Investigation of the unsteady Edney type IV and VII shock-shock interaction

$\begin{array}{c} {\bf Christian \ Windisch^1 \dagger, \ Birgit \ Reinartz^2} \\ {\bf and \ Siegfried \ Müller^3} \end{array}$

¹German Research School for Simulation Sciences, RWTH Aachen University, 52056 Aachen, Germany

²Chair for Computational Analysis of Technical Systems, RWTH Aachen University, 52056 Aachen, Germany

³Institut für Geometrie und Praktische Mathematik, RWTH Aachen University, 52056 Aachen, Germany

Edney type IV and type VII shock-shock interactions are complex hypersonic flow phenomena. They are characterized by a supersonic jet which reaches far into the flow field. An experimental investigation of the inner jet structure is difficult, especially in cases where the jet is subject to high-frequency unsteady movements. The present paper provides insight into the jet structure by means of a highly-resolved Computational Fluid Dynamics analysis in thermochemical nonequilibrium. Simulations of an Edney type IV interaction in nitrogen flow are presented. Multiple resolution levels support the identification and analysis of the mechanisms of the jet unsteadiness. The second configuration is an Edney type VII interaction. This shock-shock interaction type was observed and defined in nitrogen flow by Yamamoto et al. The present results demonstrate that this interaction may also be observed in CO_2 -dominated flow with a gas composition similar to the Martian atmosphere. The results provide insight into the jet structure of this less known interaction.

Key words: Hypersonic flows, shock-shock interaction, grid adaptation, thermochemical nonequilibrium.

1. Introduction

The proper prediction of thermal and structural loads is crucial for the design of future space transportation systems. Especially the thermal and structural loads caused by shock-shock interactions may pose significant restrictions on the overall system. Shockshock interactions are frequently found in supersonic and hypersonic flow fields and are characterized by a wide range of relevant flow phenomena on different length scales. Pertinent examples of shock-shock interactions are the Edney type IV interaction, cf. Lind & Lewis (1995), as well as the less known Edney type VII interaction, which was defined by Yamamoto *et al.* (1999). These configurations are the result of an incident shock wave which impinges on the bow shock in front of a blunt body. A supersonic jet forms between two triple points and reaches far into the subsonic region behind the bow shock.

The Edney type IV interaction is frequently used in theoretical and experimental investigations as it leads to high aerothermal loads on the body surface. Depending on

† Email address for correspondence: windisch@igpm.rwth-aachen.de