ARTIFICIAL SYNTHESIS OF CHONDRULES UNDER MICRO GRAVITY, S.V.S. Murty, Planetary Sciences Division, Physical Research laboratory, Ahmedabad, India **(murty@prl.res.in)**

Introduction: Chondrules are roughly spherical, molten objects of about 1 mm size, occur at an abundance of upto ~80% (by volume) in chondritic meteorites and mostly made of silicate minerals (olivine and pyroxene) with minor amounts of metal (FeNi) and troilite (FeS). Chondrule textures range from porphyritic (with crystals upto hundreds of microns) to crypto crystalline (very fine grained) and these petrographic features can be duplicated by partly or wholly melting fine grained material at 1700-2100K and cooling at 10-1000K/hr, suggesting their formation by a flash heating and subsequent fast cooling in the early solar system. Chemical composition suggests that chondrules have lost some volatile elements during their formation, without any resultant isotopic fractionation [1]. The source of heat, and the environment (pressure, redox state, distance from Sun) have not been clearly recognized so far. There are two possible environments in which chondrules could have formed; in the nebula (under micro gravity), by some heat source (most probably by shock waves) [2], or on a parent body, by impacts/volcanism [3]. Due to the constraint on the time of formation (~2 Ma after CAIs, based on extinct radioactive nuclides [4]), the parent body can not be larger than few hundred kilometers in diameter (with feeble gravity).

Artifitial Synthesis of Chondrules: Available lab experiments conducted under vacuum or simulated environments have shown that under nebular conditions (10^{-4} atm. H_2), the FeNi metal as observed in chondrules could not be produced. Only at 1 atm. H_2 pressure, FeNi appears [5]. Also, open system melting under simulated nebular conditions (under Earth's gravity) have resulted in loss of volatiles (Na, S etc.), the degree of loss being proportional to the heating duration. But, this loss is accompanied by large isotopic fractionation [7], not observed in real chondrules. The presence of metal viens as well as blebs is very common in chondrules. The precise mechanism by which metal fractionation occurred and its place and time relative to chondrule formation are unknown. The role of gravity (or lack of it) in producing the observed physical, chemical, isotopic and petrographic features under plausible early solar system environment (low H_2 pressure or vacuum) has not been simulated so far, in the artificial chondrule synthesis. Such studies under micro gravity will provide valuable clues in the understanding of chondrule formation. Depending on the type of pre-existing solids (how refractory they are?) the heat needed is ~ 2100 J/g for complete melting [6]. Earlier attempts to understand the crystallization of material under microgravity gave relied upon parabolic flights and/or drop towers wherein only several seconds of microgravity conditions can be realized [8,9]. It has been shown that only glass spheres would form under microgravity due to difficulty in capturing nucleation seeds [8,9]. The aspect of agglomeration of chondrules into porous dust by impacts has also been studied under microgravity [10].

ISRO's Space Recovery Experiment (SRE): Indian Space Research Organisation has initiated a series of SREs, to demonstrate safe retrieval of space vehicle put in earth orbit, providing opportunities to conduct experiments under micro gravity. We have proposed artifitial synthesis of chondrules in one of the future SREs, which provide ~10^{-5}g for several days, to understand the chemical, isotopic, mineral and petrographic changes during chondrule formation. Some preliminary details will be discussed.

References : [1] Lauretta D.S. et al. (2006) MESS II 431-459; [2] Connoly H.C. Jr. and Love S. (1998) *Science* **280**, 62-67; [3] Hutchison et al. (2005) 'Chondrites and the Protoplanetary Disk', 811-820; [4] Rudraswamy N.G. and Goswami J.N. (2007) *EPSL* **257**, 231-244 ; [5] Cohen B.A. and Hewins R.H. (2004) *GCA* **68**, 1677-1689; [6] Wasson J.T. (1996) 'Chondrules and the Protoplanetary Disk' pp 45-54; [7] Hewins R.H. et al. (2005) 'Chondrites and the Protoplanetary Disk' pp 286-316; [8] Tsukamoto K. et al. (2001) *LPSC* **32**, 1846.pdf; [9] Nagashima K. et al. (2006) *J. Crystal Growth* **293**, 193-197; [10] Teiser J. and Blum J. (2006) 4th Planet Formation Workshop, Heidelberg.