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Dust charge distribution in the Interstellar Medium

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The dynamics of dust grains vary depending on the forces that act on them at different environments in the multi-phase interstellar medium (ISM). Grains interact with the gas through collisions, gravitational attraction and long-range coulomb forces, and also experience varying coupling strengths to magnetic field lines depending on their charge. The charge distribution of dust grains in the ISM depends on the flux of charged particles from the grain surface, which is strongly dependent on the local properties of the ISM temperature, density, local radiation field and, within dense molecular clouds and protostellar disks, cosmic ray flux. We examine the charge distribution, f(Z), of a dust grain population in a radiative, turbulent, multi-phase, interstellar medium, accounting for collisional charging of grains by electrons and ions, photoelectric charging due to a background ultraviolet interstellar radiation field (ISRF) and cosmic rays. We use three-dimensional, adaptive-mesh-refinement, hydrodynamic colliding flows simulations, including gas self-gravity, gas and dust (self-)shielding, on the fly non-equilibrium chemistry, diffuse heating and radiative cooling, to model the complex structure of the multi-phase interstellar medium.
We find that mean charge is strongly dependent to the phase of the ISM where dust is present. Grains in molecular gas have predominantly neutral charge, while grains in the cold-dense and warm-diffuse ISM have predominantly positive charges, varying from charges of order unity, $\langle Z \rangle \sim 1$, for small (5 Angstrom) grains, to $\langle Z \rangle \sim 200$, for large ($0.1\ \mu$m) grains. We found a combination of parameters that can be used to immediately find an approximate value of the charge centroid depending on the grain composition, size and ambient conditions. We then compare the timescale required for dust grains to reach equilibrium charge, to local dynamical timescales of the turbulent flow and find that in the diffuse ISM and within dense clouds dust charge equilibrium is a good approximation.

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Yes

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