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Polarized imaging of visible synchrotron emission from runaway electron plateaus in DIII-

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Post-disruption runaway electron (RE) beams can carry majority of flattop current and loss of RE confinement could be detrimental for continuous safe operation of tokamaks. Synchrotron emission (SE) is a great diagnostic tool for in-flight high-energy REs, but since it depends on both runaway electron density nRE and pitch angle θ, to understand RE evolution from SE, an independent measure of pitch angle is necessary. In this work we study polarized visible RE SE as a way to constrict the RE phase space and interpret data in RE mitigation experiments.
In DIII-D runaway plateau discharges, synchrotron emission was imaged in several repeat discharges with a linear polarizer in vertical (PZ) or horizontal (PX) orientation. Image average <Pz>/<Px> ratio, ranging ~ 3-14, is found to be a valuable tool to isolate pitch angle change.
Leading synthetic diagnostics tools were used to analyze SE polarization by generating SE images and modeling <Pz>/<Px> vs. θ dependence. For easier comparison of images simulated with: 1) guiding center and hollow cone radiation model in SOFT [1] and 2) full orbit and full angular radiation model in KORC [2], mono-energy (20 MeV) and mono-pitch angle (0.2 rad) RE beams were initialized in both codes and, due to analysis approach, in KORC allowed to evolve.
Simulated images reproduced experimental images well under given assumptions and returned polarization ratios 7 and 5.8, which gives ground for subsequent use of synthetic polarization ratio vs. θ to infer measured pitch angle.
SE decrease following D2 massive gas injection (MGI) into RE plateau was assumed to be related to the purge of impurities by MGI, causing a rapid drop in pitch angle due to decreased pitch angle scattering and was used to recover pitch angle evolution based on <Pz>/<Px> ratio parametrization obtained from SOFT and KORC for 20 MeV REs.
Measured/inferred pitch angle time evolution was compared with values from kinetic test particle simulations combined with a 1D impurity radial diffusion model [3], in equilibrium and non-equilibrium cases. The comparison showed good agreement in values, and while differences in the rate of change indicate further effects should be considered, considering SE polarization increases accuracy diagnosing confined high-energy REs.
[1] Hoppe, NF 58 026032, 2018
[2] Carbajal, PPCF 59 124001, 2017
[3] Hollmann, PoP 27 042515, 2020

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Speaker's Affiliation

University of California San Diego, San Diego, California, USA

Member State or IGO

United States of America

Authors: POPOVIC, Zana (UCSD); HOLLMANN, Eric M. (University of California San Diego); DEL-CASTILLO-NEGRETE, Diego (Fusion Energy Division. Oak Ridge National Laboratory); Dr BYKOV, Igor (General Atomics); MOYER, Richard (University of California San Diego); HERFINDAL, Jeffrey (UsOakRidge); SHIRAKI, Daisuke (Oak Ridge National Laboratory); EIDIETIS, Nicholas (General Atomics); Prof. PAZ-SOLDAN, Carlos (Columbia University); LVOVSKIY, Andrey (Oak Ridge Associated Universities)

Presenter: POPOVIC, Zana (UCSD)

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