SIMULATING MICRO-GRAVITY IN THE LABORATORY. A. Thomen[1] and A. Pack[1], [1]CNRS Centre de Recherches Pétrographiques et Géochimiques, 15 rue Notre Dame Des Pauvres, F-54501, Vandoeuvre-lès-Nancy, France, apack@crpg.cnrs-nancy.fr.

Introduction: Experimentalists are often facing the problem of choosing an appropriate container for their high-*T* experiments. Experiments with liquid silicates are conducted in metal containers (either loops or crucibles). For experiments with liquid metals, one chooses preferably oxide containers, such as Al_2O_3. For experiments with both, liquid metals and silicates the choice of the right container becomes difficult. Important processes, such as the core formation on planets, however, involved liquid silicates and metals. The problem of reaction of the experimental loads with the container can partly be overcome by short run durations. Equilibration of liquid metals and silicates with crystalline phases of appreciable size, however, is then difficult to achieve. Also chondrules represent complex mixtures of once molten silicates, metals and sulfides (Fig. 1).

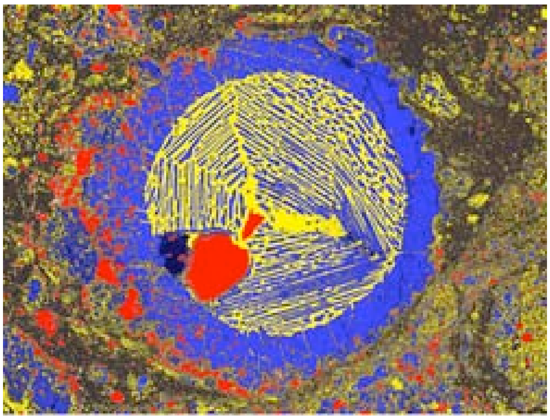

Fig.1: False color image of a barred olivine chondrule with coarse-grained rim from Vigarano (CV3). It formed by melting of silicate, sulfide and metal (*blue*: olivine; *red*: sulfide and metal; *yellow*: mesostasis; *brown*: matrix).

Another problem when using container is heterogeneous nucleation of phases at the sample to container interface. Chondrules are suggested to have formed by fast crystallization from silicate melts while they were freely floating in the solar nebula [1,2]. Hence, chondrule simulation experiments should be conducted without any type of container.

In our ongoing project, we develop a technique for conducting containerless experiments under controlled gas atmosphere and well-known temperature using an aerodynamic levitation device. A number of levitation techniques are currently available to study liquids materials at high temperatures. These techniques include electromagnetic levitation [3], electrostatic levitation [4], acoustic levitation [5], gas-film levitation [6], aero-acoustic levitation [7] and aerodynamic or conical nozzle levitation [8,9]. Containerless levitation is used to study the structure, density, viscosity, electrical conductivity or surface tension [10,11] of liquids materials. Containerless techniques also allow to investigate structures of highly undercooled liquids [12,13] or to synthesize glasses from materials that easily crystallize [*e.g.* forsterite or REE oxide glasses; 14,15]. Levitation has also been used to conduct high temperature *in-situ* structural measurements including synchrotron X-ray scattering [16], neutron scattering [17], NMR [18] and EXAFS [19]. Disadvantage of all currently described techniques is the uncertainty in temperature as well as the problem of controlled atmospheres. Experimental charges are either heated by laser light (CO_2-laser) or by induction. In both cases large temperature gradients are inevitable and temperature determination relies only on pyrometric measurements.

Levitation apparatus: Techniques like electromagnetic levitation are not suitable for studying non-conducting silicate materials. For our approach, aerodynamic levitation is the most appropriate technique for the study of coexisting silicate and metal liquids as well as for simulating the chondrule forming process. In aerodynamic levitation, the molten sample is supported by a vertical gas flow. The sample is centered and stabilized in the flow above the nozzle (Fig. 2).

Fig.2: Basaltic liquid freely floating in an alumina nozzle. The sample is heated from top using a 30 W CO_2 laser. The diameter of the droplet is ~1 mm.

For the first experiments, we have used a 30 W CO_2 laser to heat only the sample, since our test nozzles were machined in aluminium. The optimum opening angle was found to be ~60° with a gas flow of approximately 200 cm^3/min and a diameter of the hole of ~0.8 mm. Using this set up we could keep a molten sphere of approximately 1 mm in diameter stably floating. The optimum gas flow was adjusted according to the mass of the sphere. Heating at full power resulted in considerably mass loss due to evaporation and required continuous readjustment of the gas flow.

We have conducted evaporation experiments with basaltic glass that were colorless at the end of the experiments due to loss of FeO and most probable moderately volatile components like alkalies. From the loss of mass, we also conclude that a fraction of Si and Mg was lost (chemical analyses are in work). The resultant glass hence may resemble a CAI in composition.

Although the diameter of the laser beam was adjusted so that is covered the entire sphere, heating with a laser has several disadvantages. Firstly, the sphere is heated only from on side whereas the bottom side is cooled by the gas flow. Usage of more than one laser [20] can ensure a better temperature homogeneity in the sample. Another disadvantage is that the temperature can only be determined by means of measurement of the black body spectrum, which, at this temperatures (T = 1000-2000°C) still a function of the material.

We have machined a levitation device in alumina (Fig. 2) that will be introduced in a vertical gas-mixing furnace. Using this set up we combine the advantages of containerless high temperature experiments with well controlled conditions (T, f_{O2}, $\frac{\partial T}{\partial t}$) in a vertical gas-mixing furnace.

Conclusion: We have shown that a gas stream can stably levitate a silicate liquid for hours and days. Using our new technique inside the furnace, we will be able to conduct experiments with complex compositions of metal and silicate liquids at high temperatures without using any crucible material. Unresolved issues are preheating of the gas stream and the problem of quenching. We will also apply this technique to the problem of chondrule formation and relation between chondrule textures and cooling rate.

Acknowledgement: This study was supported through grants within the Programme National de Planétologie and the German Science Foundation (DFG Emmy-Noether Programm).

References: [1] Zanda B. (2004) *EPSL,* 224, 1-17. [2] Hewins R. H. and Fox G. E. (2004) *GCA,* 68, 917–926. [3] Muck O. 1923 *German Patent,* 42204. [4] Bolsaitis P. et al. (1989) *High Temp. High Pressure,* 21, 301. [5] Trinh E.H. et al. (1985) *Rev.Sc.Instrum.,* 56 , 2059-2065. [6] Granier J. et al. (1986) *Proc. 6th European Symposium on Material Science under Microgravity Conditions,* Bordeaux, p.421. [7] Weber J.K.R. et al. (1994) *Rev.Sci.Instrum.,* 65, 456. [8] Winborne D.A. et al. (1976) *Metall.Trans.,* B7, 711. [9] Coutures J.P. et al. (1987) *6th European Symposium on Material Science under Microgravity Conditions,* 427-430. [10] Glorieux B., *Thesis,* (2000) Université d'Orléans . [11] Chandrasekhar S. (1959) *Proc.Lond.Math.Soc.,* 9(3) 141-149. [12] Frank F.C. (1952) *Proc. R.Soc.London,* A215, 43 . [13] Kelton K. F. et al. (2003) *Phys.Rev.Let.,* 90, 195504, 1-4. [14] Weber R. et al. (1998) *Nature,* 393, 769-771. [15] Tangeman J.A. et al. (2001) *Geophysical Research Letters,* 28, 2517-2520. [16] Landron C. et al. (1997) *Nucl.Instrum.Meth.Phys.*Res., B 124, 627-632. [17] Landron C. et al. *Phys. Rev. Let.,* 86, 4839-4842. [18] Coutures J .P. et al. (1990) *C. R. Acad. Sci.Paris.,* 310, 1041-1045. [19] Launay X. et al. (1997) *C.R. Acad.Sci.Paris IIB,* 324, 527-535. [20] Millot, F. et al. (2002) *J. Am. Ceram. Soc.* 85, 187-192.