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Probing the spatial distribution of counterions in charged soft matter by ASAXS

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The precise knowledge of spatial distribution of counterions is a key ingredient for the better understanding of the microstructure and interactions in charged soft matter systems such as polyelectrolytes, proteins, surfactant micelles, membranes, DNA, etc. Quantitative Anomalous Small-Angle X-ray Scattering (ASAXS) can elucidate this unique information provided that an atomic absorption edge of the counterions is accessible within the available X-ray energy range of measurements [1]. Recent advances in instrumentation and data reduction have made ASAXS a suitable method for the quantitative characterization of the charge distribution in a variety of soft matter systems [2]. The emphasis has been to derive the weak self-term in the partial intensities and the Fourier transform of this term yields the spatial distribution of counterions. Furthermore, quantitative analysis of the two ASAXS partial intensities could reveal unique information about the counterion concentration fluctuations in the system [1]. This presentation will give an overview of experimental facilities available for ASAXS studies at the ESRF. The virtue of this method will be illustrated by a comparative study of surfactant micellar systems of alkyltrimethyl ammonium bromide with varying length of alkyl chains from 12 to 16. The scattered intensities from these systems display spectacular changes when the incident energy is varied near the K atomic absorption edge of Br which allowed us to derive the profile of counterions with high accuracy [2]. Furthermore, a comparison of the partial intensities of the macroions and counterions, and their cross-term reveal semi-quantitative agreement with computed partial scattering functions by molecular dynamics simulations [3]. Finally, results from recent ASAXS studies of counterion distribution around DNA and comparison with Poisson-Boltzmann cell model will be presented.

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