2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

A nonlinear model for the formation of plasma density grating

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Laser-induced plasma density grating (PDG) has obtained increasing attention due to its ultra-high thermal damage thresholds compared to conventional grating. Recently, the PDGs were proposed for many prospective applications in the cross beams energy transfer (CBET)[1], the manipulation of intense laser beams [2,3,4,5,6], and the plasma holograms [7,8]. The PDG is produced typically with two oppositely propagating laser beams at the moderate intensity (10^{14}-10^{16} W/cm^2) in plasma. So far the formation process of the PDG in the nonlinear stage is not yet fully understood. In this work, the whole formation process of the PDG is studied theoretically and numerically by particle-in-cell (PIC) simulations. From PIC simulations, it is found that the PDG can also be induced and grow up to a high amplitude when even two laser beams have a frequency difference. More interestingly, the geometry of the PDG can be modified by changing the frequency difference between two laser pulses, which provides a new freedom to control the PDG. In order to understand the formation process of the PDG, a nonlinear analytical model is established, which is capable of describing the nonlinear growth process of the PDG including the 'peak rupture'. The results of our analytical model are in good agreement with PIC simulations.

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Acknowledgments

The work was supported by the National Basic Research Program of China (Grant No. 2013CBA01504), National Natural Science Foundation of China (Grant Nos. 11675108, 11655002, 11721091, and 11774227), National 1000 Youth Talent Project of China, Science and Science Challenge Project (No.TZ2018005).