in the suprathermal torque instead of the collisional damping time leads to perfect Davis and Greenstein alignment, in agreement with Purcell's theory.

The Monte-Carlo method described above appeared to be the most powerful to investigate the intermediate cases. However, at the present time, only a few cases have been run, of which the results are promising, but which do not yet constitute a sufficient sample to make sure that the thermal formulation may be extended to the suprathermal behaviour.

References :

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