NTHU Physics Colloquium

Neutron Scattering Reveals Flow-Induced Structural Transformation and Orientational Alignment in Soft Condensed Matter

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Abstract: The microstructural response of soft condensed matter to external fields governs macroscopic behavior such as stability, transport, and rheology. Yet, because soft aggregates access a wide range of equilibrium and non-equilibrium morphologies, quantitatively connecting field-driven structural changes to material function remains challenging.

In this talk, I will briefly review the essentials of elastic neutron scattering for probing soft matter under controlled conditions and introduce analysis tools that extract microstructural parameters directly from two-dimensional scattering patterns. Central to this approach is a spectral decomposition based on the real spherical harmonics expansion (RSHE), which enables unified, quantitative reconstruction of local strain signatures and orientational distribution functions (ODFs).

As a case study, I will examine rod-like micellar solutions under steady shear. Using small-angle neutron scattering (SANS) coupled with rheology on aqueous CTAB rod-like micelles in sodium-nitrate brine, we observe a pronounced increase in angular anisotropy in the 2D SANS patterns with increasing shear rate, without evidence of shear banding. RSHE analysis reveals concurrent strengthening of flow alignment and a systematic reduction of the mean micellar contour length. The resulting shear-rate scaling of the mean contour length agrees with predictions from first-principles analytical theory and dissipative particle dynamics simulations. Together, these results provide direct experimental evidence for flow-induced alignment and scission in rod-like micelles and establish a general framework for interpreting shear-dependent microstructural transformations from 2D neutron scattering.

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