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Addressing Physics Grand Challenges Using the Jefferson Lab FEL[1]

GWYN P. WILLIAMS[2], Jefferson Lab

The Jefferson Lab Free Electron Laser[1] is the first of the so-called 4^{th} generation light sources to go operational. Capable of delivering extraordinarily bright, tunable light in ultrafast pulses from THz[2] through infrared to UV, the facility extends the experimental reach of accelerator-based light-sources by many orders of magnitude. This allows new opportunities to study many of the "Grand Challenges" recently defined by the Office of Science, Basic Energy Sciences Division, most of which are concerned with understandings of equilibrium and non-equilibrium behavior of materials in physics, chemistry and biology using precise pump and probe techniques. Specifically, in condensed matter physics, the JLab FEL permits new studies which go beyond earlier studies of reductionist behavior to those which examine emergent behavior. Thus, the understanding of high Tc superconductivity, colossal magneto-resistance, and observations of the breakdown of the Born-Oppenheimer approximation, are examples of collective behavior which is now treated theoretically via the concept of quasiparticles. In this presentation we will describe the dual pathways of light source development and physics challenges, and then show how they are combined in experiments that allow new insights to be developed to understand material function. We will illustrate this with details of the evolution of accelerator-based light sources, and with examples of work performed to date.

References:

[1] Neil et al. Phys. Rev.Letts **84**, 662 (2000).
[2] Carr, Martin, McKinney, Neil, Jordan & Williams, Nature **420**, 153 (2002).

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[2]and the FEL Team