64th International Astronautical Congress 2013

Paper ID: 17367
oral
student

SPACE PROPULSION SYMPOSIUM (C4)
Advanced and Combined Propulsion Systems (8)

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A STUDY OF LASER PROPULSION: AN OVERDRIVEN DETONATION MODE FOR A LASER-ABSORPTION WAVE

Abstract

Propagation process of the laser-absorption wave was introduced by analysis of one-dimensional steady-state flow with heat interaction. The shock wave is sufficiently strong so that the shocked heated gas is hot enough to begin absorbing the laser irradiation. This is an analog of the chemical detonation wave that can be viewed as a shock followed by a strong deflagration. However, the velocity given by a Chapmann-Jouguet relation does not agree with the measurements. Raizer suggested that some-nonhydrodynamic ionization mechanism is more dominant than the shock wave, from the analog of overdriven detonation. Overdriven detonation is categorized into strong and weak detonation, and a pressure specific volume (p-V) diagram can describe these situations with a Hugoniot curve, a Rayleigh line and a shock adiabatic curve. Strong-overdriven detonation occurs in the presence of additional external agency acting on the gas, such a supersonic piston. However, it is difficult to show a von-Neumann spike on the shock adiabatic curve because there is no piston in this case. The weak-overdriven detonation wave is a suitable situation for the laser absorption wave because the laser absorption occurs ahead and afterwards behind the shock wave. The pressure increases continuously from the preionized layer to the back surface of the laser absorption layer. To investigate the LSD states following the theory of chemical detonation, the shadowgraph visualization and pressure measurement are utilized for the laser-supported detonation. As a result, the pressure of plasma front was 16.4 atm. The velocity of laser-detonation was less than 3,000 m/s. The p-V diagrams drawn by experimental results reveal that the laser-detonation is the over-driven detonation state and chooses the weak-solution. The reason being that, the plasma expansion plays a role as piston that pushes the shock wave during high laser irradiation. Furthermore, the heating layer is broadened in front of and behind the shock wave. The weak solution is possible because the compression is continuous from the front surface of the plasma layer until the back surface.