ELECTROMAGNETIC EFFECTS ON HYPERBOLIC COSMIC DUST PARTICLES

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The effects of electromagnetic forces on charged interstellar grains and β-meteoroids - both moving on hyperbolic orbits - are investigated. It is shown that the unipolar field regimes at high latitudes lead either to a "focussing" or a "defocussing" of interstellar dust and β-meteoroids with respect to the solar magnetic equator. This should lead to a solar cycle variation. The stochastic magnetic fluctuations in the equatorial region, caused by the warping of the current sheet which separates the polar fields, lead to a diffusive description of particle transport at the low mass end. Consequences for the ability of interstellar dust particles to penetrate the inner heliosphere are discussed. It is concluded that dust particles with radii $s > 10^{-5}$cm can penetrate deeply into the heliosphere if their incidence direction at the heliopause is almost radially inward and close to the solar magnetic equatorial plane, whereas dust particles with radii $s < 10^{-5}$cm are prevented from reaching the inner heliosphere. The relationship between interstellar dust and β-meteoroids is discussed.

REFERENCE

Morfill G.E., and Grün, E., 1979, The Motion of Charged Dust Particles in Interplanetary Space. II. Interstellar Grains, Planet. Space Sci., to be published.

DISCUSSION

Roach: What fraction of the zodiacal cloud could be of interstellar origin?
Morfill: The connection between interstellar grains and beta meteoroids, as suggested by our trajectory calculations, is an interesting possibility which we shall investigate in greater detail. We have not yet calculated possible consequences for the zodiacal dust cloud.

Greenberg: If you had made a better choice for the parameters of your interstellar particles -- core-mantle grains with unity density and an

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approximate size of a = 0.15 μm -- you should get about the same result as you have quoted for silicate grains of 0.1 μm radius (same mass). However this depends on whether the charge of an interstellar "ice" is the same as that of a silicate.
Morfill: Ice grains present a problem for trajectory calculations because sputtering in the solar wind and evaporation change the mass. The inner (<2-3 AU) heliosphere ought to be ice free, with evaporation being the dominant loss process for interstellar grains.

Lokanadham: How are the E.M. effects related to particle size? Are they maximum for 5 μm size?
Morfill: In our calculations we assumed that the potential of the dust grains was 6 volts independent of size. This means that the E.M. effects become progressively more important as the particle size decreases.

Gustafson: The charge on an ice (or ice enveloped) grain is much lower than on silicates, since the work-function for ice is near the Lyman edge. What value did you assign to the speed of the particles as they hit the detector?
Morfill: The speed chosen was 100 km/sec. If they are produced by collisons near the sun they will presumably have the corresponding local orbital velocity. The measurements also suggest such a value.

Lamy: Are you using the "random walk" in the sense of a Langevin equation or Fokker-Planck equation? (See for instance Chandrasekhar.) If so, did you solve a Fokker-Planck equation (i.e., obtain a distribution function) including the gravitational term which is always non-negligible?
Morfill: Random walk is treated in the Fokker-Planck formalism. In velocity space this is always justified (perturbation of v about a mean along the zero-order trajectory and corresponding spread in the particle distribution). In coordinate space one requirement is that systematic changes in v (eg., due to gravity) should occur slower than stochastic perturbations (due to magnetic forces). This situation obtains for dust particles with radii <0.1 μm. Other constraints (eg., size of the heliosphere) lead to similar numbers.

Singer: Does Liouville's Theorem not apply to the present situation? Otherwise how can you get a focussing leading to an increase in directional intensity?
Morfill: Near the solar magnetic equator the "sector structure" of the interplanetary magnetic field introduces a time-varying stochastic force so that Liouville's Theorem does not apply. The amount of focussing, caused mainly by the interplay of E.M., gravitational, and radiation pressure forces, has not yet been fully evaluated. However it is clear that in the heliosphere, interstellar dust, if seen at all, would come either from large inclinations or appear to come from the direction of the sun.

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