UNIVERSITY OF LEEDS

# CANDIDATE BRIEF

## Research Fellow in Planetary Atmospheres,

## Faculty of Engineering and Physical Sciences

**Salary: Grade 7 (£37,099 – £44,263 p.a.)**

**Reference: EPSCH1091**

**Closing date: Wednesday 22 November 2023**

**Fixed-term until 30 September 2025**

**We are open to discussing flexible working arrangements**

## Research Fellow in Planetary Atmospheres,
## School of Chemistry and School of Earth and Environment.

**Would you like to help explore the frontiers of our knowledge of cloud formation on other planets, by addressing our lack of knowledge on the fundamental nucleation and crystal growth mechanisms? Do you have a background in physical or chemical science, and do you want to further your career in a one of the world's leading atmospheric science Universities?**

You will become a key team member of the Ice Nucleation Group and the Atmospheric and Planetary Chemistry group in Leeds. You will be responsible for exploring the mechanisms of ice clouds in a very poorly understood clouds in the atmospheres of Venus and Mars through novel experiments.

Recent missions reveal conditions where $CO_2$ and $H_2O$ ice clouds can exist in the mesosphere of both Mars and Venus. Comparable ice clouds in Earth's atmosphere are important for the redistribution of condensable materials, atmospheric chemistry and, in the case of denser ice clouds, radiative transfer. These cloud-atmosphere interactions depend critically on ice particle size and number, which is determined by the nucleation mechanism. However, our understanding of how ice particles in these clouds form in the mesosphere of Mars and Venus is in its infancy.

We have identified two specific issues that we wish to address:

1. *$H_2O$ 'cirrus' ice cloud formation on Venus from sulphuric acid haze droplets. We think that these ice clouds on Venus form in a cold layer above the main sulphuric acid clouds and are analogous to cirrus on Earth. Our hypothesis is that they form in a similar way to cirrus on Earth, but the droplet freezing experiments have never been done under the much colder conditions on Venus.*
2. *$CO_2$ ice nucleation on $H_2O$ ice surfaces under Martian conditions. This is thought to be a viable mechanism of $CO_2$ cloud formation, but again, the specific measurements have never been made.*

See the Scientific Background section below for a brief scientific rational and description of the experimental programme.

## What does the role entail?

As a Research Fellow, your main duties will include:

- Working with and in support of the STFC funded Programme of Research in Planetary and Solar System Science as well as contributing to the research culture of the University, where appropriate;
- Taking a lead on the planning and running of a programme of experimental research focused on improving our understanding of very cold ice clouds;
- Generating and pursuing original research ideas connected to the subject of ice clouds formation in planetary atmospheres;
- Developing research objectives and proposals and contributing to setting the direction of the research project and team including preparing proposals for funding in collaboration with colleagues;
- Making a significant contribution to the dissemination of research results by publication in leading peer-reviewed journals and by presentation at national and international meetings;
- Working independently and as part of a larger team of researchers, both internally and externally, to develop new research links and collaborations and engage in knowledge transfer activities where appropriate;
- Evaluating methods and techniques used and results obtained by other researchers and relating such evaluations appropriately to your own research;
- Maintaining your own continuing professional development and acting as a mentor to less experienced colleagues as appropriate;
- Contributing to the training of both undergraduate and postgraduate students, where appropriate, including assisting with the supervision of projects in areas relevant to the project.

These duties provide a framework for the role and should not be regarded as a definitive list. Other reasonable duties may be required consistent with the grade of the post.



## What will you bring to the role?

As a Research Fellow, you will have:

- A PhD (or have submitted your thesis before taking up the role) in atmospheric or planetary atmospheric science, or a closely allied discipline;
- A strong background in the relevant physical sciences;
- A robust understanding of the physics and chemistry of phase changes in relation to cloud formation;
- Strong experience in relevant experimental science;
- Good time management and planning skills, with the ability to meet tight deadlines and manage competing demands effectively without close support;
- A developing track record of peer-reviewed publications in international journals;
- Excellent communication skills both written and verbal, and the ability to communicate your research at national and international conferences;
- A proven ability to work well both individually and in a team;
- A strong commitment to your own continuous professional development.

You may also have:

- Knowledge of low temperature ice clouds and aerosol-cloud interactions;
- Experience of manipulating large datasets;
- Experience in Ultra-high vacuum, low-temperature optical microscopy and low-temperature X-ray diffraction, applied to studies of nucleation and crystallisation of ice;
- Knowledge of clouds in the atmospheres of other planets;
- Experience of pursuing external funding to support research.

## How to apply

You can apply for this role online; more guidance can be found on our How to Apply information page. Applications should be submitted by **23.59** (UK time) on the advertised closing date.



## Contact information

To explore the post further or for any queries you may have, please contact:

**Ben Murray, Professor of Atmospheric Science**
Email: B.J.Murray@leeds.ac.uk

**John Plane, Professor of Atmospheric Chemistry**
Email: J.M.C.Plane@leeds.ac.uk

## Additional information

Find out more about the School of Earth and Environment, the School of Chemistry, the Faculty of Environment and the Faculty of Engineering and Physical Sciences

**A diverse workforce**
As an international research-intensive university, we welcome students and staff from all walks of life and from across the world. We foster an inclusive environment where all can flourish and prosper, and we are proud of our strong commitment to student education. Within the Faculty of Engineering and Physical Sciences we are dedicated to diversifying our community and we welcome the unique contributions that individuals can bring, and particularly encourage applications from, but not limited to Black, Asian and ethnically diverse people; people who identify as LGBT+; and people with disabilities. Candidates will always be selected based on merit and ability.

The Faculty of Engineering and Physical Sciences are proud to have been awarded the Athena SWAN Silver Award from the Equality Challenge Unit, the national body that promotes equality in the higher education sector. Our equality and inclusion webpage provides more information.

**Working at Leeds**
We are a campus-based community and regular interaction with campus is an expectation of all roles in line with academic and service needs and the requirements of the role. We are also open to discussing flexible working arrangements. To find out more about the benefits of working at the University and what it is like to live and work in the Leeds area visit our Working at Leeds information page.

**Information for disabled candidates**

Information for disabled candidates, impairments or health conditions, including requesting alternative formats, can be found on our Accessibility information page or by getting in touch with us at hr@leeds.ac.uk

## Criminal record information

**Rehabilitation of Offenders Act 1974**

A criminal record check is not required for this position. However, all applicants will be required to declare if they have any 'unspent' criminal offences, including those pending.

Any offer of appointment will be in accordance with our Criminal Records policy. You can find out more about required checks and declarations in our Criminal Records information page.

## Scientific background

We have identified two specific issues that we wish to address:

*$H_2O$ 'cirrus' ice cloud formation on Venus from sulphuric acid haze droplets*

In this part of the project we will experimentally test the hypothesis that hygroscopic growth of very viscous sulphuric acid solution droplets in the upper haze layer of Venus leads to their freezing when they become sufficiently dilute and cold. There is also the possibility of using a 1-D model to understand the interplay between cooling rate and nucleation in order to predict hydrometeor size and number concentration.

There is a cold pocket in the atmosphere of Venus at around 85 km where the temperature is around 160 K. This layer is at the top of the sulphuric acid haze layer and it has been suggested that the observed 'detached haze' layer at this altitude is due to swollen sulphuric acid droplets. We propose instead that these detached haze layers are the result of sulphuric acid solution droplets (haze) becoming sufficiently dilute that they freeze homogeneously. An example pathway through the aqueous sulphuric acid phase diagram are shown in Fig 2 (blue arrow). Venus' haze is normally considered to be around 80 wt% $H_2SO_4$, but in this part of the atmosphere the temperature and humidity is such that these droplets will become so dilute that they may freeze homogeneously. This is much like ice nucleation in cirrus or nacreous

clouds on Earth. However, this mechanism has only been tested under conditions relevant to the Earth's atmosphere and not at the colder conditions relevant for these clouds. We therefore need dedicated experiments to test the freezing of solution droplets under the conditions pertinent to Venus' ice clouds for two reasons. It is also the case that these haze particles are supersaturated with respect to an array of crystalline sulphuric acid phases, but it is not known if these phases crystallise at the same time as ice when haze droplets freeze. To explore freezing of sulphuric haze droplets on Venus we will use a combination of cold stage microscope and X-ray diffraction experiments (e.g. Murray and Bertram, 2008; Holden et al. 2021).

*$CO_2$ ice nucleation on $H_2O$ ice surfaces under Martian conditions*

Mesospheric clouds on Mars were first unambiguously identified as being composed of $CO_2$ by instruments on board the Mars Express satellite. Mars is the only planetary atmosphere in the solar system where $CO_2$ ice clouds have been conclusively observed. Conditions are not thought to be conducive to homogeneous nucleation of $CO_2$ ice, meaning something is required to reduce the energy barrier to nucleation. $CO_2$ ice nucleation for Martian clouds is typically described in models using Classical Nucleation Theory (CNT), where the crucial input is the contact parameter (*m*) describing the efficiency of the particle at nucleating $CO_2$ ($0 \leq m \leq 1$, where 1 is the most efficient nucleus possible). By analogy with the terrestrial mesosphere, Meteoric Smoke Particles (MSPs) were thought to be probable nuclei. However, measurements of $CO_2$ nucleation on nanoparticles of MSP analogues ($Fe_xO_y$ and $SiO_2$) gave an average *m* value of only 0.78 between 64 and 73 K. This low *m* value for the nanoparticles suggests they could only form clouds under exceptionally cold temperatures (~18 K below the $CO_2$ frost point temperature), too infrequently observed in the Martian atmosphere to explain cloud observations. More recently, we have shown that "dirty ice" particles should form in the Martian mesosphere by hydration of highly polar meteoric metal carbonates (e.g., $MgCO_3$), which then aggregate to serve as nuclei for solid $CO_2$.

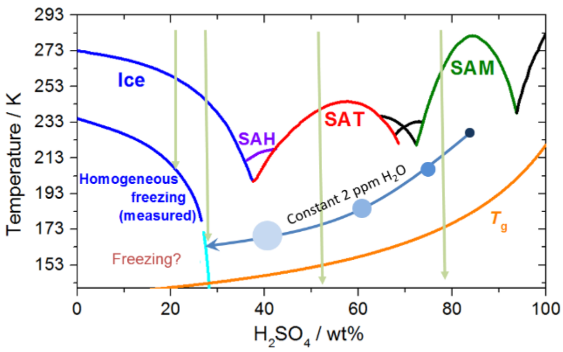


Figure 1. Phase diagram of aqueous $H_2SO_4$. We will study freezing of droplet in a cold stage using both constant composition (green arrow) and variable composition (blue line) trajectories.

Currently the only measurement of $CO_2$ ice nucleation on water ice was made at temperatures ~40 K warmer than Martian mesospheric clouds (*m* = 0.95 over 130 – 140 K; Glandorf et al. 2002). The high *m* gives weight to the viability of water ice as a suitable nuclei for $CO_2$ clouds; however, *m* values typically decrease with temperature, so measurements of *m* under conditions much closer to those of the Martian mesosphere are a priority. This will involve using an ultra-high vacuum instrument to deposit ice layers on a substrate under controlled conditions.