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Development of Key Components of the UCN-Optics System of PanEDM

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The PanEDM experiment aims to measure the neutron electric dipole moment, using ultracold neutrons (UCN) produced by the superfluid-helium UCN source SuperSUN at the Institut Laue-Langevin (ILL). UCN will be stored in double-chamber spectrometer for spin-precession measurements, with a sensitivity of $4\times10^{-27}\,e\,\mathrm{cm}$ anticipated after 100 days of measurement time.
A UCN-optics system serves as the interface from SuperSUN to PanEDM; it is responsible for bringing polarised UCN through a polariser into the two precession chambers, and back to the detection system after the spin-precession period. Due to space limitations and dilution losses during extraction and transport, the interface components must be as compact as possible – while also satisfying the competing requirement that UCN should survive in the guide system for long times without significant loss. Major sections of the guide system now employ metallic guides for improved mechanical stability, precision, and robust mounting.
We present a first characterisation of two key interface subsystems, carried out at the ILL using a prototype superfluid-helium UCN source SUN-2 and the PF2 UCN turbine user facility.

The guide-manifold (GM) splits UCN into two branches feeding the two spin-precession chambers, and consists of eight individual nickel-phosphorus (NiP) coated guides arranged in an asymmetrical Y-shape with a total length of $1.2\,\mathrm{m}$. This design features a simple mechanism to connect and seal guides, and ensures that the two precession chambers can be filled simultaneously.
To determine the transport efficiency for low-energy UCN through the GM, we performed several transmission and storage measurements at SUN-2, reaching a spectrally-integrated transmission efficiency of more than 0.95 and storage times of approximately $100\,\mathrm{s}$. A corresponding wall-loss factor of $\eta \approx 4\times10^{-4}$ is consistent with literature.

PanEDM's UCN detection system relies on simultaneous spin detection, using magnetised iron-foil analysers and adiabatic radiofrequency (RF) spinflippers. While these well-established techniques are usually limited to non-conductive guides with at most thin metallic coatings, we have developed short RF spinflippers that can be used with thin-walled metal guides (coated internally with NiP).
For the first time, we demonstrate the efficient operation of such spin-flippers with metallic guides, obtaining average efficiencies of 1.002 ± 0.008 within the relevant UCN longitudinal-velocity range at PF2.

Having shown that these components function adequately in isolation, they will be commissioned as modular subsystems at SuperSUN to sequentially validate performance of the entire UCN interface.

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