GRAVITATIONALLY BOUND FRAGMENTS IN A PROTOPLANETARY DISK AS POSSIBLE PLACES OF CHONDRULES FORMATION.

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Introduction: The origin of chondrules, the mm-scale previously molten droplets remains as one of the most enigmatic issue in meteoritics (e.g. [1]). There are many theories of chondrules formation. We think the formation of chondrules from tiny dust agglomerates that massively formed in primordial protoplanetary disk is most plausible. The theory must explain at least two major features – quick heating of dust agglomerates up to temperature as high as ~1000 K and wide spread of chondrules over the bulk of protoplanetary disk. The idea that chondrules formed from dust aggregates melted by shocks in the solar nebula was discussed in a number of papers (e.g. in [2]). Major criticism of this is based on chemical analyses of chondrule olivine, together with Na vapor pressure considerations, which indicate that dust enrichments and total pressures must have been orders of magnitude higher than at background nebular conditions [3]. That is why idea of formation of chondrules in "impact-generated plumes" was developed. It was demonstrated in [4] by numerical simulation that during accretionary collisions between protoplanets, the process of impact jetting creates massive sprays of mm-scale chondrules. However to put this mechanism into action one needs to have protoplanets which requires some time for their formation. Here we argue that even at earliest stage of the protoplanetary disk evolution we have conditions for chondrule formation. We demonstrate in hydrocode simulation that the transient ensemble of gravitationally bound fragments appears in disk and the fragments can provide the necessary conditions for chondrules formation. The fragments are dynamically active and are heated up in the process of gravitational contraction up to high temperatures. Density in the fragments are orders of magnitude higher than average over the nebula.

Model: To study the formation and long-term evolution of a gas-dust protoplanetary disk we use the self-consistent 2+1-dimensional numerical model FEOSAD, taking into account the key physical processes: gas dynamics, self-gravitation, accretion and photospheric luminosity of the protostar, non-stationary thermal disk evolution, drift and growth of dust. A detailed description of the model can be found in [5-7].

Results: A key feature of the evolution of a gas-dust disk around very young low-mass star, i.e. formation of a large number (a transient ensemble) of gravitationally bound fragments heated up to thousands K is illustrated in Fig.1.

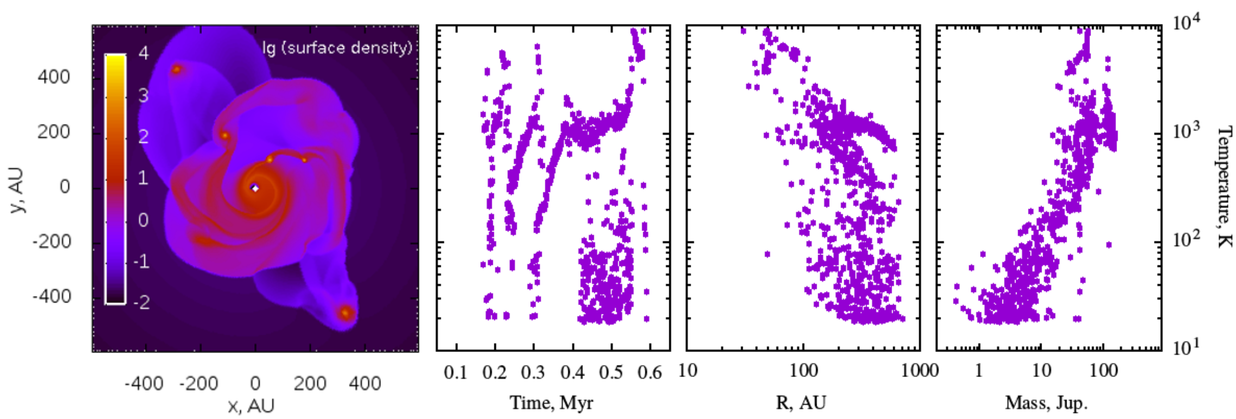

Fig.1 Gas surface density in a model of protoplanetary disk around low-massive star (left panel) and dependences of fragment temperature on time, radius and mass of fragment (three right panels consequently).

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