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ABSTRACT TITLE

Investigation of nonlinear waves dynamic in protoplanet disk by alternative numerical method

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ABSTRACT

Dynamics of nonlinear density waves appearing in protoplanet disk due to gravitational force is a subject of extensive research in astrophysics. To investigate it one needs to find numerical solution of PDE system which consists of gas dynamics and Poisson equations for self consistent gravitation field.

The aim of current work is to study the influence of hydrodynamic methods and methods for gravitational force computation on structure of appearing density waves in frame of protoplanet disk model including central body.

For hydrodynamical calculations in astrophysics both Lagrangian meshfree (SPH is the most popular) and Eulerian grid based techniques are widely adopted. There are several works where comparative study of methods abilities to reproduce dynamical structures in gaseous phase has been carried out. Commercon et al. (2007) and Mayer et al. (2007) have shown that both SPH and grid (AMR) methods yield similar results following fragmentation of gaseous objects, while Agertz et al. (2006) have reported that SPH introduced spurious force describing Kelvin-Helmholtz and Rayleigh-Taylor instability. Despite of 99% of disk mass is concentrated in gas, presence of 1% of solid dust particle, as it has been shown by Snytnikov et al. (2004), has important influence on disk stability and originated waves dynamics. Therefore we have considered dynamics of spouting density waves in multiphase medium of protoplanet disk in central and self consistent gravitational field. We used grid method by Belotserkovsky-Davydov and mesh less method SPH to treat gas dynamics. Poisson equation was also solved by two methods: fundamental solution based method and combined method of Fourier transformation and sweep. Vlassov equation for dust particles describing was solved by PIC method.

As a result of numerical experiments it was established that under the same initial parameters and commensurable resolution the same pattern wave structures have been appeared nearly simultaneously. Although changing of applied numerical schemes has more serious impact on spiral waves dynamics then on ring waves dynamics. This conclusion allows originated wave structures to be estimated as genuine for the system and gives possibility to study such features as distribution velocity, character half-width and number of waves generated by the system.

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