Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA21126

Grantee name: Francis Daly

Details of the STSM

Title: Electronic Spectroscopy of HNC^+ for the comparison with the Diffuse Interstellar Bands

Start and end date: 13/09/2025 to 30/09/2025

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

As part of the STSM, I joined Prof. Paola Caselli's group at the Max Planck Institute for Extraterrestrial Physics (MPE) in Garching, Germany; working day-to-day with Dr. Pavol Jusko, Dr, Miguel Jiménez-Redondo and Chiara Schleif. Previously in the group a low-resolution spectrum of HNC^+, by Laser Induced Reactions (LIR) with CO_2, in the visible (400-750 nm) was recorded by a continuous laser (NKT Photonics SuperK) revealing broad, unresolved features overlapping many catalogued DIBs. For direct comparison to these observations, to determine whether HNC^+ is a carrier of the Diffuse Interstellar Bands (DIBs), a high-resolution spectrum was required to reveal the underlying structure of these bands, possible by a smaller bandwidth radiation source.

The majority of the time was spent at MPE aligning and optimising an Nd:YAG (Innolas) pumped dye laser (Radiant Dyes), Rhodamine 6G (554-585 nm); the source of radiation for spectroscopic measurements inside the 22-pole ion trapping apparatus. The laser was then aligned into a fibre coupled wavemeter to record accurate wavelengths; with enough power going through the trap to initiate the reaction between HNC^+ and CO_2, allowing spectroscopic measurements to begin.

The band of HNC^+ at ~570 nm, identified by the low-resolution electronic spectrum, was targeted by LIR reactions following a proton transfer shown in Equation 2:

$$HNC^+ + CO_2 \rightarrow HCO_2^+ + CN. \quad (2)$$

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

The electronic spectrum of HNC^+ was then recorded by monitoring the appearance of HCO_2^+ (*m/z*: 45), from 568-573 nm revealing 5 rotationally resolved lines. The data is fundamentally useful to spectroscopists and astronomers alike as the first high resolution electronic spectrum of HNC^+ to be recorded, which will aid the search for this species in space.

Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

The main outcomes from the STSM were the successful alignment and optimisation of a dye laser to perform high resolution experiments. This allowed 5 rotationally resolved electronic transitions to be recorded by LIR, achieving the main goals of the STSM. The spectrum is still being recorded in the group with the number of lines currently equalling 9. This data will then be compared to the DIBs to determine whether it is a carrier.

In the near future, leak out experiments are planned to occur at The University of Edinburgh (UoE). During the STSM I was able to use leak out spectroscopy to measure an overtone transition of HNC^+, with CO_2 as the collision partner. This experience will be useful to help implement the experimental technique here in Edinburgh.

This STSM strengthened a previously established collaboration between the MPE and UoE, from a previous visit by Dr. Julianna Palotás, a postdoc from our group. The HNC^+ spectrum is still being completed and the data will be fitted by a full spectrum analysis. This work will complement the previously recorded low-resolution spectrum with the plan for the data to be published. An online meeting between institutions is planned in the coming weeks to bring the paper into fruition.