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Fundamental physics and materials science enabled by multi-scale and multi-modal neutron imaging

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In this talk we'll discuss how the properties of the neutron provide a diverse set of interactions with matter and fields, yielding unique image contrasts. Since neutron interact primarily via the strong nuclear force and are net electrically neutral, neutrons readily penetrate through centimeters of many common metals, lead being especially transparent in stark contrast to X-rays. We exploit the different views offered by neutrons and X-rays to capture simultaneous tomography data sets which allows for facile discrimination of material phases within heterogeneous materials, such as concrete, shale, and batteries [1]. The intrinsic spin of the neutron allows one to image bulk magnetic fields; exploiting v x E, one can even image the electric field distribution due to the finite spin rotation [2]. Grating interferometry further expands the possibilities. Using a long baseline interferometer enabled by the 3-grating far-field geometry, one has the potential to make a competitive measurement of the Newtonian gravitational constant [3]. Meanwhile, the 2-grating field geometry allows one to measure, in each pixel or voxel, the pair-correlation function of a system, resulting in data sets that span the nm to cm [4]. References: [1] J.M. LaManna et al, RSI 88, 113702 (2017); DOI: 10.1063/1.4989642 [2] Y.Y. Jau et al, arXiv:2006.03728 [3] D. Sarenac et al, PRL 120, 113201 (2018); DOI: 10.1103/PhysRevLett.120.113201 [4] A.J. Brooks et al, Materials and Design 140 (2018) 420–430; DOI: 10.1016/j.matdes.2017.12.001