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Dead Zones in protoplanetary disks : accumulation and coagulation of dust

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Abstract

The growth of micronic dust to macroscopical sizes (>meter) in a turbulent protoplanetary disk is still largely debated. In particular the dust coagulation process must go through two barriers imposed by their coupling with the gas: the “meter” barrier due to an efficient radial migration of dust when their Stokes number is about one and the “fragmentation barrier” implied by the critical fragmentation velocity (around cm/s) preventing any further growth of particle when they reach a macroscopic size due to the two fast relative velocities of particles. So, paradoxically, a protoplanetary disks may seem quite a hostile place for dust-growth, despite the frequent detection of exoplanets showing that planetary formation is in fact an efficient process.

We then explore a new possibility suggested by the stratified nature of a protoplanetary disk. Protoplanetary disks are expected to harbour non-ionized regions in their mid-plane, the so called “dead zone” inside which the gas flow should be laminar. Dust coagulation in these regions could be quite effective and in addition, since they are regions of low diffusivity, they are expected to be able to accumulate efficiently dust.

Using hybrid numerical simulations, coupling dust-growth and dust dynamics, we explore how dust penetrate a dead-zone and how dust coagulate up to macroscopic sizes and compare it to coagulation efficiency in the active layers of the disk, subject to turbulence. Different disk structures will be explored and discussed. Implication for observations by ALMA will be also presented.

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