Project Title: Characterizing the Electrical Properties of Protein Crystals through Impedance Spectroscopy

Supervisors: Dr. Maggie Klureza (Postdoc), Prof. Arwen Pearson (PI/Group leader)

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Start Date: Preferred start in mid-October 2025, such that the thesis project would run during winter semester 2025 and summer semester 2026; other timing possible by mutual agreement.

Scientific Background

Electric field-stimulated X-ray crystallography (EF-X) is a recent biophysical technique that offers a novel means to understand protein mechanics. When a protein crystal is placed into an electric field, that electric field creates a pattern of forces on each protein molecule, localized to the presence of charged amino acids. These forces result in protein motions that are observable through time-resolved X-ray diffraction data. However, quantifying these forces has been challenging. Calculating the electric field created by an applied voltage across a protein crystal requires information about that crystal's electrical resistance. As protein crystals contain both biological macromolecules and the aqueous crystallization solution, their electrical properties cannot be easily derived from theoretical principles.

Thesis Project

The master's thesis will characterize the electrical properties of protein crystals using impedance spectroscopy, a technique that uses a low-amplitude alternating current to measure the impedance ($Z \equiv V/I$) as a function of the frequency. These measurements will be facilitated by the custom microelectrodes originally created for EF-X data collection and an accompanying electrical setup located in HARBOR. The first semester of preparative work will include growing protein crystals and learning to align them on the electrodes, as well as a review of the scientific literature around impedance spectroscopy and the material properties of protein crystals. There is also the possibility to take part in an EF-X experiment scheduled for early December 2025. The second semester of thesis research will then focus on collecting and analyzing impedance spectra of protein crystals, including comparison to some prior simulations of the EF-X experiment.

Interested?

Please email Maggie (margaret.klureza@uni-hamburg.de) with your CV and a bit about your scientific background, what interests you about the project, and what you're hoping to gain from your master's thesis. If it seems like this might be a good fit, we can then arrange a time to meet and discuss further, either over Zoom or in person in HARBOR (located on the Bahrenfeld campus).