CHARACTERISATION OF UNDULATOR I411 ON MAX II

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Abstract

The spectral properties of the I411 undulator on MAX II have been analysed. The high harmonic content and the line shapes have been studied to confirm the magnetic perfection of the device. The dynamic influence on the electron beam have been studied.

1 INTRODUCTION

The beamline I411 at MAX-lab is under its last steps of installation. In waiting for the final beamline [I] characterisation of the undulator source has been performed using a borrowed soft X-ray spectrometer.

1.1 MAX-lab

MAX-lab [II] is a Swedish national laboratory for synchrotron radiation research and nuclear physics research. It operates three accelerators: a Racetrack microtron injector, a 550 MeV 2nd generation storage and pulse stretcher ring and the new 3rd generation 1.5 GeV storage ring MAX II.

1.2 Undulator I411

The undulator is one out of a series of undulators installed on MAX-II. They are all hybrid devices built by VTT [III], with slightly different parameters to suit the different beamlines.

Table 1. Data for undulator I411

	Design	Measured
Period	60 mm	58.95 mm
K_{max}	3.63	3.62
# of poles	87	
Total length	2.65 m	
Magnet gap	22 - 300 mm	
Peak field	0.65 T	0.658 T
Type	Hybrid, taper	

1.3 Beamline I411

The undulator radiation is collected and focussed in horizontal direction by a gold-coated, water-cooled cylindrical premirror.

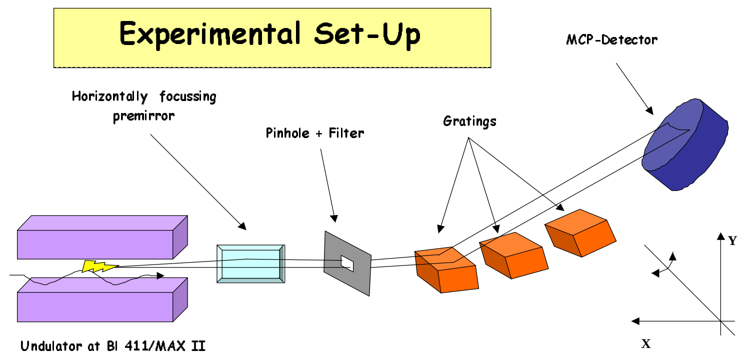

Figure 1: Experimental setup of the beamline during the characterisation.

The experimental set-up during these measurements used a very versatile soft x-ray spectrometer, originally designed at Uppsala University for high resolution soft x-ray emission spectroscopy [IV,V]. It is based on a variable entrance slit, three spherical gratings mounted at fixed angles of incidence and a large two dimensional detector, which can be accurately positioned and oriented on the tangential to the Rowland circle of the respective grating by means of motorised coordinate tables. Each of the three gold-coated, ion-etched gratings is optimised for a different energy range with different radii, groove densities and blaze angles (see table 1). The whole spectrometer covers the spectral range of E = 50 eV to E = 1000 eV which offers, in particular, the opportunity to investigate undulator radiation in the entire VUV-region. The MCP detector has two modifications that make it more efficient, than a bare MCP, in the soft x-ray region. The first is a 300 nm CsI photoemissive coating on the front surface to enhance its efficiency and the second is an input electrode in front of the MCP to force any electrons emitted from the front surface of the MCP into the detector.
If the power of the undulator radiation exceeds more than 1 Watt at the surface of the detector the CsI-coating will start to melt. And the detector cannot handle more than 2.5 10^6 photons/sec. Therefore the instrument had to be slightly modified by putting a small pinhole and a filter in the optical path [VI].

In the actual beamline the first mirror is followed by a modified Zeiss SX 700 PGM monochromator [VII] with water-cooling on the first elements. The beamline is mainly designed for high resolution gasphase core electron spectroscopy.

Grating	Radius	Groove density	Grazing angle	Operating range
1	5 m	1200 l/mm	1.9°	≈ 300 - 1000 eV
2	5 m	400 l/mm	2.6°	≈ 100 - 450 eV
3	3 m	300 l/mm	5.4°	≈ 50 - 200 eV

Table 1: Characteristics of the three gratings used in the soft x-ray emission spectrometer.

2 INFLUENCE ON THE ELECTRON BEAM

2.1 Beam displacement

The undulator (in fact all undulators on MAX II) are creating a vertical kick on the electron beam which comes into the scene below 40 mm gap. The kick is more or less the same for all IDs, and has so far no explanation. This effect can be handled by the correction system running on the ring (Fig 2).

The horizontal beam position is kept well within specifications by powering of the built-in correction coils.

2.2 Focusing

No change in focusing can be seen while closing the gap of the undulator.

A slight increase in the coupling can be seen from 0,7 % to 1,5 %. Whether this is due to the change in beam position or a direct effect in the undulator is not clear.

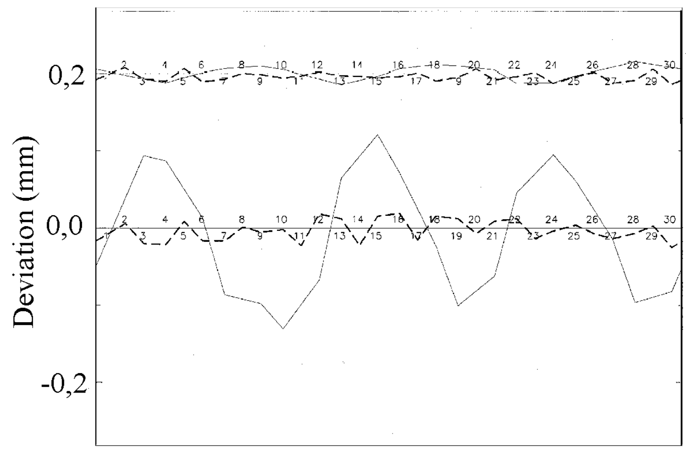

Figure 2: Electron beam position with closed undulator. (bottom - before correction, top - after correction. Dashed line - horisontal, solid line - vertical)

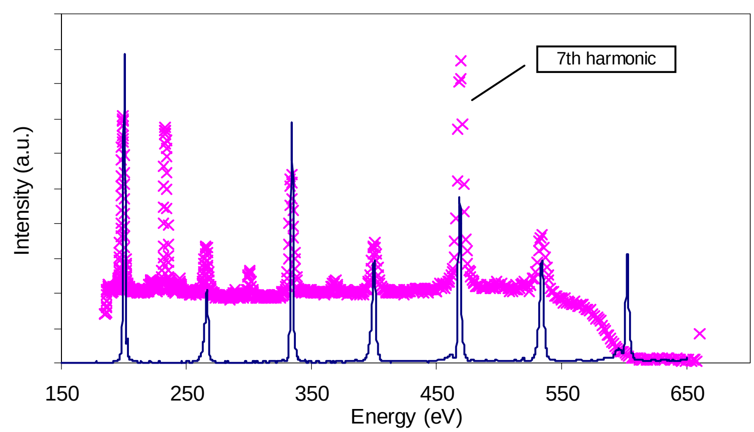

Figure 3: Measured and calculated undulator spectra at 25 mm gap using grating 3. Not corrected for transmission functions and detector sensitivity (x - measured, solid line - simulated).

3 THEORETICAL PREDICTIONS

The undulator is produced to achieve clear high harmonics by a very precise magnetic field. Predictions about the quality have been made by using a measured magnetic field in calculations of the undulator spectra. The resulting simulated spectra can then be compared to actual data.

4 SPECTRAL PROPERTIES

The spectral properties of the undulator has been analysed by a number of runs. The factor of quality here is if the width of the measured spectra agree with what can be expected from theoretical calculations. In principle the main contribution to line widths should be other sources than the undulator imperfections. It is thus necessary to operate at conditions where these effects are small: high harmonics, small apertures, small energy spread = low electron beam currents etc. The magnetic properties in the undulator has been taken into account by using measured magnetic fields of the device and tracking electrons through the device. The tool has been the code UR [VIII].

The overall spectrum from the undulator looks very regular and high harmonics can easily be resolved. (fig 3). One can also clearly see some higher orders from the grating.

To achieve a more detailed picture of the radiation a better grating (grating 1) was used and other harmonics recorded (fig 4.)

In these recordings the line width is dominated by energy spread. The agreement between measured and calculated data though is extremely good.

To resolve other effects than energy spread some recordings at "zero current" were performed, where the energy spread is much smaller (fig 3).

The overall reconstruction of the spectra is good, but here one clearly sees tails on the curves that do not agree. The source can be multi-fold: slightly larger energy spread, decentered aperture, small deviations in the magnetic fields, larger emittance of the e-beam. It is not possible to give the precise explanation, but the effects are very small.

5 SUMMARY

The undulator behaves according to predictions and is well described by common theory. High harmonics are well resolved and no broadening of unknown effects has any importance.
The influence on the electron beam are in most cases negligible. The only cloud in the sky is a vertical beam displacement induced by the device.

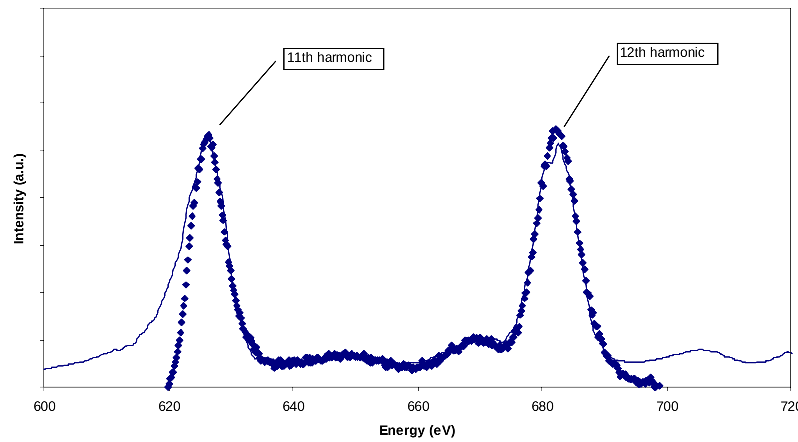

Figure 4: Harmonic 11 and 12 for 23,5 mm gap with grating nr1. High current and energy spread 0,22%. (dots - measured, solid line -simulation)

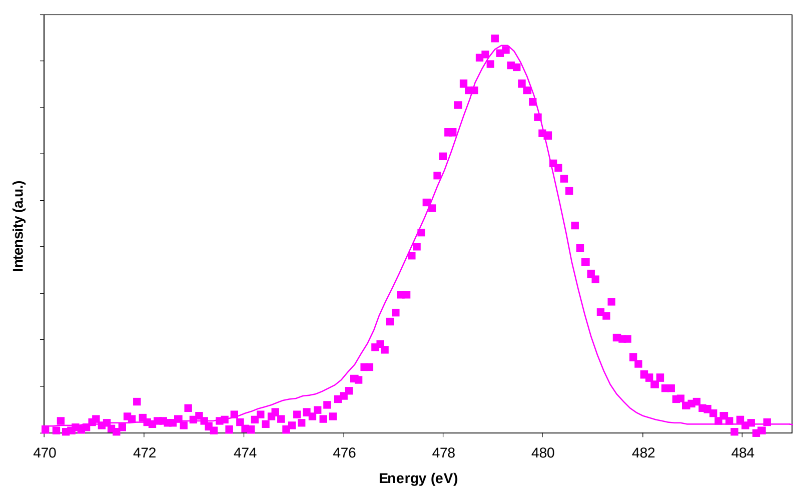

Fig 5. The 8th harmonic at 24 mm gap, using grating 1 with an energy spread of 0,07%. (dots - measured, solid line - simulated)

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