【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Discharge Induced in a High-Energy Electromagnetic Beam and its Engineering Applications

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Research Area : General Engineering
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【Purpose and Background of the Research】

Discharge induced in a high-energy electromagnetic-wave beam drives optical detonation, in which electromagnetic-wave energy is efficiently converted to gas pressure. This phenomenon can be used in many engineering applications. Figure 1 shows high-speed camera images of discharge front in a laser beam and a millimeter-wave beam. Discrete plasma structure was observed in a millimeter-wave beam, and filamentary plasma structure was observable in a long exposure image. These phenomena cannot be explained by the conventional detonation theory.

In this project, a high-energy optical detonation is induced in one-dimensional setup, and a scaling law effective for both laser and millimeter-wave discharge is developed. And, the law is extended to a 3-D computational code for future study on large-scale high-power wireless applications.

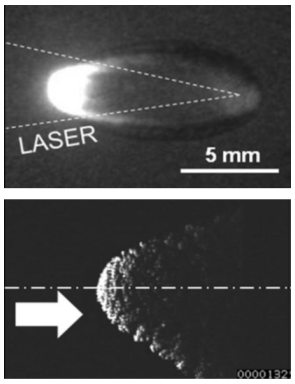

Figure 1 Atmospheric discharge driven by a laser beam (top) and a millimeter-wave beam (bottom).

【Research Methods】

First, one-dimensional experimental setup will be conducted, varying frequencies and ambient conditions of gas species. We study its geometrical features such as the filament pitch in millimeter-wave discharge, while we measure distributions of plasma parameters in the laser discharge. Second, a physical model will be developed to reproduce using a universal transport equation and a common ionization model. And then, develop a simulation code.

Finally, we'll evaluate various application devices/systems using millimeter-wave/laser discharge by the developed simulation code.

【Expected Research Achievements and Scientific Significance】

Until now, atmospheric discharges by millimeter-wave and laser have not been clearly explained. With recent development of a high power generator (gyrotron), experimentation in the intensity range around 0.1 MW/cm^2 has just started. Thus, our objective is to construct a universal plasma/discharge model in this intensity range while referring to streamer discharge and laser supported detonation.

For engineering applications, we expect that this study would lead to the development of future space infrastructure advanced space projects, such as a space launcher propelled by millimeter wave and laser beams, a megawatt to gigawatt class wireless power transfer/energy conversion system, and a detonation-driven plasma wind tunnel.

【Publications Relevant to the Project】

1)Replacement of Chemical Rocket Launchers by Beamed Energy Propulsion, M. Fukunari, K. Komurasaki, *et al.*, *Applied Optics*, Vol. 53, No. 31, pp. 16-22, 2014.

2) Precursor ionization and propagation velocity of a laser-absorption wave in 1.053 and 10.6 μm wavelengths laser radiation, K. Shimamura, K. Komurasaki, J. A. Ofosu, and H. Koizumi, *IEEE Transactions on Plasma Sciences*, Vol.42, No.10, pp.3121-3128, 2014

【Term of Project】 FY2015-2019

【Budget Allocation】 154,500 Thousand Yen

【Homepage Address and Other Contact Information】

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