Synchrotron radiation of relativistic runaway electrons

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The understanding of runaway electrons (RE) in magnetically confined plasmas is key for the success of the controlled fusion program. If not avoided or mitigated, high energy relativistic RE can significantly damage the plasma facing components of ITER. The study of synchrotron radiation (SR) of RE in these plasmas is important because it provides a limiting mechanism for the maximum energy that RE can reach, and because it can be used as an experimental diagnostic to infer RE parameters including energy and pitch-angle distributions. Here we report recent results on SR taking into account full-orbit effects and the details of the SR camera geometry. The results were obtained using the recently developed SR synthetic diagnostic [1] for the Kinetic Orbit Runaway electrons Code (KORC) [2] that computes the full-orbit relativistic dynamics in electric and magnetic fields including radiation damping and collisions. SR is studied in axisymmetric fields and in 3-D magnetic configurations exhibiting magnetic islands and stochasticity [3]. For passing particles in axisymmetric fields, neglecting orbit effects might underestimate or overestimate the total radiation power depending on the direction of the radial shift of the drift orbits. For trapped particles, the spatial distribution of synchrotron radiation exhibits localized “hot" spots at the tips of the banana orbits. The spatial distribution of synchrotron radiation in stochastic magnetic fields, obtained using the MHD code NIMROD, is strongly influenced by the presence of magnetic islands. 3-D magnetic fields also introduce a toroidal dependence on the SR spectra, and neglecting orbit effects underestimates the total radiation power. In the presence of magnetic islands, the radiation damping of trapped particles is larger that the radiation damping of passing particles. Results modeling synchrotron emission by RE in DIII-D quiescent plasmas are also presented. The computation uses EFIT reconstructed magnetic fields and RE energy distributions fitted to the experimental measurements. Qualitative agreement is observed between simulations and experiments for simplified pitch angle distributions. However, it is noted that to achieve quantitative agreement it is necessary to use pitch angle distributions that depart from simplified 2-D phase-space Fokker-Planck models.

References

[1] L. Carbajal and D. del-Castillo-Negrete, Plasma Phys. Control. Fusion, **59**, 124001 (2017).

[2] L. Carbajal, D. del-Castillo-Negrete, D. Spong, S. Seal, and L. Baylor, Phys. Plasmas, **24**, 042512 (2017).

[3] D. del-Castillo-Negrete, L. Carbajal, D. Spong, and V. Izzo, Accepted for publication Phys. Plasmas (2018).