Experimental Investigation of Coherent Cherenkov Diffraction Radiation: Polarization and Spatial Properties

Pavel Karataev[1], **Sergei Alexeev**[2], **Anton Baldine**[2], **Vitold Bleko**[2], **Angelina Bulavskaya**[3], **Elizaveta Bushmina**[2,3], **Ekaterina Kidanova**[2,5], **Ivan Kishin**[4,5], **Artemiy Klenin**[4], **Vahan Kochyaryan**[6], **Alexandr Kubankin**[4,5], **Vardan Margaryan**[6], **Irina Miloichikova**[3], **Semen Mitrofanov**[2], **A. Podojnicyn**[4], **Alexander Potylitsyn**[3], **Vasiliy Semin**[2], **Sergei Stuchebrov**[3] IS

[1] John Adams Institute at Royal Holloway; University of London, Egham, United Kingdom
[2] Joint Institute for Nuclear Research, Dubna, Russia
[3] Tomsk Polytechnic University, Tomsk, Russia
[4] Belgorod National Research University, Belgorod, Russia
[5] P.N. Lebedev Physical Institute of the Russian Academy of Sciences, Moscow, Russia
[6] Institute of Applied Problems of Physics NAS RA, Yerevan, Armenia

Cherenkov Diffraction Radiation (ChDR), which occurs when a fast charged particle moves parallel to and near a dielectric interface, has become the focus of intense research. As a form of polarization radiation, ChDR arises due to the dynamic polarization of the medium. Its properties are highly sensitive to various beam parameters, including the beam size, position, direction, energy, and bunch length.

Coherent ChDR is produced when the radiation wavelength is longer than or comparable to the longitudinal size of the bunch. In this regime, all electrons radiate nearly in phase, mutually enhancing each other's emission. As a result, the radiation intensity becomes proportional to the square of the bunch charge, leading to a significant increase in photon yield.

When coherent ChDR is generated by a periodic train of bunches, the radiation fields from each bunch interfere constructively. This leads to further amplification at discrete frequencies determined by the accelerating RF frequency. This regime is known as super-radiant emission [1], and it enables the production of ultra-monochromatic radiation lines [2], with intensity governed by the single-bunch length.

In this report, we present the fundamental properties of super-radiant ChDR in the millimeter-wavelength range, as experimentally observed at the MT-25 microtron in Dubna. We will discuss the spatial distribution of the radiation in the pre-wave zone, and present an investigation into the polarization characteristics of super-radiant spectral lines at various frequencies.

We thank FLAP Collaboration for in-kind contribution and discussing the results. This research was supported by TPU development program Priority 2030. This work was partially carried out within the framework of the state assignment of the National Research University "BelSU" number FZWG-2025-0010.

References

[1] A. Gover, et al., Rev. Mod. Phys. 90, 035002 (2018).

[2] P. Karataev, et al., Scientific Reports (2020) 10:20961