

Report on the outcomes of a Short-Term Scientific Mission¹

Action number: CA20219

Grantee name: Konstantinos Kaleris

Details of the STSM

Title: Collaboration for the development of crystalline undulator devices for gamma-ray generation

Start and end date: 02/10/2023 to 07/10/2023

Description of the work carried out during the STSM

This report outlines the activities undertaken during the Short-Term Scientific Mission at the National Institute for Nuclear Physics (INFN). The objective of this mission was to engage in the development of Bent and Periodically Bent Crystals (BCs and PBCs) and prepare for forthcoming experiments involving innovative γ -ray light sources with crystalline undulators.

During the first 3 days of the visit (Monday – Wednesday), the grantee had multiple in-person meetings with the members of the INFN team that work on the development of BCs and PBCs but also on the design and execution of experiments for γ -ray generation with such novel devices. The grantee acquired invaluable information and know-how from the INFN team, mainly Dr. Laura Bandiera, Prof. Vincenzo Guidi and PhD candidate Riccardo Negrello, regarding channeling experiments with BCs and PBCs in accelerator facilities as well as on simulations of the corresponding experimental chain, including vacuum conditions and light detectors. develops detectors for the measurement of channelling and undulation radiation. The grantee had the chance to visit the laboratories of the Ferrara division of the INFN, where the development and characterization of BCs and PBCs takes place and investigate about the collaboration in sample characterization in the facilities of the INFN or the grantees affiliation, namely the Institute of Plasma Physics and Lasers (IPPL - HMU).

Importantly, the grantee along with the INFN team designed joint experiments for the characterization of crystalline undulators and γ -ray generation in the Mainzer Microtron (MAMI) accelerator, where a new high-quality positron beam is being developed. The groundwork for the forthcoming experiments was laid during these first days, including the definition of experimental parameters, scheduling, and identifying the necessary resources and equipment. The experiments are expected to take place in late spring or summer 2024.

During the next two days (Thursday – Friday) the grantee attended the Workshop of the TECHNO-CLS Pathfinder project that was organized and hosted by the Ferrara team. During the Workshop, the grantee presented the progress

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.

of the IPPL-HMU team towards the development of acoustically excited crystalline undulators. He also had the chance to interact with other groups involved in the research and establish collaborations for the design and development of the mentioned novel crystalline light sources. More details on the established collaborations are presented in the next section of this report.

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

The main achievements of this STSM were the following:

- Acquisition of knowledge regarding experimental conditions and requirements for γ -ray generation experiments via crystalline undulators in accelerator facilities. Information was given by the host team (INFN). Specifications and experimental conditions regarding the following facilities were discussed:
 - CERN 1-15 GeV PS and 20-300 GeV SPS electron / positron beamlines
 - DESY 5.6 GeV electron / positron beamline
 - MAMI 0.5 GeV positron beamline
 - SLAC 20 GeV Facet II electron beamlineParameters of interest are beam radius, angular divergence, purity (in terms of particles), accessibility and vacuum availability for experiments.
- Future joint experiments with Dr. Werner Lauth in MAMI involving the novel crystalline undulator devices developed by the HMU team were scheduled for late spring 2024. Dr. Laura Bandiera and the INFN team will participate providing experience with accelerator beamline experiments and particle / light detection.
- The possibility of Germanium crystal characterization in the European Synchrotron Radiation Facility (ESRF) was discussed and confirmed by Dr. Thu Nhi Tran Caliste, which is impossible to achieve with pulsed infrared laser interferometry techniques available in IPPL-HMU. The characterization activities were scheduled for February – March 2024.
- Progress on the common publication with the MBN Research Centre and Profs. Andrey Solov'yov and Andrey Corol was discussed. The publication will present computational results from γ -ray generation by acoustically excited crystalline undulators, which is an ongoing work of the two groups since March 2023. Particularly, the findings regarding the cone of emission of the undulator with respect to the radiation harmonics were analyzed and discussed.
- Finally, the possibility to use MoO₂ crystals for positron channelling and undulation was investigated with Prof. Davide de Salvador from the University of Padova. Preliminary discussions on this aspect were carried out and follow up communication was agreed.

All the aforementioned activities and achievements are related to WG1 and WG2 objectives of the COST MultiChem action and particular:

- photon and ion irradiation of metal or metal oxide nanoparticles.
- experimental validation of the multiscale models of radiation-induced biodamage.

The described activities effectively entail progress on the computational and experimental study for the development of monochromatic and potentially coherent γ -ray light sources. Such sources are highly anticipated as they will allow for experiments related WG1 and WG2 at photon regimes which are strictly not accessible with current state-of-the-art light sources. Also, the described collaborative research is expected to result in 3 or more publications (one is already under preparation) within the next 12 months that will be related to the COST MultiChem action.