



Contribution ID: 650

Type: **Oral contribution**

3D Theory of the Ion Channel Laser

Thursday 25 September 2025 16:20 (20 minutes)

The ion channel laser (ICL) is similar to the free electron laser (FEL) but utilizes the electric field from a blowout regime plasma wake rather than the magnetic field from an undulator to oscillate particles. Compared to the FEL, the ICL can lase with much larger energy spread beams and in much shorter distances, making it an attractive candidate for a future compact plasma accelerator driven coherent light source. We present a novel full 3D theory of the ICL accounting for numerous effects including transverse guided mode shape, diffraction, frequency and Betatron phase detuning, and nonzero spread in energy and undulator parameter. This theory is used to predict the gain, radiation mode profile, gain bandwidth, and emittance and energy spread constraints of the ion channel laser.

U.S. Department of Energy, Office of Science, Office of High Energy Physics, Award Number DE-SC001796;
National Science Foundation Grant Number PHY-2047083

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Session Classification: PS5: Applications

Track Classification: PS5: Applications