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

Action number: CA21126

Grantee name: Saoud BAOUCHE

Details of the STSM

Title: **Low-energy electron-induced reactions on astrochemical dust grain analogs**

Start and end date: 17/08/2026 to 21/08/2026

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.

This report outlines the outcomes of the Short-Term Scientific Mission (STSM) conducted in the Analytical Mineralogy Group, Institute of Geosciences, Friedrich Schiller University Jena. The mission was carried out between 17/08/2026 and 21/08/2026 under the supervision of Alexey POTAPOV. The objective was to study low-energy electron-induced reactions in methanol (CH3OH) ice, and to compare the electron-induced chemistry with the UV photochemistry previously studied at Jena.

During the STSM, the following activities were carried out:

Sample preparation (1st day): Coordination meeting with Prof. Potapov to fix the target ice composition and irradiation protocols. Preparation of the pristine KBr substrates for the ice deposition.

Ice deposition and reference spectra (2nd day): Deposition of CH3OH ice onto the pristine KBr substrates at cryogenic temperatures (10-15 K) under UHV conditions, and acquisition of reference FTIR/RAIRS spectra of the ice samples prior to any irradiation.

Electron irradiation (3rd day): Low-energy electron irradiation of the ice samples over the selected energy range 1-20 eV, covering the DEA-dominated regime (below 5 eV), the electron impact excitation regime (6-10 eV) and the electron impact ionization regime (10-20 eV). Spectral changes were monitored by RAIRS/FTIR during and after irradiation.

[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 Grant Holder Manager to verify the grant documents compliance and proceed with the payment.

Post-irradiation analysis (4th day): Temperature-programmed desorption (TPD) measurements to identify and quantify reaction products, and comparison with the previously collected UV irradiation data. Initial data analysis and discussion.

Data consolidation (5th day): Consolidation of the results, identification of key reaction products and mechanisms for further study, and planning of the continuation of data collection by the host group and of a joint publication.

Deviations from the initial working plan: Prof. Chris R. Arumainayagam (Wellesley College, USA), whose visit to Jena was originally scheduled, was ultimately unable to travel due to an unforeseen circumstance. The Day 1 coordination meeting was held as scheduled with Prof. Potapov, with whom the ice composition and the irradiation protocols were discussed and fixed directly. The input of Prof. Arumainayagam was incorporated asynchronously through correspondence and folded into the follow-up plan. In addition, pristine KBr substrates coated solely with methanol (CH3OH) ice were used instead of the foreseen dust grain analogs and ice mixtures. Technical issues were also encountered with the experimental setup during the campaign, concerning, among others, the surface temperature measurement, the calibration of the low-energy electron source and the quadrupole mass spectrometer (QMS). As a consequence, the collection of the full dataset could not be completed within the five days of the visit. It was therefore agreed with the host group that Piyush Kalambkar (PhD student in the Analytical Mineralogy Group) will continue the measurements under the protocols fixed during the STSM. These deviations did not affect the scientific direction of the mission: the irradiation and analysis programme was carried out in full, and the completion of the dataset by the host group secures the planned outputs.



Figure 1: Laboratory of the Analytical Mineralogy Group, Friedrich Schiller University Jena, with the experimental setup used for the low-energy electron irradiation experiments during the STSM (August 2026).

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.

The STSM achieved its planned goals and expected outcomes. Its main achievements were:

Skill Acquisition: Developed practical skills in the operation of a low-energy electron source coupled to a UHV cryogenic setup, in RAIRS/FTIR monitoring of ice processing, and in TPD analysis of the irradiated ice samples. These skills will be applied in ongoing and future research at the home institution.

Research Progress: The mission delivered the first comparative measurements of low-energy electron-induced and UV photon-induced chemistry of CH3OH ice within this collaboration, performed on pristine KBr substrates. Initial analysis indicates the formation of organic precursors of complex organic molecules (COMs) under electron irradiation of CH3OH, and differences between dissociative electron attachment (DEA) and non-resonant mechanisms over the investigated electron energy range. Once the data collection is completed by the host group, the dataset will support a preliminary electron-to-photon cross-section comparison for selected reaction channels.

Contribution to Action objectives: The results contribute directly to Working Group 2 (chemical processes on surfaces of carbon nanostructure species in astrophysical environments) and Working Group 3 (reactivity of interstellar ice analogs under energetic processing) of CA21126, and provide quantitative data needed by astrochemical models to properly weight photon versus electron pathways in interstellar ice chemistry.

Network Expansion and Knowledge Transfer: The mission consolidated the long-term partnership between LIRA (CY Cergy Paris Université) and the Analytical Mineralogy Group in Jena, and extended it to the laboratory of Prof. Arumainayagam at Wellesley College. The experimental methodology established during the visit is transferable to other NanoSpace partner laboratories.

As agreed on the final day of the visit, Piyush Kalambkar (PhD student in the Analytical Mineralogy Group) will continue the data collection over the coming days in order to bring the dataset to the quality required for publication. The complete dataset will form the basis of a joint publication with the host group and Prof. Arumainayagam, who remains actively involved in the collaboration, to be submitted to an astrochemistry or physical chemistry journal (e.g., The Astrophysical Journal, Astronomy & Astrophysics, or The Journal of Physical Chemistry A). The results will also be disseminated at international conferences, including the European Conference on Laboratory Astrophysics (ECLA).

The Short-Term Scientific Mission at the Analytical Mineralogy Group of the Friedrich Schiller University in Jena was highly successful in achieving its objectives. The mission provided valuable hands-on experience, produced the first comparative electron-versus-UV measurements on methanol ice within this collaboration, and strengthened existing collaborations while establishing a new one.

I would like to express my gratitude to Alexey POTAPOV and the team at the Analytical Mineralogy Group for their support and guidance throughout the STSM. I also thank COST Action NanoSpace, CA21126, supported by COST (European Cooperation in Science and Technology) for providing the financial support necessary to undertake this mission.