Plasma Poynting-Robertson effect for a dust aggregate

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The impact of solar wind particles exerts a drag force on interplanetary dust grains in the same manner as electro-magnetic drag so called the Poynting-Robertson effect. We study this plasma drag for fluffy aggregates taking into account of penetration of incident solar wind ions.

First, the plasma drag for a single grain is studied as a basis of evaluating the drag for fluffy aggregates of spherical monomers. It is found that the size dependence of the plasma drag analogous to the electro-magnetic drag. Namely, 1) for the monomers smaller than the penetration depth of the solar wind ions, the plasma drag is proportional to the volume of the grain, whereas 2) for the monomers smaller than the penetration depth, the drag is proportional to the geometrical cross section of a monomer. The penetration of solar wind ions through a monomer is effective for monomers smaller than than 0.1 micron. Nevertheless,the plasma drag is still stronger than drag due to the Poynting-Robertson.

Next, we calculate drag force on fluffy aggregates. If the monomer size is larger than the penetration depth of solar wind particles, then the drag force is proportional to the geometric cross section of the aggregates as in the monomer case. We show that the plasma drag on the aggregates is comparable to and in some cases even higher than the (electro-magnetic) Poynting-Robertson effect.This contradicts the general understanding that the lifetime of small dust particles is limited by the Poynting-Robertson effect. The lifetime of aggregates against both drag forces is shorter than that of spherical particles of the same mass. Our results refer to the case of a monomer size of 100 nm, which we think is a plausible value for solar system dust. The importance of the plasma drag compared to the electro-magnetic drag may increase as the size of monomers decreases, even if we consider the influence of the solar wind penetration into the material that limits the momentum transfer from solar wind particles.