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**Characterization of statistical properties of x-ray FEL radiation by means of two-photon processes**[1] NINA ROHRINGER, ROBIN SANTRA, Argonne National Laboratory, Argonne, IL 60439, USA — The pulsed radiation from a free-electron laser (FEL) in the self-amplified spontaneous emission mode changes its time-dependent electric field from shot to shot in a completely chaotic fashion. For experiments in the x-ray regime with data acquisition over several FEL pulses, the characterization of the statistical properties of the radiation is essential, i.e. spectral or time correlation functions of the electrical field have to be determined. By treating the matter-field interaction perturbatively within a quantum electrodynamic framework, we determine the relevant correlation functions for one- and two-photon processes, i.e. for single and double photon absorption and elastic scattering. The radiation field is described by a general multi-mode density matrix. The possibility of utilizing two-photon-induced double ionization to determine the second-order spectral correlation function of the radiation field is discussed. Considering the example of helium we study the two-photon absorption probability in dependence of spectral correlation functions estimated for different FEL electron-bunch geometries and compare them to signal strength obtained from a single-mode field and from totally chaotic, incoherent x-ray radiation.

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