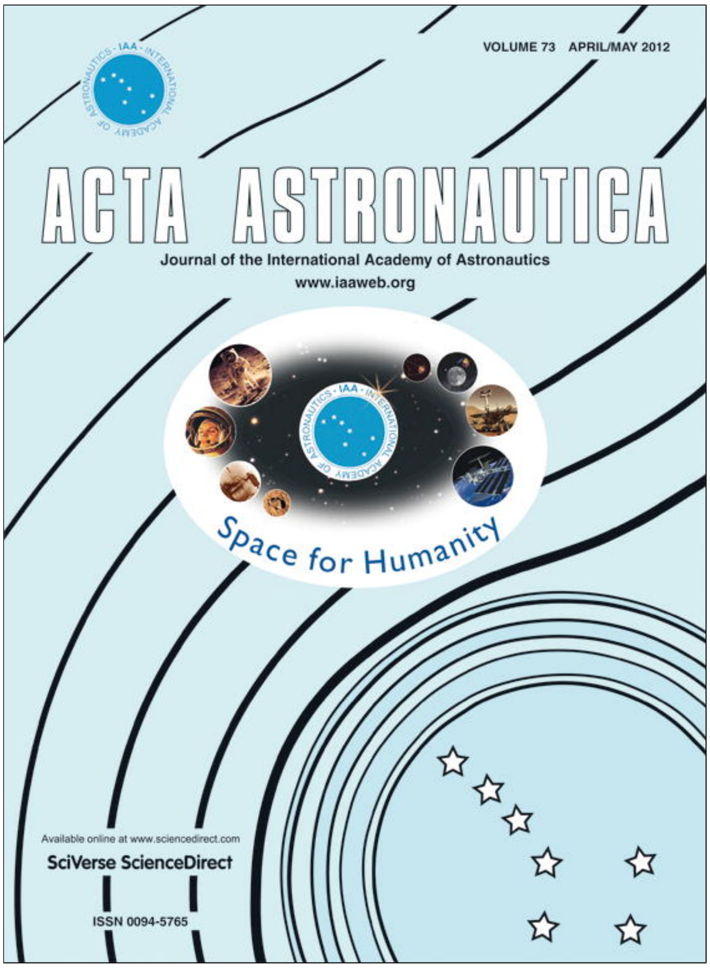
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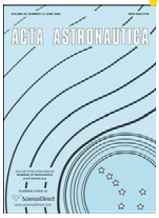

Transient analysis of counterflowing jet over highly blunt cone in hypersonic flow

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ABSTRACT

Understanding the characteristics of various Counterflowing jets exiting from a nose cone is crucial for determining heat load reduction and usage of this device in various conditions. Such jets can undergo several flow regimes during venting, from initial supersonic flow, to transonic, to subsonic flow regimes as the pressure of jet decreases. A bow shock wave is a characteristic flow structure during the initial stage of the jet development, and this paper focuses on the development of the bow shock wave and the jet structure behind it. The transient behavior of a sonic counterflow jet is investigated using unsteady, axisymmetric Navier–Stokes solved with SST turbulence model at free stream Mach number of 5.75. The coolant gas (Carbon Dioxide and Helium) is chosen to inject into the hypersonic air flow at the nose of the model. The gases are considered to be ideal, and the computational domain is axisymmetric. The jet structure, including the shock wave and flow separation due to an adverse pressure gradient at the nose is investigated with a focus on the differences between high diffusivity coolant jet (Helium) and low diffusivity coolant jet (CO_2) flow scenarios.

1. Introduction

High speed vehicles are designed to withstand severe aerodynamic heating conditions. Such vehicles include hypervelocity projectiles, re-entry vehicles and hypersonic aircraft. Even with the use blunt cones the heat transfer in the nose region, where the flow almost stagnates, is high enough that conventional materials cannot withstand the associated high temperatures. The safety of the hypersonic vehicles is thus ensured by providing appropriate thermal protection system. Several techniques have been developed with the target of significantly reducing the aerodynamic heating of blunt nose cones. Various techniques such as concentrated energy deposition along the stagnation streamline, retractable aerospikes ahead of the blunt body, forward-facing jet in the stagnation zone of a blunt body, and also supersonic projectiles fired in the upstream direction from the stagnation zone are being evaluated by many research groups around the world for keeping the heating of the blunt body to acceptable levels during its atmospheric ascent [1–6]. Also, several numerical simulations were currently done in order to analyze of flow field of each technique [7–9]. Although, mechanical spike and ablator are currently used for thermal protection systems, the use of a counterflowing jet adjusted at the nose cone of the hypersonic vehicle seems to be the most effective and reusable method.

In recent years, there has been strong interest in using weakly ionized nonequilibrium plasma (WINP) jets to reduce wave drag and heat flux of bodies in supersonic and hypersonic flows. More recent works [10–14] have revealed that various shock-dissipating and anomalous effects are produced by WINP jets in high-speed flows. These experiments also revealed short penetration mode

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