Experimental report

15/02/2024

Proposal: **9-10-1762** **Council:** 4/2023

Title: Dynamics of foam films studied by Neutron Spin-Echo

Research area: Soft condensed matter

This proposal is a new proposal

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Samples: CTAB solution

Instrument	Requested days	Allocated days	From	To
D22	1	0		
IN15	2	2	29/11/2023	01/12/2023
D33	1	1	27/11/2023	28/11/2023

Abstract:

Herein, we aim at probing the dynamics of liquid foam films by using neutron spin echo. Foams will be prepared and followed in-situ by slowing bubbling air into the foaming solution through a porous frit. The formed foam will be humid at the bottom and dry at the top.

The SANS patterns of liquid foams have evidenced that liquid foam exhibit very well defined film thickness, of few tens of nanometer thickness. NSE will be employed to probe this thickness fluctuations, which are related to the foam-film membrane rigidity. To the best of our knowledge, this is the first attempt to measure such a quantity in a real, three dimensional foam.

Aim of the experiment was to verify if the dynamics of liquid foams can be followed using the spin-echo technique. The short answer to this question is yes, spin-echo can be used to probe the intermediate scattering function providing q-dependent relaxation times from liquid foam systems, using the same setup used for the SANS experiments.

During experiment 9-10-1762, we have investigated the behavior of liquid stabilized by the cationic surfactant tetradecyl trimethylammonium bromide ($C_{14}TAB$) in both pure water and in the presence of 5 mM sodium chloride. To extend the foam's lifetime, aligning with the longer measurement times of an NSE experiment, we employed a mixture of Nitrogen and fluorocarbon vapors (perfluorohexane, C_6F_{14}), effectively minimizing coarsening. To probe the effect of variable electrostatic repulsion between the repulsive air/water layers, a small amount of Sodium Chloride has been added. A picture of the setup installed on IN15 and the obtained relaxation times are shown in Figure 1.

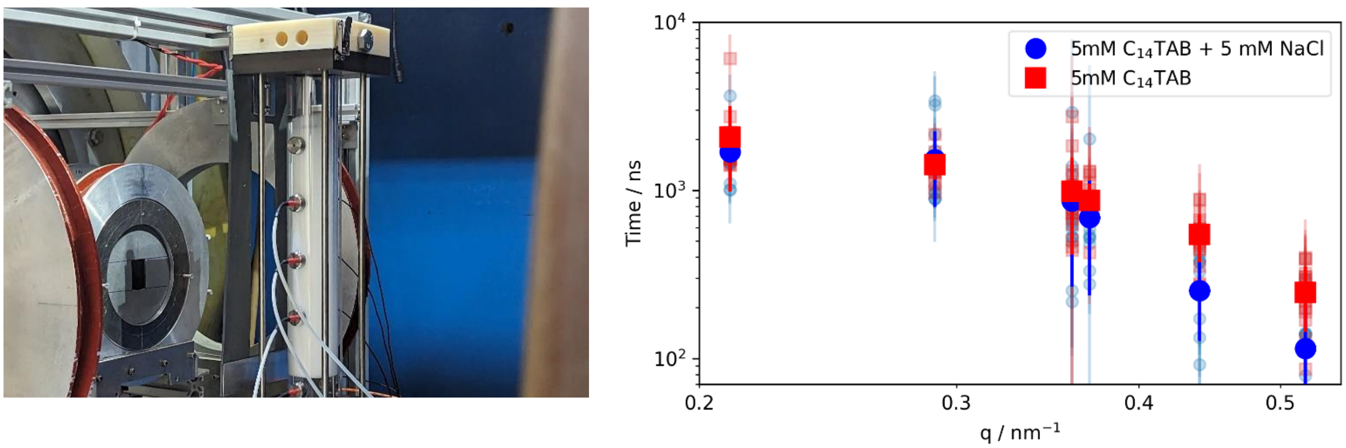

*Figure 1: **Preliminary Neutron-Spin Echo Experiments on Liquid Foams**. Left: A snapshot of the foam setup integrated into the IN15 Neutron spin-Echo apparatus at ILL. Right: Relaxation rates derived from experiments on surfactant-stabilized foams, plotted against the scattering vector q. Small, semi-transparent symbols denote relaxation times from multiple replicates, while larger, fully-opaque symbols represent the averaged values.*

The data were obtained from at least three replicas of the foam, each foam being measured several times with two different configurations, showing a surprisingly good reproducibility of the measured relaxation times.

Notably, the data adheres to a $\sim \mathrm{q}^{-2}$ power law decay, as predicted by the Zielman-Granek formalism, grounded in the undulations of an infinitely thin membrane as described within the Helfrich theory for membrane bending. When applied to the experimental data recorded for liquid foams stabilized by ($C_{14}TAB$) in pure water and in the presence of fluorocarbon vapors, we derived a bending modulus of $8 \pm 3 \times 10^3$ kT. With the addition of small amounts of salts, a value of $4 \pm 3 \times 10^3$ kT was determined. These values are notably large, being a factor of 100 greater than those observed for surfactant bilayers and a factor of 1000 for the oil/water interface of (micro)emulsions. However, these results should be interpreted cautiously, and further experiments are essential to verify whether the experiment genuinely probes membrane oscillations.