Ice Nucleation – A Vital Factor in Climate Change

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Ice formation by nucleation in the upper atmosphere is a critical factor in the energy balance of the earth and in climate change. The number and size of ice crystals in cirrus clouds determine their reflectivity and absorption of radiation, and thereby the net heating effect of the sun. Ice in the lower atmosphere typically forms by the freezing of liquid water or solution droplets, which is the origin of precipitation. By contrast, ice formation in the upper atmosphere occurs by deposition from water vapour on micron-size aerosol particles of terrestrial origin, carried aloft by winds. These are usually aluminosilicate minerals like clays or feldspars, which differ both in the chemical and physical nature of their surfaces. The particles are often far from smooth with a profusion of topographical features like pits and grooves. The relative importance of surface chemistry and topography is currently a hotly debated topic, both from a fundamental perspective and with regard to predicting the ice-nucleating efficiency of different surfaces. This is of great significance, not only in the atmospheric sciences, but also for medical and biological processes like cryopreservation of physiological samples.

In this project you will study ice nucleation on surfaces, in particular minerals such as feldspar and mica, in order to increase our understanding of the relative importance of the chemical composition of the surface and its topography. You will use both naturally occurring mineral samples and surfaces patterned with topographical features, using techniques like ion-beam milling and lithography, to study nucleation and crystal growth from water vapour and from liquid water.

You will be part of a large group involving researchers in Physics, Chemistry and Earth and Environment. The project will give ample opportunity for inter-disciplinary collaboration and to become familiar with techniques like optical microscopy, scanning and transmission electron microscopy, atomic force microscopy (AFM), Raman spectroscopy, X-ray diffraction and various surface-modification techniques. Because crystallization is of great importance across many areas of science, medicine and technology your future career prospects will be excellent.

Recent research by the group relevant to ice nucleation and topographical effects on crystallisation:

1. Murray et al. Phys. Chem. Chem. Phys. 12, 10380 (2010).
2. Holbrough, Campbell, Meldrum, Christenson Cryst. Growth Des. 12, 750 (2012).
3. Campbell, Meldrum, Christenson Cryst. Growth Des. 13, 1915 (2013)
4. Christenson, CrystEngComm, 15, 2030 (2013).
5. Campbell, Meldrum, Christenson J. Phys. Chem. C 119, 1164 (2015).