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Advancements in Light Source Research with the Duke FEL

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Storage-ring based free-electron lasers (FELs) are a eneration of FELs that predate the current high-gain, single-pass FELs driven by advanced linear accelerators. The Duke FEL is such an oscillator FEL that has provided a rich environment for light source research. In this talk, we will recount the diverse territories explored using this FEL. The Duke FEL has allowed us to produce coherent radiation over a wide range of wavelengths, from infrared (2 microns) to vacuum ultraviolet(below 170 nm), and to establish high-gain operation (about 50% per pass) using a distributed optical klystron. With this FEL, we demonstrated the first FEL polarization control and manipulation using non-optical means. Later, we developed a new FEL configuration to achieve full control of beam polarization, producing a linearly polarized FEL beam with a rotatable direction of polarization using two crossed helical undulators of opposite helicities. We explored two-color FEL operation, achieving simultaneous lasing in the infrared (near 720 nm) and ultraviolet (360 nm), including harmonic lasing and wavelength tuning.We also demonstrated the first structured light generation by producing orbital angular momentum beams in the coherent superposition of opposite helicities. Furthermore, we developed the Duke FEL as the photon driver for producing Compton gamma rays at the High Intensity Gamma-ray Source (HIGS), the highest flux Compton gamma-ray source in the world for nuclear research. The capabilities developed for the Duke FEL have enabled the development of new gamma-ray capabilities for a wide range of nuclear physics research, from nuclear astrophysics to few-nucleon reaction and nuclear structure research, to fundamental symmetry studies.

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