Spatial distributions of laser-plasma instability in the beam overlapping region

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Multibeam beam laser-plasma instabilities (LPIs) are significant instabilities in laser-driven inertial confinement fusion (ICF), since multiple lasers will inevitably overlap in the fusion plasma. The multibeam LPI has a much higher growth rate than the single-beam LPI and its scattering direction is usually not the common backward scattering, therefore complicating the prediction of LPIs.

Some existing multibeam LPIs have already been observed to have significant impacts on ICF [1], such as cross-beam energy transfer (CBET), multibeam two-plasmon decay (TPD), common-wave stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS). However, multibeam LPI becomes complicated when the degree of freedom, such as beam number, configuration and polarization, increases. A general model for predicating the dominance of multibeam modes is still an open question.

Here, we present a model for multibeam SRS and SBS with arbitrary beam number, configuration, and polarization. The general dispersion relation for such model is derived analytically, reduced to a simplified form for numerical calculation, and verified via particle-in-cell simulations [2-4]. The dispersion relation includes combined effects of self-coupling, interaction with other beams by sharing a common scattered light (SL modes), and by sharing a common plasma wave (SP modes). The latters are two most prominent collective effects of all. We have solved the dispersion relation numerically for stimulated Raman scattering, and set different beam configurations and polarizations to discuss the spatial distributions of the temporal growth rate. The instability in the beam overlapping region is complicated, but there are still a few simple rules that govern the system, such as the dominancy of SL modes and subdominancy of backscatter and SP modes. The maximum growth rate always occurs at these special modes, or new mode combined by two or three of special modes. The reduced model provide us the ability to understand the underlying physics of multibeam instabilities under general laser and plasma conditions. We also apply this model to analyze the LPIs in the large laser facilities in China, such as SG-III laser facility and SG-Octopus.

References

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