Technical commissioning results of the new High-Dynamics Double Crystal Monochromator (HD-DCM-Lite) at Sirius/LNLS: sub-nanometric stability for SAXS and sinusoidal motion for quick-EXAFs*

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Abstract

Two new second generation High-Dynamics Double Crystal Monochromators (HD-DCM-Lite) were installed at Sirius/LNLS in 2024, with offline results that fulfil the requirements of each beamline: for SAPUCAIA (**S**cattering **Ap**paratu**s** for **C**omplex **A**pplications and **I**n-situ **A**ssay, dedicated to small angles X-Ray scattering techniques - SAXS), a stability in the Short-Stroke in the order of greatness equal to 5 nrad (RMS) for pitch and less than 1 nm (RMS) for gap in air, and 6.5 nrad (RMS) for pitch and less than 1.5 nm (RMS) for gap in vacuum and cryogenic conditions; for QUATI (**Qu**ick X-Ray **A**bsorption Spectroscopy for **Ti**me and Space resolved experiments, dedicated to quick EXAFs techniques), periodic scans up to 10 Hz in high energies and up to 2 Hz in low energies. Figure 1 shows both Sapucaia and Quati beamlines at Sirius/LNLS.

Figure 1: beamlines that received the new monochromators: Sapucaia (left) and Quati (right)

This work aims to show the developed implementations that allowed the visualization of the monochromatic beam for both beamlines and a brief discussion about the controllers designed in frequency domain that allowed the DCMs to bring outstanding results and motion robustness. Figure 2 shows the in-air validation and test phase.

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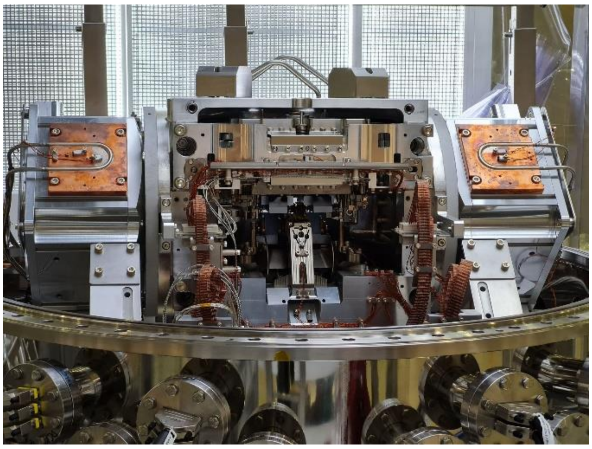

Figure 2: HD-DCM-Lite in air

First, it will describe the functionalities and variables available for the beamline staff in the EPICS level so that the DCMs could be completely operational in a user-friendly manner, from commands of degrees-of-freedom to system monitoring – which is exceptional during the technical commissioning phase and calibration of the DCM. In this moment, the imperfections of fabrication and alignment due to the ultra-high vacuum process must be compensated in a polynomial function gathered by minimization of minimum squares. In order to have a model from engineering positions (feedback from encoders and interferometers) to scientific data (energy selection in the monochromatic beam) that fits the beamline tolerances and requirements, several tests and data collection shall be done by the detectors and beam visualization systems, demanding the HD-DCM-Lite to move as many times as required by the calibration process. This work will present the flexibility of the variables and functions, allowing the integration with different experiment scripts (usually in Python codes) implemented by the beamline staff or by the optics group.

Then, this work aims to show concepts for the controllers' design for all degrees of freedom (Short-Stroke and brushless Rotary Stages) that allowed the monochromator to outfit the beamlines' optical requirements of stability and motion robustness in terms of capability to follow trajectories in high speed precisely. For example, 2.5°/s in the Bragg angle synchronously without losing control filtering the internal vibrations. Some techniques to deal with resonances present in the Short-Stroke will also be discussed, with the objective to filter external disturbances, from cryocooler to vacuum valves positioned close to the DCM.