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

Action number: CA20129

Grantee name: Ouassim Hocine Hafiani

Details of the STSM

Title: Beamtime title: Search for "neighbor-induced recapture" in dielectric clusters

Start and end date: 21/07/2024 to 29/07/2024

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.

Upon arrival on July 21st, we began setting up the experimental apparatus, which included a cluster source, an interaction region, a fluorescence spectrometer, a quadripole mass spectrometer and a vacuum system. On the 22nd, we encountered difficulties achieving the necessary vacuum conditions due to a malfunctioning pump within the fluorescence spectrometer. Troubleshooting and repairs consumed the entire day.

By the 24th, we successfully isolated and fixed the pump issue, achieving a vacuum of 10^-6. However, initial attempts to measure fluorescence light using the grating spectrometer were unsuccessful. To verify the presence of fluorescence, we temporarily removed the grating and placed the detector directly in front of the interaction region. This allowed us to observe fluorescence signal and calculate the NEXAFS spectrum, confirming the presence of emitted photons.

With the grating reinserted, we attempted to measure the fluorescence spectrum with energy resolution but were again met with no signal. The following two days were spent realigning the optics and attempting various techniques to optimize light collection, we also created clusters with Liquid nitrogen and small cluster nozzle but to no avail.

Ultimately, we decided to proceed with measurements despite the low signal-to-noise ratio, suspecting we were primarily detecting background noise. We collected data for several hours using the 0th order grating, which allowed for maximum light throughput. However, the signal remained too weak to utilize the first-order grating for energy resolution.

[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.

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.

While the beamtime did not yield the desired high-resolution fluorescence spectra, it was not without significant achievements. We successfully identified and resolved the vacuum issue, confirmed the presence of fluorescence signal, and gained valuable insights into the limitations of the current experimental setup. The experience gained during this beamtime will be invaluable in planning future experiments.

The main findings of the STSM are:

1. **Fluorescence Signal Confirmation:** Despite the challenges, we confirmed the presence of fluorescence signal from the atomic clusters, suggesting the Bremsstrahlung-like recapture process may be occurring.
2. **Experimental Setup Limitations:** The beamtime highlighted the limitations of the current setup in terms of light collection efficiency, particularly for weak fluorescence signals.
3. **Need for Optimization:** The experience gained during the STSM will inform future optimization efforts to improve the sensitivity and resolution of the experimental setup.

Planned Follow-Up Activities:

A thorough analysis of the data collected during the beamtime will be underway. This analysis will help us to better understand the observed fluorescence signal and to quantify the limitations of the current experimental setup. Based on the results of this analysis, we will decide on the next steps, which may include:

1. **Redesigning the Light Collection System:** We may explore alternative designs for the fluorescence spectrometer and detector to enhance light collection efficiency and improve the signal-to-noise ratio.
2. **Optimizing Cluster Source:** We may investigate methods to increase the density and stability of the cluster beam, potentially leading to stronger fluorescence signals.
   Repeating the Experiment: With an optimized setup, we will repeat the experiment to obtain high-resolution fluorescence spectra and definitively confirm the existence of the Bremsstrahlung-like recapture process.

This STSM has contributed significantly to the MultIChem Action's objectives by providing valuable insights into radiation-induced processes in atomic clusters. The results will inform future research directions and contribute to developing more accurate theoretical models and simulations. Furthermore, the collaboration between the applicant's and host institutions has strengthened the research network within the MultIChem Action, fostering knowledge exchange and paving the way for future collaborations.