A novel X-ray source could be brightest in the world

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Oscillator projected to increase current brightness by millions of times

The future of high-intensity x-ray science has never been brighter now that scientists at U.S. Department of Energy's Argonne National Laboratory have devised a new type of next generation light sources.

"The free electron laser oscillator (X-FELO) we are proposing can create x-rays up to one hundred million times brighter than currently operating machines," Argonne Distinguished fellow Kwang-Je Kim said.

Current technology uses undulators to create bright x-ray beams of spontaneous emission at the Advanced Photon Source (APS) at Argonne. Much of the research for x-ray free electron lasers has been concentrated on self-amplified spontaneous emission (SASE), which would amplify the spontaneous emission by a factor of a million or more in a single pass. A user of SASE will see x-ray brightness which is higher on the average about ten thousand times brighter than the APS is delivering.

In an X-FELO, the electron pulse enters an undulator and generates an x-ray that is reflected back into the undulator entrance by crystals and connects with the next electron bunch and again travels back along the undulator. This pattern is repeated indefinitely with the x-ray intensity growing each time until equilibrium is reached.

X-FELO will open up breakthrough scientific opportunities in various research fields. For example, the inelastic x-ray scattering and nuclear

resonant scattering experiments at the APS are severely limited by small x-ray flux in meV bandwidth. An X-FELO will enhance the flux by six to eight orders of magnitudes, shortening the data collection times by the same factor. Time-resolved measurement of the Fermi surface is a powerful way to study complex materials such as high-temperature super conductors. The characteristics of X-FELO are ideally suited for bulk-sensitive, hard x-ray photo-emission spectroscopy for this purpose.

The brightness, or more precisely the spectral brightness, is proportional to the intensity of coherent photons per unit spectral bandwidth. It is a standard figure of merits for the strength and purity of an x-ray source.

The intensity of individual x-ray pulse from an X-FELO is lower by about three orders of magnitudes. However the X-FELO pulse has extremely narrow bandwidth, three to four orders of magnitude narrower than the SASE. Furthermore, the pulses come with a repetition rates higher by two to four orders of magnitudes higher than in SASE.

Therefore a user of an X-FELO will see an x-ray brightness which is higher on the average about six to eight orders of magnitude brighter than any previously created and three to four orders of magnitude brighter than proposed SASE technology.

"Collaborators from around the world are working to develop the high-quality electron beam necessary for the oscillator," Kim said.

Source: DOE/Argonne National Laboratory