NASA SBIR/STTR Technologies

A4.01-8847 - Optical Mach Probe

PI: Daniel Bivolaru
Michigan Aerospace Corporation - Ann Arbor, MI

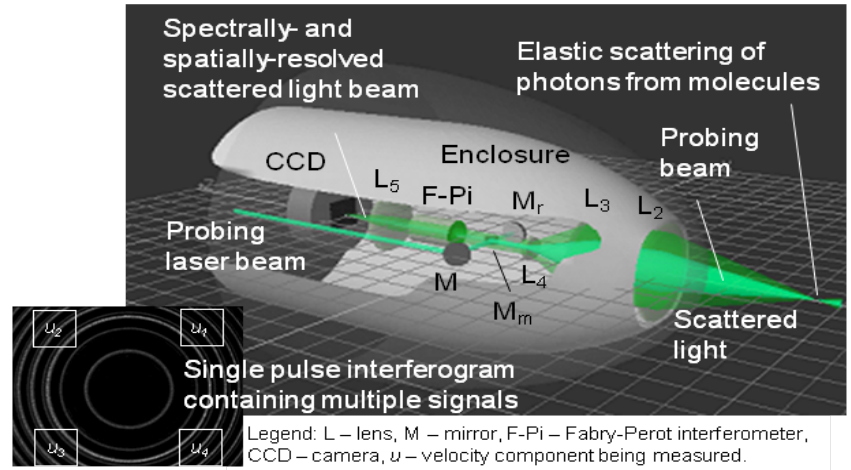
Identification and Significance of Innovation

Nonintrusive diagnostics techniques capable of simultaneously obtaining multiple fluid properties are critical for aerospace testing of flows about vehicles, components, and structures as well as for use in basic fluid mechanical research. Michigan Aerospace Corporation (MAC) proposes to demonstrate the concept feasibility of a nonintrusive Optical Mach Probe (OMP) to obtain simultaneously the flow Mach number and the flow direction among the flow density, temperature, and the velocity. Other turbulence-specific parameters, such as components of the stress and heat flux tensors and the mean values and fluctuations of properties, are obtained from these measurements.

This proposed research work is consistent with NASA's goal to develop and demonstrate nonintrusive measurement technologies to increase capabilities and characterize ground test facility flow performance in terms of flow quality, turbulence intensity, and Mach number measured up to and including hypersonic speed regimes.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 3)

Non-intrusive Mach number and Flow Angularity Probe



Legend: L – lens, M – mirror, F-Pi – Fabry-Perot interferometer, CCD – camera, u – velocity component being measured.

Technical Objectives and Work Plan

Technical Objectives:
Objective 1: Determine the range of applicability through both analytical and computational approaches.
Objective 2: Perform optical, electrical, and mechanical design and simulation of a prototype instrument.
Objective 3: Develop and perfect the required instrument specific software tools.

Work Plan:
--Scope: The scope of the Phase I effort is to design and simulate an optical probe to measure, in a nonintrusive manner, the flow Mach number and the flow direction. The instrument will analyze Rayleigh scattered light from molecules to obtain simultaneously the flow velocity, temperature and density, and calculate the Mach number and the flow direction together with other turbulent specific properties.
--Task 1: Requirements Definition: Establish the baseline requirements for the instrument.
--Task 2: Instrument design and Simulation: Perform design studies through modeling to determine the hardware and software requirements for the instrument.
--Task 3: Development of Specific Software Processing Tools: Develop routines to obtain flow properties from spectroscopic data and minimize processing errors.
--Task 4: Documentation and Reporting: Complete design plan to serve as the reference for the fabrication and tests of the prototype instrument in Phase II.
--Managerial plan include timelines and milestones for the proposed research

NASA Applications

The proposed non-intrusive Optical Mach Probe is essential across multiple aerospace ground and flight research support facilities in characterizing and understanding of the complex flow behavior in terms of flow quality, turbulence intensity, and Mach number measured up to and including hypersonic speed regimes. The probe also could be used for on-board monitoring of vehicle dynamics and propulsion processes as well as in aiding the development of new computational models.

Non-NASA Applications

Other organizations (US Air Force, US Navy, etc.) and prime contractors will have similar uses for this technology. Also, the academic and scientific community will have use for the instrument for high speed flow studies and CFD modeling.

Firm Contacts

Daniel Bivolaru
Michigan Aerospace Corporation
1777 Highland Drive, Suite B
Ann Arbor, 481082285
PHONE: (734) 975-8777
FAX: (734) 975-0239

NON-PROPRIETARY DATA