Targeting Soft Matter Research: Innovations in Small Angle Neutron Scattering and Imaging at SINQ

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In this seminar, I will introduce the Swiss Spallation Neutron Source (SINQ) at the Paul Scherrer Institute (PSI), and the instrument under commissioning SANS-LLB, shared among PSI and the Laboratoire Léon Brillouin (LLB) from France. Then, I will focus on three projects that are all intricately linked to soft matter research and the development of Small Angle Neutron Scattering (SANS) and imaging methodologies. Through innovative techniques and advanced experimental setups, we aim to enhance our understanding of soft matter systems and their behavior under various stationary and dynamic conditions, contributing to both fundamental science and practical applications.

1) Microfluidic-SANS for Studying Structural Changes Under Flow: Microfluidic-SANS enables the study of structural changes in materials under flow, addressing the limitations posed by low neutron fluxes which constrain sample volumes and time scales. By developing neutron-transparent fused silica microchannels through selective laser-induced etching (SLE), we parallelize the flow into 16 microchannels, thereby increasing the sample volume exposed to the neutron beam while maintaining high spatial and temporal resolution of the flow measurements. This technique facilitates in situ contrast matching, mixing, and time/spatial-resolved experiments with small sample volumes, paving the way for new scientific discoveries within our user community.
2) Neutron Imaging for Freeze-Drying Process Optimization: Freeze-drying is a crucial method for preserving high-value products in the pharmaceutical, food, and biological industries. The process involves sublimating frozen water under vacuum conditions, with low temperatures mitigating biological deterioration and preventing undesirable effects such as color alteration and flavor loss. However, precise control and observation of the freezing process remain challenging. Neutron imaging provides a solution by enabling in situ observation of freezing front formation and development. Specifically, this technique has been used to study the structuring of cellulose foams in deuterium oxide (D_2O). A neutron-transparent freezing chamber maintained at –10°C, coupled with controlled ventilation and a heatsink for unidirectional cooling, allowed us to control and optimize the freezing fronts' impact on foam structures, while measuring the transmission signal. Factors such as cooling rates, solvent viscosity, and sample composition are investigated to refine freeze-drying processes, enhancing the quality and uniformity of the final foam products.
3) Neutron Grating Interferometry for Soft Matter Systems: Neutron grating interferometry (GI) presents a promising technique for studying soft matter systems with high spatial resolution at length scales in the micron range, complementary to SANS. We combine imaging with small-angle scattering by two approaches: conventional Talbot-Lau GI and directional hexagonal gratings. Previous experiments using directional GI on emulsions revealed the presence of Taylor vortices and deformation of emulsion droplets under shear flow. These findings highlight the potential of GI to resolve flow fields and detect structural changes in soft matter systems. By comparing the sensitivity of GI to different structural characteristics with that of SANS, we aim towards deeper insights into the structure under flow.

Friday, June 7, 2024

10:45 AM (UTC-05:00) Eastern Time (US & Canada) | Hybrid format

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