Student Name: Ofosu Joseph Ampadu Student ID №: 47-126068
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Supervisor: Professor Komurasaki Kimiya

Influence of the ambient gas content on the propagation properties of laser supported detonation wave: A case study on Argon and Nitrogen gases

－雰囲気ガスがレーザー支持爆轟波の伝播特性に与える影響: アルゴンと窒素の比較－

Key Words: Laser supported detonation (LSD), 2-wavelength Mach-Zehnder interferometry, Optical Emission Spectroscopy, Electron number density distribution, Electron excitation temperature

Abstract

Laser propulsion technology is potentially capable of influencing the design of rockets with an advantageous combination of the requisite performance characteristics such as high specific impulse and high thrust as well as low propulsion weight since the source of energy need not be carried on-board. Hence, as a beamed energy propulsion concept and a future propulsion system, it is vital to understand the sustenance and termination conditions of the laser supported detonation (LSD) wave, which enhances efficient thrust generation.

In this study, different ionization front velocities of different gas species namely: Air, Argon (Ar) and Nitrogen (N_2), were experimentally observed with respect to laser intensity per unit density. The aim of the study was to predict the LSD wave velocity prior to its termination using a 1-D radiative hydrodynamic model. Thus estimated ionization front velocities (obtained from the 1-D radiative model and measured parameters) were compared with measured ionization front velocities in Ar and N_2. The rationale was to compare a monoatomic and a diatomic gas. The diagnostics tools used were two-wavelength Mach-Zehnder interferometry and optical emission spectroscopy.

The model predicted the LSD wave velocities precisely in terms of tendency but not accurately. This is due to the dimensional, translational ionization frequency and molecular ionization assumptions of the model. The computed flux and corresponding estimated front seed electron number density in both Ar and N_2 indicated and further validated the applicability of the model to other gases by corroborating measured results.