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BRIEF DESCRIPTION OF A SIX-AXIS MANIPULATOR FOR THE CASSIOPÉE BEAMLINE

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BRIEF DESCRIPTION OF THE NEED

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1. Presentation of SOLEIL

Located in the heart of the Paris-Saclay cluster, around 20 kilometres from Paris, SOLEIL is the France's synchrotron radiation source. Experiments conducted at this Very Large Research Infrastructure rely on the use of light radiation produced by electron beams travelling at almost the speed of light in a ring. This exceptionally bright radiation covers a very wide range of wavelengths: from infrared to X-rays and ultraviolet. The characteristics of this radiation (intensity, focus, stability, etc.) enable matter to be observed at all scales, down to the atomic level, for experiments in fundamental research, applied research and industrial research. Since 2008, SOLEIL has been serving many fields that are currently mobilising science and industry, including physics, biology, chemistry, materials science, environmental sciences, Earth sciences and cultural heritage. Under the dual supervision of the CNRS and the CEA, SOLEIL provides its staff with a multidisciplinary and international working environment.

The ambitious SOLEIL II project will modernise the entire facility, enabling experiments to be carried out ten thousand times faster with a thousand times greater sensitivity and nanometre-scale resolution. This will make a decisive contribution to many societal challenges in advanced materials research, energy and sustainable development, health and well-being, and the environment…

Construction of SOLEIL II began in 2024 with the arrival of the first supplies. The current facility will continue to operate in parallel until autumn 2028. SOLEIL II is scheduled to begin operation at the end of 2030, with a phasing-in period until 2035.

2. Presentation of the beamline and context

CASSIOPÉE is one of 29 beamlines that use the synchrotron radiation produced by SOLEIL. Dedicated to photoemission experiments, this beamline consists of two branches: one for angle-resolved photoemission spectroscopy (ARPES) and the other for spin-angle-resolved photoemission spectroscopy (spin-ARPES). The latter is equipped with a cutting-edge 3D spin detector that can measure spin polarisation in three perpendicular directions, enabling the reconstruction of the spin polarisation vector of any system. However, the cryogenic ultra-high vacuum (UHV) manipulator currently installed on the spin-ARPES arm is manual and offers only four degrees of freedom: three translations and one polar rotation along the vertical Z axis. Our goal is to replace this manipulator with a motorised six-axis manipulator that will provide precise and reliable positioning control, thereby making the 3D spin-resolved photoemission station more attractive to the user community.

3. BRIEF DESCRIPTION OF THE NEED

The cryogenic manipulator is mounted on the spin-ARPES analysis chamber via a CF150 rotating flange. Samples are glued onto modified flag-style sample holders, with the sample positioned approximately 4 mm from the rear face of the holder. The supplier must provide a manipulator that is compatible with this type of sample holder and that has its centre of rotation located 4 mm above the rear face of the holder at the sample position. The sample holder is transferred to the manipulator via a transfer rod. The angle between the axes of the transfer rod and the analyser nose is 112°. The sample holder is then firmly attached to the manipulator stage to ensure good electrical and thermal contact. Finally, the sample is rotated into the measurement position (facing the analyser) using polar rotation.

The six axes must be independent, decoupled from each other, and motorised. The motorisation system for each axis must be able to be integrated into the TANGO software control system that manages the line. Due to the small size of some samples, it is increasingly important that a rotation of the manipulator does not displace the sample translationally; ideally, the sample should be struck by the beam in the same place each time. Translations must also be reproducible and reliable. This is particularly important given that the beamline will have a small beam size with the new generation of radiation sources, such as SOLEIL II. The manipulator must be able to reproduce movements precisely with an accuracy of at least 5 µm for translations and 0.05° for rotations.

The experiments are conducted under ultra-high vacuum conditions (pressure below 2×10^{-10} mbar). It is therefore essential that the manipulator components are either capable of withstanding the bakeout temperature (generally 150°C) or can be removed for the bakeout.

The samples are cooled to cryogenic temperatures (using liquid helium), which enables high-resolution energy measurements. Additionally, an increasing number of experiments are being conducted on samples that undergo phase transitions depending on temperature. Consequently, several projects submitted to the programme committee therefore require the ability to reliably adjust the temperature of samples between the minimum temperature and room temperature (i.e. 300 K). To this end, the manipulator must be able to maintain the sample at cryogenic temperatures, i.e. ideally at a minimum temperature below 15 K, although 20 K would possibly be acceptable. It must also be able to quickly stabilise the intermediate temperatures required for each experiment (e.g. 100 K in ~20 minutes, 180 K in under an hour and 250 K in under 2 hours, starting from the minimum temperature).

4. QUANTITY AND DEADLINES

Quantity:

- A cryogenic manipulator compatible with ultra-high vacuum (UHV), with six independent and fully motorised axes: three XYZ translations and three $\theta\psi\varphi$ rotations.

Deadlines:

Delivery is scheduled to take place in 5 stages:

- 1st stage: order before the end of 2025,
- 2nd stage: acceptance of detailed drawings within four months of the order being placed,
- 3rd stage: acceptance of the factory tests in autumn 2026,
- 4th stage: delivery and preliminary acceptance tests before the end of autumn 2026,
- 5th stage: final acceptance before the end of 2026,