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# Laser Thomson Scattering Measurement around Magnetized Body in Rarefied Arc-Heated Flow

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Magnetohydrodynamic (MHD) aerobraking [1] (Fig. 1) is expected to be a new thermal protection system for planetary atmospheric entry vehicles. It can actively control the weakly ionized plasma in the shock layer ahead of the planetary entry vehicle using Lorentz force generated by an onboard magnet. The Lorentz force enlarges the high temperature shock layer and exerts the reaction force on the magnet. The shock layer enlargement directly reduces the heat flux to the vehicle. And the deceleration by the reaction force drastically reduces the total heating amount through the entry trajectory.

Several researchers have recently conducted experiments using arc-jet wind tunnels [2] and expansion tubes [3] to investigate the MHD aero-breaking effect. As a result, these studies demonstrated the MHD effects in dense flow at low altitudes. However, the MHD effects in rarefied flows at high altitudes remain unclarified because the Hall effect, which becomes strong in rarefied flow, complicates the Lorentz force generation mechanism.

As a first step toward understanding this mechanism, we investigated the ambient pressure dependency of the drag force of the magnetized body in a rarefied argon arc-jet wind tunnel (Fig. 2) [4]. However, the pressure dependency of the drag was different from that of our computational fluid dynamic (CFD) analysis.

To clarify the reason of this disagreement, we recently measure the electron temperature and density around the magnetized body in the rarefied arc flow using the laser Thomson scattering method [5].

Figure 3 shows the example of the measured Thomson scattering image and its spectrum at 5 mm in front of the body without magnet. The measured electron temperature and density are 0.4 eV and 3.6×10$^{19}$ m$^{-3}$, respectively. In the cases without the magnet, the measured temperature and density qualitatively agree with the CFD predictions, as shown in Fig. 4.

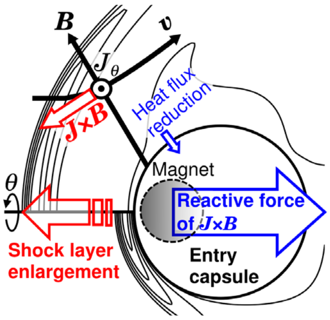

Fig. 1 MHD aerobraking

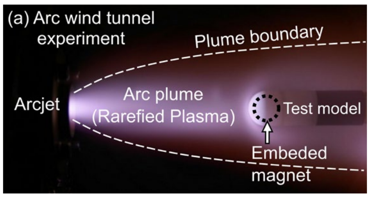

Fig. 2 MHD experiment using rarefied arcjet wind tunnel

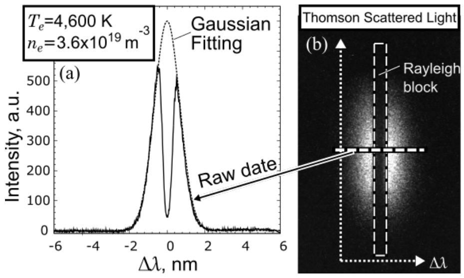

Fig. 3 Thomson scattered light and its spectra

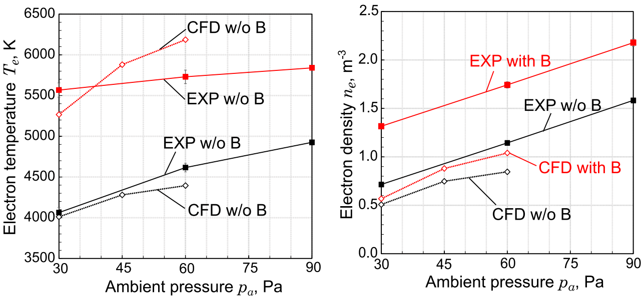

Fig. 4 Ambient pressure dependency of electron temperature and density

However, in the case with the magnet, the experimental and computed pressure dependencies of electron temperature and density are different. To clarify this discrepancy, we now try to measure the radial and axial distribution of electron temperature and density with and without the magnet.

## References

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