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Fast 4D X-ray Imaging at European XFEL

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Fast 4D X-ray imaging is an emerging method that allows seeing fast-changing phenomena in opaque samples. This novel method will enable capturing stochastic phenomena happening at km/s speed into 3D volumetric videos. 2D X-ray phase-contrast microscopy with a sampling rate of 1.128 MHz has already been demonstrated at the European XFEL [1] by attaining videos with micrometer-scale spatial resolution. The contrast and spatial resolution are superior to previous synchrotron MHz microscopy due to the high brilliance of the source. 4D X-ray imaging at MHz rate is attained by dividing the main beam into many beamlets, each having a different view angle of the sample [2]. Therefore, this method requires a main beam with an even higher brilliance, and it is enabled by the new generation of XFEL sources. MHz 4D X-ray imaging has never been possible before and for this reason, there are fast phenomena never captured in 3D. These include modern emerging technologies, such as additive manufacturing, bioprinting, and new material production, whose development will benefit from fast volumetric imaging by probing the high-speed dynamics happening in such systems. MHz 4D X-ray imaging will also improve the understanding of industry and society relevant phenomena such as the formation and propagation of cracks in metals and aerospace alloys, which modeling is currently left to simulations and speculations with no possibility for direct observation. Experimental observation would facilitate the development of branches of science depending on fast phenomena such as material science, with the specific example of advanced and high-performance alloys.

[1] P. Vagovič et al.," Optica. 2019, 6, 1106-1109.
[2] P. Vagovic, V. Bellucci, P. Villanueva-Perez, W. Yashiro, Patent pending, Application number: EP21200564.9

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