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Theoretical studies on stimulated Raman scattering in inhomogeneous plasmas and their mitigation with broadband lasers

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The excitation of various parametric instabilities of intense lasers in plasmas and their mitigation remain a critical challenge for the realization of fusion ignition with high gains. The technical difficulties in dealing with this issue are to the fact that they are still not yet completely understood physically and the required laser technologies for beam smoothing in space and time have some limitations. In this talk, I will present our recent progress on the physics of stimulated Raman scattering (SRS) in inhomogeneous plasmas and its mitigation with broadband lasers.

Firstly, some new features associated with SRS in inhomogeneous plasmas will be discussed [1,2], including anomalous high energy electron acceleration by electron plasma waves (EPWs) due to the evolution of the EPW phase velocity, the absolute instability modes due to secondary scattering of SRS in a large inhomogeneous plasma and related hot electron generation. Secondly, we show that electromagnetic emission can also be found via linear mode conversion from EPWs excited by SRS of an incident laser pulse in inhomogeneous plasma with positive density gradients [3]. This may provide a new source of tunable broadband radiation as well as a diagnosis of the development of SRS. Thirdly, we present some examples to show how SRS could be considerably reduced with broadband laser beams, which may either have continuous spectra or be made of polychromatic laser beamlets [4-9].

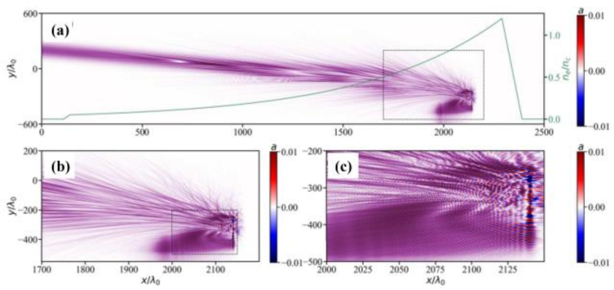

Figure 1. (a) Snapshots of the laser fields in a large-scale LPI simulation in inhomogeneous plasma using the PM2D code. (b) and (c) show the closeups of the laser fields in the dashed rectangular regions of (a) and (b), respectively.

Finally, we report the new development of the code PM1D/PM2D to simulate various laser plasma instabilities (LPIs) in large space and time scales [10,11]. The numerical noise in our code is much lower, which makes it more robust than PIC codes in the simulation of LPIs for the long-time scale above 10 picoseconds. Our PM2D code can run on GPU clusters with total mesh grids up to several billions, which meets the requirements for the simulations of LPIs at the ICF experimental scale with reasonable cost.

References

[1] X Y Jiang, S M Weng, H H Ma, C F Wu, Z Liu, M Chen, B Eliasson, and Z M Sheng, Plasma Phys. Control. Fusion 66, 035015 (2024).
[2] Y. Zhao, Z. Sheng, S. Weng, S. Ji, and J. Zhu, High Power Laser Science and Engineering 7, e20 (2019).
[3] X. Y. Jiang, S. M. Weng, H. H. Ma, X. F. Li, C. F. Wu, Z. Liu, Y. Zhao, M. Chen, and Z. M. Sheng, Phys. Plasmas 30, 022105 (2023);
[4] Y. Zhao, S.M. Weng, H.H. Ma, X.J. Bai, Z.M. Sheng, Rev. Mod. Plasma Phys. 7, 1 (2023).
[5] Z. Liu, H.H. Ma, W. Wang, X.F. Li, P.P. Wang, C. Wang, S.H. Yew, S.M. Weng, Z.M. Sheng, and J. Zhang, Nucl. Fusion 63, 126010 (2023).
[6] X. F. Li, S. M. Weng, P. Gibbon, H. H. Ma, S. H. Yew, Z. Liu, Y. Zhao, M. Chen, Z. M. Sheng, J. Zhang, Matter Radiat. Extremes 8, 065601 (2023).
[7] M. Luo, S. Hueller, M. Chen, and Z. Sheng, Phys. Plasmas 29, 032102 (2022).
[8] M. Luo, S. Hueller, M. Chen, and Z. Sheng, Phys. Plasmas 29, 072709 (2022).
[9] Y. Zhao Z. Sheng, Z. Cui, L. Ren, J. Zhu, New J. Phys. 24, 043025 (2022).
[10] H. Ma, C. Wu, S.M. Weng, S. H. Yew, Z. Liu, X. Li, S. Kawata, Z.M. Sheng, J. Zhang, Plasma Phys. Control. Fusion 63, 095005 (2021).
[11] H. Ma, L. Tan, S. Weng, W. Ying, Z. Sheng, J. Zhang, Comp. Phys. Comm. 304, 109295 (2024).