Acceleration of small astrophysical grains due to charge fluctuations in dust space clouds

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We discuss a novel mechanism of dust acceleration operating in interstellar media. The acceleration is caused by direct electrostatic interactions between particles arising from fluctuations of grain [1-3] charges, the mechanism dominates for particles smaller than $\sim 0.1\ \mu$m. The energy source for the acceleration are the irreversible plasma processes occurring on the grain surfaces. This mechanism of charge-fluctuation-induced acceleration affects the rate of grain coagulation and shattering of the population of small grains in many astrophysical dust clouds. The main results are presented on Fig. 1.The Table for most important dust clouds in interstellar molecular clouds (ISM) is given in Fig.2. The simplest case of natural thermal fluctuations have been taken into account in calculations of dust acceleration by dust charge fluctuations. The rate of acceleration (stochastic heating) is proportional to averaged square of dust charge fluctuations $< \delta Z_d^2 > /Z_d^2$, to the dust density through the ratio of square of dust plasma frequency to the dust charging frequency (describes the inverse time of individual dust charging and estimated as ion plasma frequency times the ratio of dust size to the Debye screening size) and is proportional to the dust temperature. In some sense this acceleration mechanism is similar to Fermi acceleration but the energy is obtained not in many collisions with randomly distributed clouds but is obtained during the time of passing of one grain through the region with substantial field around another grain. The time of passing is much larger than the time of dust charge fluctuations (that can be estimated by inverse charing frequency). The distance where the field of individual grain effects the motion of another grains is determined not by Debye screening distance but by the distance requited for thermal ion to pass the charging length which is larger than the screening length by the ratio of screening length to the grain size. The temperature of dust reached in acceleration that is shown in Fig.2 is determined by balance of dust charge acceleration and energy release due to dust collisions with atoms of neutral gas. The dust charge fluctuations should be enhanced in the process of dust interaction with MHD turbulence, ultraviolet sources of charging etc increasing the estimated duet temperatures given in Fig. 1. Given curves describe the minimal acceleration due to natural dust charge fluctuations. The acceleration by dust fluctuations increase with decrease of average dust size. Therefore the interpretation of microwave emission from accelerated dust grains due to dust charge fluctuations could be one of issue of

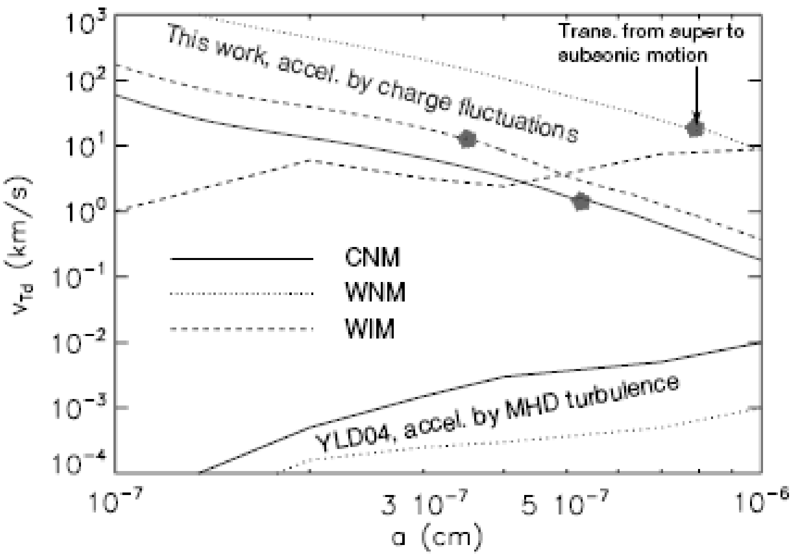

Figure 1: Thermal rotational velocity of accelerated grains v_{Td} for parameters of interstellar medium (ISM) phases given in Fig.2. The Grain size distribution is used according to[4], diamond symbols denote the transition from supersonic to subsonic velocities of dust motion ,solid lines correspond to warm neutral medium (CNM), dotted lines correspond to Warm neutral Medium (WNM), dashed line correspond to warm ionized medium (WIM), three upper curves at the left of the figure correspond to the present novel mechanism of grain acceleration by grain charge fluctuations, three lower curves at the left of the figure correspond to previously investigated acceleration of grain by magneto-hydrodynamic (MHD) turbulence [5](YLD04)

future research for many astrophysical clouds. The effectiveness of acceleration of electrons and ions due to dust charge fluctuations in collisions with dust is much weaker than the dust acceleration and can be used only as mechanism of electron and ion acceleration to relative low energies as compared to their rest mass energy.

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Idealized Environments for the Interstellar Matter

Parameter	CNM	WNM	WIM	RN	PDR
$n_H(cm^{-3})$	30	0.4	0.1	10^3	10^5
T (K)	100	6000	8000	100	1000
T_{dm} (K)	20	20	20	40	80
$x_H = n(H^+)/n_H$	0.0012	0.1	0.99	0.001	0.0001
$x_M = n(M^+)/n_H$	0.0003	0.0003	0.001	0.0002	0.0002
$y = 2n(H_2)/n_H$	0	0	0	0.01	0.01

Figure 2: Table for most important dust clouds in ISM; abbreviations CNM,WNM and WIM are described on caption of Fig. 2,RN is used as abbreviation of Reflection Nebula and abbreviation PDR is used for Photo-dissociation Region