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ORIGINAL ARTICLE

Effect of vapor pressure of grains in formation of planetesimals through the accretion disc

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Abstract The role of grains in evolution of accretion disc is an important issue in astrophysics. In this paper, we study the effect of vapor pressure of grains in the dead zones of protoplanetary discs. Our study is limited to some particular observed cases in which evaporation of grains would be important and their vapor gas are constrained to an approximately isolated case. Here, we use the Einstein model to investigate the thermodynamics of vapor pressure. The results show that there is a critical temperature as a function of oscillation frequency and binding energy of particles. For temperatures greater than this critical value, the system goes into unstable mode. We show that the dead zone of the disc may reach to enough conditions to condense via instability caused by vapor pressure of grains. This mechanism may play an important role in the formation of planetesimals through protoplanetary disc.

Keywords ISM: clouds · ISM: evolution · Stars: formation · Accretion disc

1 Introduction

Dust and grains play an important role in evolution and dynamics of the interstellar gases, from diffuse plasma clouds, to the more dense star forming molecular cloud cores (e.g., Wittet 2003). The life cycle of dust grains and their relative abundances in the interstellar medium are determined by the balance between dust formation, grain modification and dust destruction (Draine 2003). Some processes such as fast and slow shocks in the supernova remnants lead to dust destruction (e.g., Slavin et al. 2004). On the other hand, formation of molecules during the chemical evolution of a cold dense interstellar cloud leads to the grain growth in the interstellar medium (e.g., Acharyya et al. 2011). Of course, there is a lot of mechanisms, such as the hot plasma behind the reverse shock, that can control the grain size distribution of the newly formed dusts (e.g., Sandstrom et al. 2009).

One of the important mechanism, which can control evolution of dust and some gases, is the vapor pressure around the grains. Many astrophysicists have worked on the vapor pressure of grains in the different regions of interstellar medium. For example, Nuth and Ferguson (2006) have measured the vapor pressure of solid SiO as a function of temperature over the range from 1325 up to 1785 K in circumstellar outflows around low-mass red giants and oxygen-rich asymptotic giant branch stars. This vapor pressure was inserted into the simple model for the gas expanding from a late-stage star. Kocifaj and Klacka (2008) studied dynamics of dust grains with a vaporable icy mantle. They investigated the effects of solar gravity, electromagnetic radiation and solar wind on the motion of micrometer-sized interplanetary dust grains for initially small eccentric orbits and for heliocentric distances less than 10 AU. Miura et al. (2010) studied evaporation of the micrometer-sized silicate particles heated by a bow shock produced by a planetesimal orbiting in the gas in the early solar system, and condensation of crystalline silicate from the vapor which was produced. Recently, Pilleri et al. (2012) investigated evaporation of very small grains as tracers of the UV radiation field in Monoceros R2.

One of the key questions intimately linked with planet formation and the concept of planet habitability is how much vapor and icy water is present in discs and how it is radially distributed (Riviere-Marichalar et al. 2012). However,

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