ENERGY LOSS AND PITCH-ANGLE SCATTERING OF RUNAWAY ELECTRONS DUE TO KINETIC INSTABILITIES

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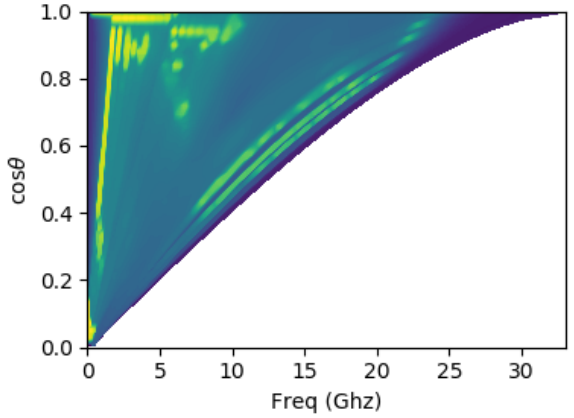
IAEA-CN-258 TH/P8-16

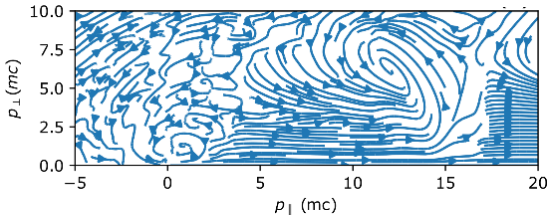
- Fan instabilities can be excited by runaway electrons in tokamak experiment due to their anisotropic distribution, with whistler waves excited.
- The instabilities can cause significant pitch-angle scattering of resonant electrons, and diffuse their energy.
  - The wave diffusion can form vortices in runaway electron momentum space, stopping it from running into higher energy.
  - The pitch-angle scattering and energy diffusion provides a new channel of runaway electron energy loss.
  - Quasilinear simulation including wave diffusion shows decaying of runaway electron population and increase of critical electric field, which agrees with experimental observations.
- ECE signals from runaway electrons can be strongly affected by fan instabilities.
  - Calculations of ECE weight function shows that only electrons in the lower energy regime with large pitch angles contribute significantly to the radiation.
  - Fan instabilities can generate such population of electrons, explain the abrupt growing ECE signals in experiments.
- Very low frequency whistler waves observed in DIII-D disruption experiments can also be explained using quasilinear theory, which can also diffuse electrons radially and even dissipate the runaway electron beam.
  - A new possible approach to mitigate runaway electrons in ITER.

C. Liu, et al., Phys. Rev. Lett. **120** 265001 (2018)
D. Spong, et al., Phys. Rev. Lett. **120** 155002 (2018)
C. Paz-Soldan, et al., Phys. Rev. Lett. **118**, 255002 (2017)

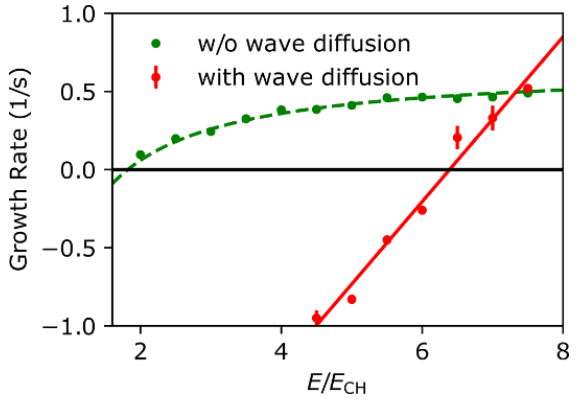
Whistler wave spectrum from simulation



Electron trajectories in momentum space affected by fan instabilities



Runaway electron growth (decay) rate varies with electric field



Abrupt growth of ECE signals from simulation due to fan instabilities