Computational Code Development of a Collisional-Radiative Model for Nonequilibrium Flows

Project Leader
OGINO, Yousuke, Ph.D.
Assistant Professor, Intelligent Mechanical Systems Engineering

1. Objective

This project is aimed at:

In most aerospace applications of air plasma flow (hypersonic flow around a reentry body, laser- driven blast wave, plasma processing techniques using electric discharges, and so on), it is well known that plasma internal states do not achieve local thermodynamic equilibrium. By considering the non-equilibrium properties of the population distribution in each plasma internal state, more reliable numerical prediction can be provided, because the properties directly affect radiative emissivities and opacities, partition functions of internal energy modes, and thermal relaxations processes. The goal of this computational work is to develop a collisional-radiative solver coupled with flow equations and radiative heat transfer equations to clarify the fundamental physics in the non-equilibrium flowfields.

2. Project Outline

To that end, the project will consist of the following phases:

(a) Multi-physics numerical simulation of plasma flows
(b) Development of a comprehensive understanding of non-equilibrium properties
(c) Numerical analysis of the radiative heat transfer

3. Expected Performance

In this project, the successful candidate would be expected to:

(a) Working independently, develop a code for compressible flowfields
(b) Develop the coupling code for hypersonic flow, collisional-radiative models, and radiation transfer
(c) Assist with the maintenance/repair of our workstation clusters

4. Required Skills and Knowledge

The successful candidate for this project will have the following knowledge and skills:

(a) Fundamental knowledge of compressible CFD (computational fluid dynamics)
(b) Fundamental knowledge of plasma physics, thermodynamics, statistical physics, chemical reactions, and molecular quantum mechanics
(c) Resilient character and abundant intellectual curiosity

References

1. Yousuke Ogino and Naofumi Ohnishi, “A Collisional-Radiative Code for Computing Air Plasma in High Enthalpy Flow,” *Shock Waves*, Vol. 21, issue 3, pp. 289–299, June, 2011.
2. Yousuke Ogino, Atsushi Nagano, Tomoaki Ishihara, and Naofumi Ohnishi, “A Fitting Formula for Radiative Cooling Based on Non-local Thermodynamic Equilibrium Population from Weakly-ionized Air Plasma,” *Journal of Physics: Conference Series*, Vol. 454, No. 012080, pp. 1–10, August, 2013.
3. Yousuke Ogino, Kosuke Totani, and Naofumi Ohnishi, “Nonequilibrium Plasma Flow Computation

with Atomic and Molecular State Transitions," 53rd AIAA Aerospace Sciences Meeting, AIAA Paper 2015-0979, pp. 1–9, January, 2015.

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Contact
E-mail: ogino.yousuke@kochi-tech.ac.jp