Contribution ID: **114** Type: **Oral presentation**

Radiation of Twisted Photons in Periodical Structures in the Classical Regime

Tuesday, 25 September 2018 17:20 (15 minutes)

It is known [1,2] that the radiation produced by classical sources may possess a well-defined projection of the angular momentum. Such a radiation is convenient to represent as a collection of the so-called twisted photons, i.e., the photons with definite the energy, the longitudinal projection of momentum, the projection of the total angular momentum, and the helicity. At present, the twisted photons find an application for fundamental science and technology (see, for review, [3-5]). There are sources and detectors of twisted photons [1-6]. However, the general formula for the probability of radiation of a twisted photon by a classical current was unknown. We derive such a formula and employ it for description of the undulator radiation. In this way, we develop the general theory of generation of twisted photons by undula-tors. Due to universality of the undulator radiation, this theory can be applied to the radiation of free electron lasers and to the channeling radiation.

We find the symmetry property of the average number of twisted photons produced by a charged particle moving along a planar trajectory. We obtain the explicit formulas for the average number of twisted photons generated by undulators both in the dipole and wiggler regimes. In particular, for the forward radiation of the ideal right-handed helical undulator, the harmonic number n of the twisted photon coincides with its projection of the total angular momentum m. As for the ideal left-handed helical undulator, we obtain that m=-n. It is found that the forward rad-iation of twisted photons by a planar undulator obeys the selection rule that n+m is an even number. We establish that the average number of twisted photons produced by the undulator and detected off the undulator axis is a periodic function of m in a certain spectral band of the quantum numbers m.

References

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Primary author: Dr KAZINSKI, Peter (Tomsk State University)

Co-authors: Dr LAZARENKO, Georgiy (Tomsk State University); Dr BOGDANOV, Oleg (LNF&TPU)

Presenter: Dr KAZINSKI, Peter (Tomsk State University)

Session Classification: S5.1 Novel Sources: FEL/Laser/Plasma