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MEMORANDUM FOR PRS (In-House Contractor Publication)

FROM: PROI (STINFO)

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15 May 2002

SUBJECT: Authorization for Release of Technical Information; Control Number: **AFRL-PR-ED-AB-2002-113**
David Campbell (ERC), "DSMC Study of Flowfield and Kinetic Effects on Vibrational Excitations in Jet-Freestream Interactions"

23rd International Symposium on Rarefied Gas Dynamics
(Whistler, Canada, 21-25 July 2002) (Deadline: 01 June 2002)

(Statement A)

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

DSMC Study Of Flowfield And Kinetic Effects On Vibrational Excitations In Jet-Freestream Interactions

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ABSTRACT

Vibrational excitation of molecular species emitting from a jet into a high-speed freestream is a process with importance to the prediction of high-altitude rocket exhaust plume infrared emissions. Accurate predictions of these emissions are necessary for the analysis of potential optical interference of on-vehicle instrumentation. Unfortunately, accurate vibrational excitation collision cross sections are not always available for the species pairs of interest and for the high relative energies encountered in this situation. In addition, accurate nozzle exit plane flowfield characteristics are always a challenge to calculate accurately.

The results of a study to characterize the sensitivity of predicted vibrational excitation to the vibrational excitation cross section and the nozzle exit plane profile will be presented in this paper. The Direct Simulation Monte Carlo (DSMC) computational technique was used to simulate the interaction between a carbon monoxide jet and a high velocity freestream of oxygen atoms oriented at 90° to the jet flow axis at 150km simulated altitude. A literature value of the vibrational excitation cross section is used as a baseline, and comparative simulations are made for cross sections that vary around that value. Similarly, the nozzle exit plane profile is varied from a "flat" profile to a fully developed laminar boundary layer profile to obtain sensitivities to the jet inflow startline.

SMILE, a software system based on the DSMC method, developed at the Institute of Theoretical and Applied Mechanics, Novosibirsk, Russia, has been utilized for this study. This code is capable of fully 3-D parallel calculations, and has a graphical user interface, xSMILE that automates the process of setting up a case, running the main SMILE code, and obtaining output in a useable form.