Impacts of reentry plasma sheaths on the radiation performance of THz array antenna

Rongxin Tang* (1), Kai Yuan (1), and Ziyang Zhao(1)
(1) Nanchang University, Nanchang, China; e-mail: rongxint@ncu.edu.cn; y_k_phy@163.com; zhaozy006@163.com.

Reentry hypersonic vehicles in near space normally move hypersonically. Aerothermal heating due to the compression of air would result in the generation of numerous free electrons[1]. Therefore, the hypersonic vehicles used to be enveloped by weakly ionized plasmas, which is the so-called 'plasma sheath'. Those plasma sheath could affect the performance of onboard high frequency antennas and yield communication blackout, which seriously threats the reentry vehicles. On the other hand, the parameters of a plasma sheath are modulated by many factors. For example, atmospheric conditions, flight speed, angle of attack, and the shape of the vehicle[2,3]. In the recent decade, the terahertz (THz) communication is considered to be a potential approach to mitigate the communication blackout. Yet, it should be aware that the dense and inhomogeneous free electron surrounding a reentry vehicle could impact radiation parameters of the onboard THz antenna[4,5].

In the present study, the impact of plasma sheaths on onboard THz antenna was investigated. The radiation performances of a 0.14 THz phase array antenna in plasma layers were modeled numerically. The antenna performance was compared with the aspects of mainlobe gain, mainlobe direction, and mainlobe width. The study showed that the antenna gain and the lobe width were impacted by both electron density and electron collision frequency. However, the lobe direction is influenced by the electron density only. Analysis on the mechanics of communication quality worsened in the expected direction were carried out based on the study. Moreover, suggestions of onboard antenna design to suppress the worsening of the onboard THz antenna are proposed in order to improve the communication quality. The present study would be helpful in solving the 'blackout' problems.

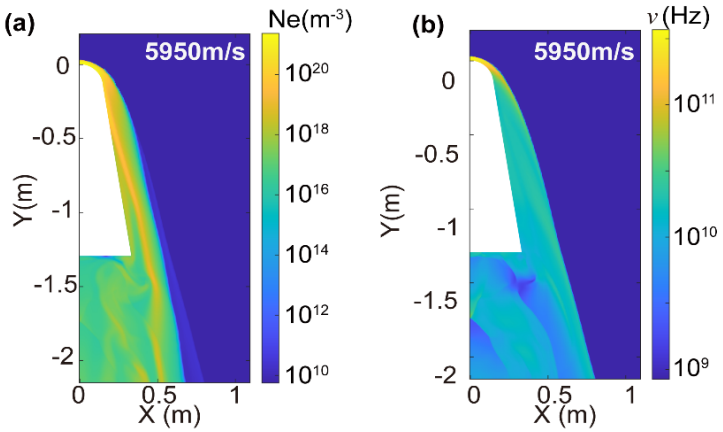

Figure 1. The electron density (a) and the electron collision frequency (b) distributions during the reentry stage of a blunt nose vehicle at the flight speed of 5950 m/s.

References

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