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

Action number: CA20219

Grantee name: Konstantinos Kaleris

Details of the STSM

Title: Positron beam installation activities and design of γ-ray generation experiments via novel crystalline undulator devices

Start and end date: 11/06/2023 to 18/06/2023

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)

The applicant participated in activities related to the installation and evaluation of the 0.5GeV positron beamline of the Mainzer Mikrotron (MAMI) accelerator of the Johannes Gutenberg University Mainz. He also participated in discussions and design of near-future experiments of γ-ray generation by positron beam undulation using acoustic wave crystalline undulators.

At first, the grantee was introduced to the structure of MAMI and the accelerator stages and systems by Dr. Werner Lauth, who also provided the grantee a tour at the halls A, B and X1 of the accelerator. Afterwards, the grantee underwent extensive safety training by Dr. Jürgen Diefenbach for the use of the accelerator facility and the secondary experimental setups, and particularly the X1 setup where the positron beam undulation experiments will take place in the future. During the safety training, he was introduced to the interlock system for accessing the critical areas of the accelerator for long- and short-term activities and instructed on tracing potential radioactivity in the accelerator halls. Next, the grantee was introduced and trained on the structure and use of the data acquisition system for positron beam generation and evaluation. The specially developed software and hardware installed in the X1 hall for positron event identification counting and position determination on the detector was analyzed, as well as the remote control software installed in the A1 control room.

With the completion of his basic training, the grantee participated in experiments of positron beam generation executed by the team of Dr. Werner Lauth. A new stage for the Tungsten target was installed

[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.

inside the 10^{-5} mbar vacuum chamber, with 2-dimensional translation capability, for precise alignment of the Tungsten target to the electron beam. The motors of the stage were found to be immobilized by the magnetic field of the magnet splitting the secondary electron and positron trajectories and appropriate proofing was used to overcome the problem. Moreover, a new positron detector with high localization accuracy of the order of ~10μm was installed and tested.

Following the preparation phase, the grantee actively participated in systematic experiments of positron generation and evaluation aiming to optimize the positron beam for the future γ-ray generation experiments. Particularly, positrons were generated with different:

a) electron beam currents
b) electron beam focusing
c) position of the slit for positron beam energy selection

The experimental results were collected by the MAMI team and will be analyzed in the next weeks.

Finally, the grantee participated, together with prof. Nektarios Papadogiannis of the Hellenic Mediterranean University (HMU) team who also visited the MAMI facility, in extensive discussions with the MAMI team regarding the design and scheduling of future experiments of γ-ray generation with the use of specially designed crystalline undulators. The particular experimental setup and adjustment in the positron beamline was determined as well as the vacuum chamber and vacuum conditions that will be used. The precise time schedules for the undulation experiments will be determined in the next few months, depending on the progress of the HMU team on the development of the acoustic wave crystalline undulators.

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 objective of this STSM was for the grantee to

a) familiarize with the MAMI facility and infrastructure,
b) gain experience regarding positron generation from electron beams, gain knowledge in the control of the positron beam in terms of energy and focusing and train on the acquisition and analysis of experimental data,
c) provide support to the MAMI team during the installation and evaluation of the new positron beamline
d) design experiments for γ-ray generation via acoustic wave Crystalline Undulators (CUs)

The installation of the positron beam in MAMI is an intermediary step for achieving narrowband γ-ray generation, which is the main objective pursued by the collaborating HMU and MAMI teams. The produced γ-rays are intended to be used, among others, for radiation-exposed experimental studies of complex biomolecular systems, which is a core objective of Work Group 1 of the MultiChem project.

In this direction, during this STSM the following goals were achieved.

a) Progress on the installation of the MAMI positron beamline:
    - installation of motorized stage for Tungsten target and sealing from the influence of external magnetic fields
    - installation of high spatial accuracy positron detector
b) Progress on the characterization of the MAMI positron beam

- data acquisition of positron events for different electron beam current, focusing conditions and positron selection slit positions

c) Gain of experience by the grantee on the control and real use of the positron beamline for future experiments of γ-ray generation via acoustic wave CUs. Experience with:
   - MAMI facility, accelerator, experiment and control halls
   - MAMI safety aspects and interlock system
   - control of electron beam focusing and current
   - use of the MAMI data acquisition and analysis system

d) Evaluation of the experimental facilities, setup and conditions for near future γ-ray generation experiments:
   - determination of the positioning of the acoustic wave CU
   - determination of the vacuum chamber that will be used
   - determination of the vacuum conditions
   - indications about the available electron flow rate for the undulation experiments
   - consideration of use of Quartz as crystal material for the development of the acoustic wave CUs
   - discussions and preliminary design of direct piezoelectric excitation of the Quartz crystal

Future activities

Based on the gained knowledge of the MAMI facilities and particularly the positron beamline setup and parameters, the grantee and the HMU team will develop suitable acoustic wave CUs based on Silicon, Germanium and potentially Quartz single crystals in the near future. The HMU team and the grantee intend to visit MAMI within the next 8 months to carry out actual experiments of γ-ray generation by positron beam undulation. Possibly, the grantee will visit MAMI also earlier, to participate and provide support in further activities of the positron beamline installation and optimization.