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微惑星弧状衝撃波：コンドリュール形成の加熱メカニズム

Planetesimal Bow Shocks: A Heating Mechanism for Chondrule Formation

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Chondrules are millimeter sized silicate particles, occupying up to 80 vol.% of a chondrite. They are formed about 4.56 billion years ago in the solar nebula. Chondrules must have experienced heating and melted to account for their spherical shape and their textures. However, the temperature of the solar nebula is a few hundred degrees at their formation age. To account for melting chondrule the heating events must have happened. One of the ideas for the heating mechanism is the shock wave heating model. The shock wave heating model explains the observational constraints for chondrule formation properly. The only problem is that no reliable sources of shocks are confirmed.
In this study, we examined the probability of planetesimal bow shocks as the sources of shocks. The idea of bow shocks excited by the supersonic planetesimal with respect to the nebula gas is offered by Hood (1998) and Weidenschilling et al. (1998). Ciesla et al. (2004) conducted the hydrodynamic simulation of the bow shocks around the supersonic planetesimals for the estimation of the bow shocks as chondrule formation sites, which is the only simulation for the planetesimal bow shocks so far. They simulated the bow shocks in two dimensional Cartesian coordinate system, regarding the planetesimal as a cylinder, and calculated the thermal histories of dust grains in one dimensional model by using the shock properties which are given by their hydrodynamic simulation.
We advanced hydrodynamic simulations by using axisymmetric spherical coordinate system, regarding a planetesimal as a sphere. Moreover, we calculated the thermal history of a dust grain along the trajectory of a dust grain by using the hydrodynamic result of the gas profile as a background. We simulated the bow shocks with various gas velocities, gas densities, gas temperatures, and sizes of the planetesimals. The flow around the supersonic planetesimal was simulated by using the Zeus code (Stone & Norman 1992).
As a result, we restricted the possible chondrule formation region in the gas density - gas relative velocity parameter space, which is well consistent with the result of the one dimensional shock model (Iida et al. 2001). In addition, it was shown that the peak temperature of a dust grain strongly depends on where the dust grain runs into the shock.

キーワード:コンドリュール,衝撃波加熱

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