Saturn’s giant moon Titan: exploring planetary atmospheres with infra-red spectroscopy from Cassini

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Figure 1: Image of Saturn’s largest moon, Titan, taken by Cassini’s ISS camera. Titan has a thick atmosphere and similar surface pressure to the Earth and is often used as an early-Earth analogue. A south polar cloud is visible near the image centre, which coincides with a region highly enriched in trace gases with Titan’s polar vortex. [NASA/JPL]

Figure 2: Example thermal infra-red spectrum of Titan from Cassini’s CIRS spectrometer, which measured over a terabyte of data during the mission (2004-2017). Observations of the gas emission peaks can be used to determine atmospheric composition and temperature. These data can be used to probe atmospheric temperature, chemistry and dynamics, providing insight into the workings of Titan’s atmosphere.

Project Background

The solar system contains a variety of planetary atmospheres, from the tenuous gas envelopes surrounding the Galilean satellites, to the thick atmospheres of organic-rich Titan, and the massive atmospheres the giant planets themselves. The main technique used to probe the composition and dynamics of these atmospheres is remote sensing and infra-red spectroscopy, where the emission lines of trace gas species are used to determine profiles of temperature and composition. These measurements can be used to improve our understanding of how the planets evolved and how planetary atmospheres work in general.

Project Aims and Methods

This PhD project will study the atmosphere of Saturn’s giant moon Titan using spectroscopic observations from spacecraft and ground/space-based telescopes. Data used during the PhD will be primarily from the Cassini spacecraft’s Composite InfraRed Spectrometer (CIRS), although there may also be opportunity to use observations from the Atacama Large Millimeter/sub-millimeter Array (ALMA) and the James Webb Space Telescope. Gas emission lines will be used as tracers to determine detailed seasonal changes in Titan’s atmospheric composition and temperature, which will allow the planetary climate, atmospheric dynamics, and photochemistry to be explored.

Spectra will be analysed using radiative transfer methods. This involves using a forward model of the atmosphere based on existing measurements along with gas spectroscopic parameters from laboratory studies. Inverse theory techniques will then be used to recover the atmospheric temperature and composition that best fit the observed data and existing constraints. The derived physical and chemical state of the atmosphere can then be used to develop interpretations for
atmospheric circulation. This will be aided by comparison to theoretical predictions and numerical simulations of Titan’s atmosphere.

Candidate

Ideally a background in physics to MSc/MSci level. A strong interest in space exploration, planetary science, atmospheric physics, and numerical data analysis techniques is essential. Familiarity with scientific computing/programming would be a definite advantage as the main component of the project will be quantitative analysis of spectroscopic datasets using a combination of existing code and new code developed by the student.

Training

Skills will be built up mainly via independent study and one-to-one supervision, but could also include attendance of specific lecture courses and workshops (as required). The student will be expected to present results at national and international conferences, interact with national/international collaborators, and to publish findings in high impact international journals. This will require excellent communication and written skills. The project will require the development of skills in atmospheric and planetary science, remote sensing, radiative transfer modelling, inverse theory, and numerical analysis. This will leave the candidate in an excellent position for a career in atmospheric/planetary science, or any field requiring numerical data analysis.

References / Reading List


Links

http://www.bristol.ac.uk/earthsciences/courses/postgraduate/
http://www.bristol.ac.uk/earthsciences/people/person/nick-a-teanby/overview.html
JWST Mission: https://www.jwst.nasa.gov
ALMA Telescope: http://www.almascience.org

Eligibility
It is possible to award non-UK residents with an STFC PhD training grant, but special conditions apply and a fee waiver by the University is required which is by no means not guaranteed.

**Application deadline: 14.00 GMT, 14th Feb 2023**

How to apply to the University of Bristol: [http://www.bristol.ac.uk/study/postgraduate/apply/](http://www.bristol.ac.uk/study/postgraduate/apply/).

**Please select PhD in Geology as the programme in the online application system.**