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Editorial

High Precision X-ray Measurements 2021

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High Precision X-ray Measurements 2021 is a Special Issue related to the HPXM2021 conference, held at the INFN Laboratories of Frascati in 2021.

In the wake of the success of the 2018 edition, HPXM2021 was planned with the twofold aim to consolidate the existing interconnections between the research teams and foster creating new ones, offering the opportunity for all the participants to discuss and share the results of their activities focusing on a common protagonist: X-ray precision detection.

The aim of this workshop was to inform the participants on the most recent developments in X-ray detection technologies and their possible impacts in various sectors such as nuclear physics, astrophysics, quantum physics, XRF, XES, EXAFS, PIXE, plasma emission spectroscopy, monochromators, synchrotron radiation, radio-protection, telescopes and space engineering, medical applications, food and beverage quality control and elemental mapping.

This Special Issue of Condensed Matter is a collection of papers presenting the most impressive results shown during the event. Contributions range from the description of new X-ray facilities to computational and analytical methods, data reconstruction algorithms, theoretical models, X-ray detectors characterization and their applications in different fields, Monte Carlo and/or ray-tracing simulations.

In [1,2], the EuPRAXIA project is described, with particular focus on the Plasma-Generated X-ray Pulses [2] and the ARIA beamline [1].

EuPRAXIA is a leading European project aimed at the development of a dedicated, ground-breaking, ultra-compact accelerator research infrastructure based on novel plasma acceleration concepts and laser technology. In particular, the INFN Laboratories of Frascati will be equipped with a unique combination of an X-band RF LINAC generating high-brightness GeV-range electron beams, a 0.5 PW class laser system and the first fifth-generation free electron laser (FEL) source driven by a plasma-based accelerator, the EuPRAXIA@SPARC_LAB facility [2], with an additional proposal to install a second photon beamline with seeded FEL pulses in the range between 50 and 180 nm [1].

High quality contributions focused on newly developed computational methods and procedures are also included in this collection. In [3], for example, a computational Self-Consistent Field procedure based on plane waves has been used, for the first time, to describe the low and high spin conformational states of the complex $[Fe(bpy)3]^{2+}$, showing the capabilities of plane wave methods to correctly describe the molecular structures of metal-organic complexes of this type and paving the way for future even more complex computational simulations. In [4], the usage of a modern deep learning framework to improve the quality of a ptychography reconstruction is reported, while [5] describes an innovative analytical method for X-ray imaging and space-resolved spectroscopy of ECR plasmas, properly developed to obtain Single Photon-Counted (SPhC) images providing the local plasma-emitted spectrum in a High-Dynamic-Range (HDR) mode and allowing for a quantitative characterization of warm electrons population.

Investigation of the electron properties in ECR plasmas are also described in [6], where X-ray Bremmsstrahlung and fluorescence emission, combined with ray-tracing simulations, are used for the scope.

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A high sensitivity X-ray phase imaging system based on a Harmann Wavefront Sensor is presented in [7], where also possible materials characterization and medical applications are reported.

X-ray spectrometers and strip detectors are the protagonist of the contributions [8,9]. In [8], ray tracing simulations are used to reproduce the Bragg spectra obtained with the VOXES von hamos spectrometer based on HAPG mosaic crystals, with particular attention to the comparison between the simulated and experimental reflection efficiencies and spectral resolutions. The strip detectors used in [8] is the MYTHEN2, produced by the Dectris company, which is also the subject of the investigations reported in [9], where the problem of X-ray response non-uniformity (XRNU) is tackled and successfully overcome with the implementation of a statistical reconstruction method.

The work presented in [10] reports, instead, a very interesting theoretical discussion of the connections between the dynamical correlated disorder at nanoscale and the functionality in oxygen-doped perovskite superconducting materials.

X-ray detectors and their applications are the protagonists of the contributions [11–13]. In [11], 3D reconstruction of X-rays with LiF crystals by means of Confocal Fluorescence Microscopy and Confocal Raman Microspectroscopy is described, while the excellent performances, in terms of spectroscopic and timing response, of large area Silicon Drift Detectors can be found in [12], with a description of their usage as X-ray detectors in strangeness nuclear physics in the framework of the SIDDHARTA-2 experiment at the INFN Laboratories of Frascati. A fascinating application of X-ray detectors can be found in [13], with X-ray Micro-Tomography is proposed as a tool to investigate the natural or artificial origin of Pearls with the possibility to highlight the cultivation methodology.

Finally, [14] describes a possible configuration of Multi Pixel Scintillator Detectors to measure polarized gamma radiation, with a particular interest in gamma imaging systems, such as Positron Emission Tomography, where it may be used as an additional tool to distinguish true coincidence events from scatter and random background.

The wide range of topics covered by this Special Issue provides then a panoramic view of the most recent advancements in the field of X-ray precision detection, and many other interesting works can be found in the references of the single contributions. A curious and interested reader will, then, be able to be updated on the most recent findings in the world of X-ray detection and investigation.

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