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Coherent effects in the ionization loss of high-energy electron bunches

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Usually the ionization loss of a beam moving in substance is just a sum of independent losses of separate particles constituting the beam. In the present work it is shown that for beams (bunches) of sufficiently high particle density and small spatial size this rule can be considerably violated. In this case the value of the bunch ionization loss can exceed the above sum by several orders of magnitude. Such an effect is similar to the coherent effect in radiation by charged particle bunches. However, extremely large particle density of the bunch is required for manifestation of such an effect in thick targets, where the density effect [1] in the ionization loss takes place. But the condition on the particle density is significantly weakened if consider the ionization loss in sufficiently thin targets (or thin boundary layers of targets of arbitrary thickness), where the density effect is absent. The same holds for the ionization loss in rarefied gases with a much smaller value of the plasma frequency than in solids. In these cases the discussed effect can be manifested for bunch parameters, which are achievable at modern free-electron lasers (e. g., European XFEL [2]), and a series of accelerators presently under construction (e. g., SINBAD [3]). This effect can be of interest for the problems of charge particle beam diagnostics.

References

- [1] E. Fermi, Phys. Rev. 57 (1940) 485.
- [2] E. A. Schneidmiller, M. V. Yurkov, Proc. FEL 2017 Conference, Santa Fe, NM, USA, JACoW Publishing (2017) MOP033.
- [3] J. Zhu, Design Study for Generating Sub-femtosecond to Femtosecond Electron Bunches for Advanced Accelerator Development at SINBAD. PhD thesis, Hamburg, 2017.

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