



Research Experience Placement (REP) Scheme 2025

Supervisor Project Proforma

Project title:	Losing our cool: far-infrared water spectroscopy in support of the FORUM mission
Host Institution:	National Centre for Earth Observation, University of Leicester
Project supervisor (name, department):	Dr Jeremy Harrison, National Centre for Earth Observation
Project enquiries (supervisor email):	jh592@leicester.ac.uk
Co-Supervisor, if any (name, department):	Dr Daniel Coxon, National Centre for Earth Observation
Proposed start date and weekly hours: (please note project must be of 6 weeks duration)	Start date is flexible, anytime from early July, 35 hours per week
Brief summary:	
The aim of this project is to produce spectroscopic line parameters of water vapour in the far-infrared region of the spectrum. These are needed to better interpret measurements taken by the upcoming FORUM mission, which aims to improve the accuracy of climate change forecasts.	
Project description:	
<p>The European Space Agency's (ESA) 9th Earth Explorer FORUM (Far-infrared Outgoing Radiation Understanding and Monitoring), scheduled for launch in 2027, will be the first satellite mission to measure the Earth's outgoing longwave spectrum at high spectral resolution and accuracy across the far-infrared (FIR). This region is responsible for over half of the Earth's longwave emissions to space. It is the imbalance between these emissions and the solar energy received by the Earth that drives climate change. A primary goal of FORUM is to improve the accuracy of climate change forecasts, however achieving this relies on our ability to perform accurate radiative transfer calculations in the FIR, which in turn relies on the accuracy of spectroscopic databases in this region. The principal absorber in the FIR is water vapour, and FORUM will provide information on its distribution in the upper troposphere – lower stratosphere, where it is a key geophysical parameter for climate sensitivity.</p> <p>Our knowledge of the quantitative FIR spectroscopy of water vapour is incomplete. Recent laboratory work has focused on improving line positions, however there still remain large uncertainties in line intensities. Increasingly, ab initio quantum mechanical calculations of line intensities are becoming more accurate (in the sub-percent range). Experimental and ab initio water line intensities in the mid- and near-infrared region are generally in excellent agreement. For water in the FIR this is not the case, largely due to the lack of accurate laboratory measurements. However, we should be able to use the calculations to validate any new experimental intensity measurements.</p> <p>Lineshape parameters, such as pressure-induced shifts and Lorentz halfwidths, are not well determined. However, theory is not yet at a stage where we can calculate these lineshape parameters accurately, so the only recourse is to take accurate laboratory measurements coupled with a multispectrum line-fitting approach. Strong FIR light sources are not available in a conventional laboratory setup, so measurements tend to be made in synchrotron facilities, such as SOLEIL and the Australian Synchrotron, using Fourier transform spectrometers.</p>	



In this project you will have the opportunity to take part in cutting edge spectroscopic research in support of the upcoming FORUM mission. You will analyse laboratory spectra to produce FIR line parameters for water isotopologues using a multispectrum fitting technique.

Project timeline:

Week 1: Learn about gas phase molecular spectroscopy, the technique of infrared Fourier transform spectroscopy, and how to use the multispectrum non-linear least-squares fitting program LabFit
Weeks 2-5: Use LabFit to derive new spectroscopic line parameters from the measured spectra
Week 6: Compare derived parameters with HITRAN and Exomol

Candidate requirements:

This project is computer-based and will involve the analysis of previous laboratory measurements. Some experience with scientific computer programming is desirable. The placement will be based at Space Park Leicester, but there could be some flexibility in terms of remote working. Overall, this project is suitable for anyone who is eager to learn new things.

Background reading and references:

The HITRAN database website: <https://hitran.org/>
HITRAN 2020 publications <https://hitran.org/media/refs/HITRAN-2020.pdf>
ExoMol website for water: <https://www.exomol.com/data/molecules/H2O/>
ESA's website dedicated to FORUM:
https://www.esa.int/Applications/Observing_the_Earth/FutureEO/FORUM/