Superradiant Parametric M"ossbauer Radiation Source

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Mössbauer nuclei form a rich platform for the exploration of X-ray quantum optics and dynamics. However, theory and experiment so far are focused on the linear low-excitation regime with on average less than one resonant exciting photon per incident X-ray pulse, owing to a restriction of the experimentally available resonant photon flux due to the narrow nuclear linewidths. This situation has changed with the availability of seeded x-ray free electron lasers, which may provide a large number of photons within the nuclear linewidth per pulse. Nevertheless, source development remains crucial for the exploration of new regimes of Mössbauer science [1].

In this talk, I will report on a novel approach to generate intense and narrow-band x-ray radiation for Mössbauer science. It is based on relativistic electrons moving through a crystal and emitting parametric Mössbauer radiation [2]. As compared to previous approaches based on electrons from synchrotron sources [3], we consider coherently modulated electron bunches exiting from x-ray free-electron laser undulators [4], which are otherwise dumped. Due to the constructive interference between the virtual-photon fields of the different electrons in a single electron bunch, the intensity of the generated Mössbauer radiation scales with the number or electrons in the bunch squared. This coherent enhancement together with an optimization of the scattering geometry leads to an enhancement of the number of generated resonant photons per pulse by orders of magnitude as compared to previous approaches [5].

References

[1] B Adams, G Aeppli, T Allison *et al.*, arXiv:1903.09317 (2019)

[2] V G Baryshevsky, I D Feranchuk and A P Ulyanenkov, Springer Tr. Mod. Phys. **213**, (2005)

[3] O D Skoromnik, I D Feranchuk, J Evers and C H Keitel, Phys. Rev. Accel. Beams **25**, 040704 (2022)

[4] I D Feranchuk, N Q San and O D Skoromnik, Phys. Rev. Accel. Beams **25**, 120702 (2022)

[5] Z-A Peng, C H Keitel and J Evers, submitted