



Optical Comb From a Whispering Gallery Mode Resonator for Spectroscopy and Astronomy Instruments Calibration

This technology can be used for surveillance of the Earth from space.

NASA's Jet Propulsion Laboratory, Pasadena, California

The most accurate astronomical data is available from space-based observations that are not impeded by the Earth's atmosphere. Such measurements may require spectral samples taken as long as decades apart, with the 1 cm/s velocity precision integrated over a broad wavelength range. This raises the requirements specifically for instruments used in astrophysics research missions — their stringent wavelength resolution and accuracy must be maintained over years and possibly decades. Therefore, a stable and broadband optical calibration technique compatible with spaceflights becomes essential. The space-based spectroscopic instruments need to be calibrated *in situ*, which puts forth specific requirements to the calibration sources, mainly concerned with their mass, power consumption, and reliability.

A high-precision, high-resolution reference wavelength comb source for astronomical and astrophysics spectroscopic observations has been developed that is deployable in space. The optical comb will be used for wavelength calibrations of spectrographs and will enable Doppler measurements to better than 10 cm/s precision, one hundred times better than the current state-of-the-art.

The concept leverages the progress of wide-span frequency comb generation in frequency standards and metrology. The source consists of a crystalline whispering gallery mode (WGM) microresonator, a near-IR tunable single-frequency CW (continuous wave) laser, an FM (frequency modulated) spectroscopy unit, and control and stabilization electronics. The coupling in and out of the resonator is fiber-based

through the evanescent waves. This approach is based on an external laser coupled to the Kerr-media WGM resonator.

This novel precision comb provides a new generation of super-stable, evenly spaced, and wideband wavelength calibration sources. In addition, this source does not age as the lamps do. Presently, this approach allows users to achieve an absolute accuracy of better than 10^{-12} per day when referenced to a suitable atomic transition.

The improved Doppler measurement accuracy and resolution will significantly enhance the current astronomy observation capability in exoplanet search and the study of cosmology dynamics.

This work was done by Dmitry V. Strelkov, Nan Yu, and Robert J. Thompson of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48135

Real-Time Flight Envelope Monitoring System

The system uses a combination of three separate detection algorithms to provide a warning at a preset number of degrees prior to stall.

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The objective of this effort was to show that real-time aircraft control-surface hinge-moment information could be used to provide a robust and reliable prediction of vehicle performance and control authority degradation. For a given airfoil section with a control surface — be it a wing with an aileron, rudder, or elevator — the control-surface hinge moment is sensitive to the aerodynamic characteristics of the section. As a result, changes in the aerodynamics of the section due to angle-of-attack or environmental effects such as icing, heavy rain, surface contaminants, bird strikes, or battle damage will affect the control surface hinge moment. These changes include both the magnitude of the hinge moment and its sign in a

time-averaged sense, and the variation of the hinge moment with time. The current program attempts to take the real-time hinge moment information from the aircraft control surfaces and develop a system to predict aircraft envelope boundaries across a range of conditions, alerting the flight crew to reductions in aircraft controllability and flight boundaries.

The concept was tested across a wide range of conditions and observed in-flight contamination, and a system and methodology of using the hinge-moment information to predict sectional airfoil stall in the presence of these contaminants was developed. An experimental test program was designed to provide the broadest test of the hinge

moment monitoring concept. A NACA 3415 airfoil section with a 25-percent chord flap was tested with a series of simulated aerodynamic contaminants. These contaminants were designed to provide a range of simulated environmental and structural hazards, which would produce varying degrees of performance degradation, primarily in the form of premature stall and loss of maximum lift. These simulated cases included both leading-edge glaze and rime ice, both moderate and severe leading-edge roughness, and both a simulated 3D leading-edge and a simulated upper surface damage case.

Data from the experimental tests were used to develop a stall prediction methodology and detection algorithm