MEASUREMENTS OF FEL POLARIZATION AT FERMI

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Abstract

We report detailed quantitative characterization of different polarization states of a single-pass, externally-seeded FEL operating with variable polarization undulators in the VUV spectral range. The experiment has been performed at FERMI FEL-1 operated in the 52–26 nm wavelength range. Three different, independent polarimeter setups, installed at the end of experimental beamlines, have been used to characterize the four "pure" polarization states: horizontal, vertical, right-circular and left-circular. The impact of downstream transport optics upon the radiation polarization has been assessed; at longer wavelengths, dichroism effects lead to a non-negligible ellipticity for an originally circularly polarized state. The results from the different polarimeter setups validate each other and allow a cross-calibration of the instruments.

INTRODUCTION

FERMI user facility relies on two different seeded FELs to cover the spectral range from 100 nm down to 4 nm using a common linear accelerator. The first FEL, namely FEL-1, has been designed for the long wavelength spectral range (100 – 20 nm) and is in operation since late 2010 [1]. The second FEL, FEL-2, is based on a double high gain harmonic generation scheme to cover the spectral range from 20 down to 4 nm [2] and user dedicated experiments will start in 2015 [3]. In order to allow the FERMI users to control the radiation polarization, FERMI uses APPLE-II type undulators [4] for the FELs. Because FERMI is the first FEL user facility in the soft-x ray spectral range allowing polarization control through the use of variable polarization undulators it is important the characterization of the degree of polarization produced.

In order to allow a detailed characterization of the degree of polarization, a collaboration has been setup between the FERMI team and other laboratories to perform dedicated experiments. In the framework of this collaboration three different polarimeters have been installed at FERMI and used during one week of dedicated beamtime. The "FERMI polarization measurements" collaboration involved in addition to the FERMI commissioning team; a team from LOA and collaborators responsible for the VUV optical polarimeter [5]; a team from DESY-XFEL and collaborators responsible for the e-TOF polarimeter [6]. In addition to the to aforementioned polarimeters a third polarimeter based on polarized fluorescence has been setup by the LDM team at FERMI and collaborators [7].

In this work we briefly report about the measurement setup. For a discussion about the results of the polarization measurements we refer to the dedicated paper recently published [8].

THE LOA POLARIMETER

The LOA polarimeter is an all-optical device based on the principle described by Schäfers et al. in [9]. The system uses a polarizer followed by an analyser. The polarizer relies on the fact that, at each reflection onto optics, the *s* and *p* components of the electric field are characterised by a different delay and a different reflectivity. Both the polarizer and the analyser can be rotated independently around the propagation axis of the input light. A polarization measurement is done by scanning one of the two angles and measuring the detected signal on the analyser.

THE E-TOF POLARIMETER

The e-TOF polarimeter uses angle resolved electron spectroscopy in order to measure the degree of linear polarization of the FEL radiation. It is based on 16 independent electron time-of-flight (e-TOF) spectrometers mounted in a plane perpendicular to the FEL beam. This configuration allows one to accurately determine the angular distribution of the photoelectrons emitted by the ionizing radiation.

THE FLUERESCENCE POLARIMETER

Polarization measurements with the fluorescence polarimeter have been carried out taking advantage of the intrinsic polarization properties of fluorescence light from resonantly excited atoms. This scheme uses the conversion of polarized VUV radiation into longer wavelength radiation that has the same polarization parameters. The scheme has the advantage to allow a polarization measurement in the visible where suitable optics are easily available and has been previously used in an experiment on synchrotron radiation [10].

CONCLUSION

A dedicated experiment has been organized at FERMI for the detailed characterization of the produced radiation. The experiment involved different groups from LOA, DESY, XFEL and SLAC. Results, recently published [8] have shown the FERMI capability of producing high degree and variable polarization.

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