Contribution ID: **1046**

Type: **Invited talk**

xLEAP: A new resources for bio-microprobe imaging

Friday 30 August 2024 11:40 (20 minutes)

Synchrotron x-ray microscopy methods are valuable tools for quantitative imaging of micronutrients and metals in a wide range of biological systems and at multiple length scales [1,2]. The Cornell High Energy Synchrotron Source (CHESS) is uniquely positioned to build a dedicated x-ray facility for the study of biological systems, especially plants, leveraging existing infrastructure and expertise in the School of Integrative Plant Sciences (SIPS) at Cornell and its many affiliated research centers.

In February 2024, the U.S. National Science Foundation announced an award that will support construction of a new x-ray beamline customized for research in plant and soil sciences at CHESS. The new beamline project, X-rays for Life, Environmental, Agricultural, and Plant sciences (XLEAP) will specialize in x-ray fluorescence microscopy, enabling quantitative imaging of micronutrients in biological systems at length scales ranging from whole tissues to cells. The science priorities for XLEAP, driven by workshops and conferences in 2020-2023, include (1) fundamental mechanisms in plant sciences, such as micronutrient uptake, transport, and storage; (2) how plants respond to external stimuli such as nanoparticles, microplastics, bacteria, and fungi, as well as climate and environmental factors; (3) mechanisms of elemental transport and cycling at the root-soil interface and in soil degradation processes; and (4) mechanisms of elemental uptake and cycling in aquatic flora, seaweeds, algae, and other organisms.

We will discuss the planned x-ray capabilities of the XLEAP beamline, which include x-ray fluorescence microscopy (2D mapping, 3D computed tomography, and 3D confocal imaging), x-ray absorption spectroscopy, and x-ray diffraction, with tunable spatial resolution from >100 μm to <1 μm, energies ranging from 5-70 keV, and high-flux or high-energy-resolution modes. XLEAP will also offer users complementary optical microscopy, plant growth, and sample preparation facilities, as well as the potential for in-situ x-ray measurements with a custom plant growth environment directly on the beamline. We will illustrate the planned experimental modes and describe new possibilities for flexible access to accommodate experiments with longer time scales.

The CHESS XLEAP beamline will be constructed over the next four years with user operations planned to begin in 2028. During construction, graduate students and faculty from the University of Texas at El Paso will collaborate with CHESS staff and Cornell faculty on pilot experiments that develop future user capabilities and workflows for XLEAP. The community is invited to shape the user experience at XLEAP by participating in workshops and designing pilot experiments during this construction phase.

[1] Kopittke, P.M., T. Punshon, D.J. Paterson, R.V. Tappero, P. Wang, F.P.C. Blamey, A. van der Ent, and E. Lombi, Synchrotron-Based X-Ray Fluorescence Microscopy as a Technique for Imaging of Elements in Plants. Plant Physiology, 2018. 178(2): p. 507-523 DOI: 10.1104/pp.18.00759

[2] Smieska, L.M., M.L. Guerinot, K.E. Olson Hoal, M.C. Reid, and O.K. Vatamaniuk, Synchrotron Science for Sustainability: Life Cycle of Metals in the Environment. Metallomics, 2023. 15(8): mfad041. DOI: 10.1093/mtomcs/mfad041

This project is made possible by a US National Science Foundation Midscale Research Infrastructure 1 award (USNSF-2330043).

I plan to submit also conference proceedings

No

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Session Classification: Mikrosymposium 7/4: Imaging and Cohrerence Applications

Track Classification: 7. Imaging and coherence applications