National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Optics

Beam Crossing Optical System

Novel system enabling 2-point Focused Laser Differential Interferometry

NASA's Langley Research Center has developed a Beam Crossing Optical System for use in two-point Focused Laser Differential Interferometers (FLDI) that are used in measuring density disturbances in hypersonic flows. Conventional single point FLDI systems only measure how flow fluctuates. In contrast, with the two-point system, velocity can be measured between the two points to compute spatial changes and measure fluctuating flow. In this design, laser beams propagating between the transmitter and receiver sides of the FLDI instrument remain parallel to one another so that velocity bias errors that occur in the conventional testing region with angled beams are eliminated, increasing accuracy and decreasing uncertainty of sensitivity measurements. The technology offers a lower-cost (half the cost) alternative to a Nomarski Prism approach and enables increased manipulation capabilities for the user, such that the separation distance between points and laser beam orientation can be manually adjusted with ease.

BENEFITS

- Enables simultaneous two-point measurement capability: Easily incorporated into a conventional single-point FLDI instrument to offer two-point measurements
- Eliminates velocity bias errors: Ensures the laser beams propagating between the transmitter and receiver sides of the FLDI instrument remain parallel to one another
- Permits tunable adjustments: The laser beams remain symmetric about the FLDI instrument's optical axis, enabling the user to quickly adjust the orientation of the laser beams by simple rotation of the proposed optical system technology
- Provides a more cost-effective approach to FLDI: The hardware of the new NASA system costs 50% of Nomarski Prism
- Promotes user manipulation of separation distance: Design allows for easy-to-make changes to precisely align the crossing point of the beams
- Polarizing prism flexibility: The relative rotation of the wedged prism pairs allows the system to operate as a variety of adjustable polarizing prisms (e.g., Nomarski, Wollaston, Rochon, beam displacer, etc.)

APPLICATIONS

The technology has several potential applications:

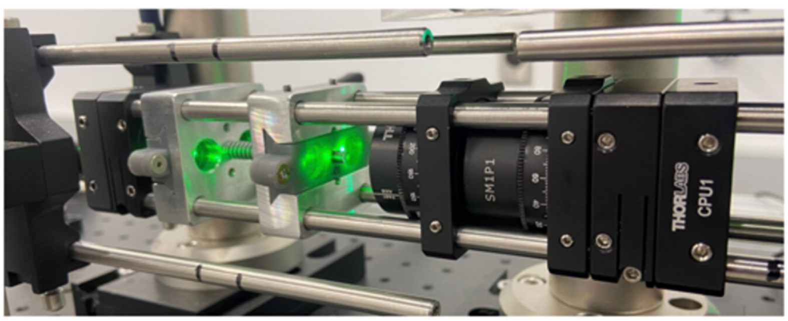
- Medical Research: Differential Interference Contrast (DIC) Microscopy for cell investigation
- Gas Leak Monitoring: Use in Laser-Induced Thermal Acoustics (LITA) for gas sensing

THE TECHNOLOGY

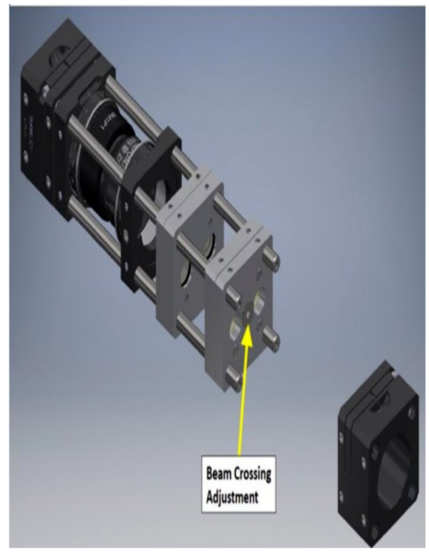
The conventional approaches for measuring focused laser differential interferometry either use a single-point mechanism that cannot calculate velocity or a system that creates non-parallel beams in the testing zone, causing differences in time to travel between beams throughout the testing zone, adding a level of uncertainty to velocity measurements.

For this technology, the inventors determined that the best approach is to use a method that ensures all laser beams propagating between the transmitter and receiver sides of the instrument are parallel to one another. This is done by crossing two orthogonally polarized beams at a Wollaston prism located just ahead of the field lens on the transmitter side of the FLDI. The polarization orientation of the two crossing beams must be at ±45 degrees to one another so that the Wollaston prism can further split the beams by a small angle (this gives the instrument its sensitivity to density fluctuations at each measurement point).

The use of wedge prisms (that comprise the beam crossing system) to redirect the split beams such that they cross the optical axis minimizes any distortion imparted to the beams. This is in contrast to the use of a spherical focusing lens to redirect the split beams, which can impart undesirable distortions to the beams and affect the focusing properties of the FLDI instrument between its transmitter and receiver sides.



Novel two-point optical system installed in a larger experimental setup for Focused Laser Differential Interferometry testing. The green laser light is seen passing through the two sets of wedged windows.



Perspective CAD rendering of proposed NASA optical system with novel beam crossing adjustment (as shown by arrow) to enable a testing zone with parallel beams.

PUBLICATIONS

Patent No: 11,796,306

Patent Pending

More Information

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LAR-19867-1-CON, LAR-19867-1, LAR-TOPS-346