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

Action number: CA21126

Grantee name: Julianna Palotás

Details of the STSM

Title: Action spectroscopy methods in cryogenic ion traps

Start and end date: 22/07/2024 to 09/08/2024

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)

During the STSM, I joined Prof. Paola Caselli's group at the Max Planck Institute for Extraterrestrial Physics (MPE) to study the CH stretch overtone transition of HCN/HNC ionic systems. The measurements were carried out in a cryogenically cooled 22 pole ion trapping apparatus. For the high-resolution measurements, we employed different action spectroscopy methods such as laser induced reaction (LIR) and leak-out spectroscopy (LOS).

The group (Dr. Pavol Jusko, Dr. Miguel Jiménez-Redondo and a guest PhD student Miroslava Kassayová) has been already working on measuring overtone transitions of the protonated HCN. Therefore, I could spend the first week of the visit learn about the setup and the spectroscopic method on this easier, closed shell system. During the rest of the stay, we have been studying the HCN^+ cation.

The ions were produced from a He and HCN gas mixture using an electron impact ionisation source. The mass selected ions were introduced into the RF ion trap that was mounted on a variable temperature cryostat. The ion cloud was irradiated by a continuous wave diode laser. Quantum chemical calculations performed by Dr. János Sarka gave us a good estimate about the wavelength range for the band origins where we needed to perform the experiments. Due to the limitations of the setup, we could not reach the overtone transition 2v1 of HCN^+, as we previously planned. Instead, we focused on low lying electronic transitions in the 1572 -1589 nm range.

For the LIR process, we worked with two different gases. First, CF_4 probing gas was added to the ions that reacted to CF_3 after interacting with the excited ions. Although, CF_4 was previously described in

[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.

literature as a good candidate for these experiments, we did not manage to use it to detect transitions. We tested Kr gas as well, that led to successful spectroscopic detection of a few lines. Due to some impurities in this latter gas, we decided to try out LOS with N_2 to lower the number of background ions. This leak-out technique worked instantly: we scanned the 1572 -1589 nm range and detected 24 lines in the rest of the visit.

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 outcome of the STSM was that we measured low-lying electronic transitions of HCN^+ by employing LOS the first time at the MPE. As we are aware this was also the first time that LOS have been used to detect electronic transitions in high resolution.

Personally, both of the used action spectroscopy methods and working with high-resolution spectroscopy were new for me. In the near future, we are planning to use LOS in Edinburgh, as well. With the STSM, I had the opportunity to learn how to set up and employ this spectroscopy technique.

This STSM started a collaboration between the MPE and UoE. We are planning to continue working on the HCN/HNC system. First, to finish recording the electronic transitions and fit our experimental data for a full spectral analysis. Furthermore, to study the radiative lifetimes of the molecular ion systems and quenching reaction rates. We are planning to publish the data in the next few months.