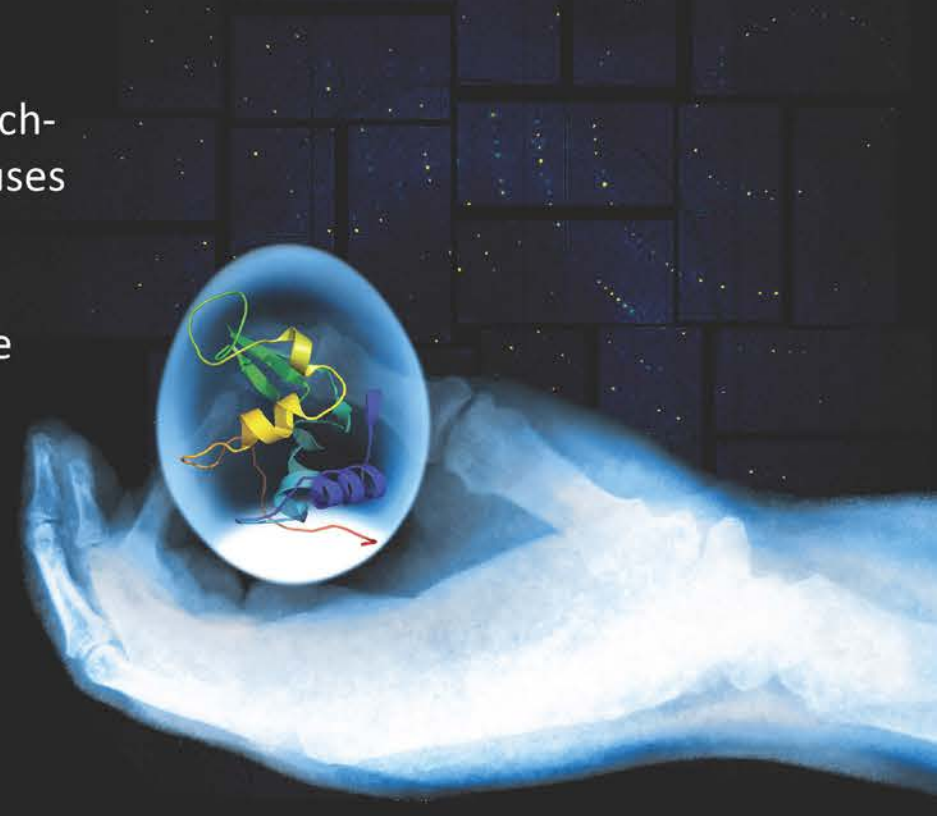
John Spence

New Approaches to Structural Biology with an XFEL

Argonne NATIONAL LABORATORY



The National Science Foundation BioXFEL Science and Technology Center is a new consortium of six research campuses devoted to the application of x-ray free-electron lasers (XFELs) to structural biology. The Linac Coherent Light source at SLAC, the first hard-x-ray XFEL, provides intense coherent hard x-ray pulses at 120 Hz, which vaporize proteins when focused to a sub-micron beam. Atomic-resolution Bragg diffraction patterns are nevertheless obtained using 50-fs pulses prior to the onset of significant damage, in this "diffract-then-destroy" mode, which outruns radiation damage. This use of short pulses instead of freezing samples to reduce radiation damage therefore opens the way to the study of protein dynamics at room temperature in a native environment. My lab in Arizona State University Physics focuses on sample delivery and diffraction physics (algorithms). This talk will review several projects, including: (1) G-protein-coupled receptor proteins solved and compared damage-free at room temperature with those frozen at synchrotrons, (2) pump-probe studies on the photocycle, (3) XFEL study of two-dimensional protein crystals, (4) prospects for XFEL imaging from single particles such as viruses, and (5) new ideas — our Lipid Cubic Phase injector (which allows protein nanocrystals to be studied also at synchrotrons); new methods for dynamics, including a mixing jet sample injector; ab initio phasing using nanoxtal shape-transform effects, which produce scattering between the Bragg spots; the use of angular correlation functions for analysis of fast solution scattering; and two-color opportunities for serial femtosecond crystallography.

John Spence is Director of Science for the NSF's BioXFEL Science and Technology Center for application of x-ray free-electron lasers to structural biology (a seven-campus consortium in the U.S.A.). He completed a Ph.D. in Physics at Melbourne University in 1972, followed by a postdoc at Oxford (UK). He is Snell Professor of Physics at Arizona State University (ASU). Since 1976 his lab at ASU (and LBNL) has specialized in theory and instrumentation for new forms of microscopy in biology and materials science. He is the author of a popular text on atomic-resolution electron microscopy (4th edition), a field in which he contributed to the determination of defect structure, mapping of chemical bonds by convergent-beam diffraction, observation of coherent bremsstrahlung and the use of electron channeling effects on x-ray emission to locate dopants. In x-ray diffraction physics, he has worked on coherent diffractive imaging. He is a Fellow of AAAS, APS, MSA, IOP, and Churchill College Cambridge, and is currently Main Editor for IUCRJ (XFEL Science). He has served on the Advisory Committee for the ALS in Berkeley and the DOE BESAC Committee. He was chair of the IUCr Commission on Electron Diffraction and a member of the commission on Charge, Spin, and Momentum densities. A Festschrift volume of Ultramic appeared in July 2011. His recent talks have reviewed the latest developments in single-particle imaging, serial nanocrystallography, and snapshot solution scattering at the SLAC XFEL, with the aim of making movies of molecular machines at work. He received the Distinguished Scientist award of the Microscopy Society of America for 2006, the Buerger Award of the American Crystallographic Society in 2012, the Cowley Medal of the International Federation of Societies of Microscopy for 2014, the Burton Medal of MSA, and a Humbolt Senior Scientist award.

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APS Colloquium

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