A new Instrument to Observe Contact Freezing of Single Supercooled Levitated Water Droplets

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Freezing of liquid water droplets is one of the most important processes that influences cloud behavior and ultimately the climate; however ice nucleation processes are at present poorly understood. It is difficult to distinguish the important parameters that affect the different mechanisms of freezing and this causes great uncertainty.

Contact freezing has been observed at temperatures greater than -20 °C (Bunker, 2012). This is significantly higher than the homogenous freezing temperature of approximately -38 °C. In addition to temperature, the activity of ice nuclei (IN), in the contact mode, depends upon: the morphology, composition and the size of the IN (Hoose, 2012).

Recent laboratory results for contact freezing are mainly based upon studies which use droplets deposited upon substrates. The efficiency of the contact freezing mode for single suspended droplets is unknown. This technique will allow for measurement of IN efficiencies without the potential bias caused by substrate contact nucleation.

In the present study a new electrodynamic balance (EDB) with cylindrical electrodes was designed and built. A schematic diagram of the instrument is shown in Figure 1. The EDB can trap single 5~100 μm diameter water droplets. The core geometrical structure of the EDB cell, including the electrodes, was described previously (Christian, 2009). Droplets can be injected into EDB cell at ~2 m s^{-1}. 0~1000 V AC are applied to the upper electrode and 0~1000 V AC coupled with 0~10 V DC are applied to the lower electrode to trap the water droplets.

After a charged droplet is trapped, a 532 nm laser is used to illuminate the trapped droplet. Two cameras are used to locate and size the trapped droplet.

Initial experiments are investigating IN composed of mineral particles. The IN collides with the supercooled droplet that is levitated in the EDB cell. A DMA will be used to obtain monodisperse IN particles which are subsequently neutralized through use of an electrofilter. The EDB can be cooled to -40 °C by the particle flow passing through a liquid nitrogen dewar.

Two optical particle counters (OPC) will be used to count the number of IN before and after collisions with the supercooled droplet. The OPC can detect 350~1000 nm particles at frequency of 100s Hz. The contact freezing efficiency of the IN is determined by comparing the difference in number concentration of the particles above and below the supercooled droplet.

We will present the contact freezing efficiency of mineral dust particles and a compare the results with other non-contact free techniques.

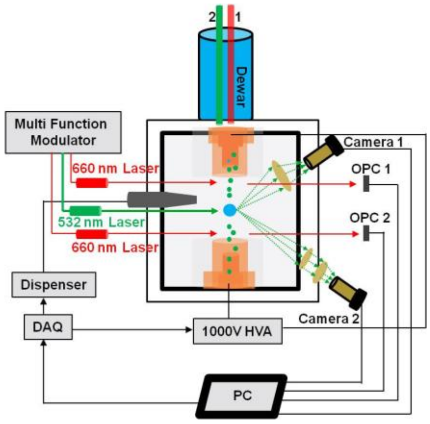

Figure 1. The low temperature EDB system. Camera 1 is for droplet location. Camera 2 is for Mie scattering detection. OPC 1 and OPC 2 are optical particle counters. DAQ is a data acquisition box. In tube 1 the aerosol is introduced through inner electrode into the EDB. Tube 2 is for sheath gas flowing between inner and outer electrode to obtain additional and uniform cooling in the EDB.

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