Physical Sciences

Method for Accurately Calibrating a Spectrometer Using Broadband Light

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A novel method has been developed for performing very fine calibration of a spectrometer. This process is particularly useful for modern miniature charge-coupled device (CCD) spectrometers where a typical factory wavelength calibration has been performed and a finer, more accurate calibration is desired. Typically, the factory calibration is done with a spectral line source that generates light at known wavelengths, allowing specific pixels in the CCD array to be assigned wavelength values. This method is good to about 1 nm across the spectrometer's wavelength range. This new method appears to be accurate to about 0.1 nm, a factor of ten improvement.

White light is passed through an unbalanced Michelson interferometer, producing an optical signal with significant spectral variation. A simple theory can be developed to describe this spectral pattern, so by comparing the actual spectrometer output against this predicted pattern, errors in the wavelength assignment made by the spectrometer can be determined.

The primary unique feature of this innovation is its ability to calibrate every pixel across a given wavelength range as opposed to only calibrating a few pixels and interpolating the other values as is currently done.

This work was done by Stephen Simmons and Robert Youngquist of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13331

Catalytic Microtube Rocket Igniter

This device can also be used on commercial combustion devices such as furnaces, power generators, and gas-fueled cooking appliances like grills, ranges, and ovens.

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Devices that generate both high energy and high temperature are required to ignite reliably the propellant mixtures in combustion chambers like those present in rockets and other combustion systems. This catalytic microtube rocket igniter generates these conditions with a small, catalysis-based torch. While traditional spark plug systems can require anywhere from 50 W to multiple kW of power in different applications, this system has demonstrated ignition at less than 25 W. Reactants are fed to the igniter from the same tanks that feed the reactants to the rest of the rocket or combustion system. While this specific igniter was originally designed for liquid methane and liquid oxygen rockets, it can be easily operated with gaseous propellants or modified for hydrogen use in commercial combustion devices.

For the present cryogenic propellant rocket case, the main propellant tanks — liquid oxygen and liquid methane, respectively — are regulated and split into different systems for the individual stages of the rocket and igniter. As the catalyst requires a gas phase for reaction, either the stored boil-off of the tanks can be used directly or one stream each of fuel and oxidizer can go through a heat exchanger/vaporizer that turns the liquid propellants into a gaseous form. For commercial applications, where the reactants are stored as gases, the system is simplified. The resulting gas-phase streams of fuel and oxidizer are then further divided for the individual components of the igniter.

One stream each of the fuel and oxidizer is introduced to a mixing bottle/apparatus where they are mixed to a fuel-rich composition with an O/F mass-based mixture ratio of under 1.0. This premixed flow then feeds into the catalytic microtube device. The total flow is on the order of 0.01 g/s. The microtube device is composed of a pair of sub-millimeter diameter platinum tubes connected only at the outlet so that the two outlet flows are parallel to each other. The tubes are each approximately 10 cm long and are heated via direct electric resistive heating. This heating brings the gasses to their minimum required ignition temperature, which is lower than the auto-thermal ignition temperature, and causes the onset of both surface and gas phase ignition producing hot temperatures and a highly reacting flame.

The combustion products from the catalytic tubes, which are below the melting point of platinum, are injected into the center of another combustion stage, called the primary augmenter. The reactants for this combustion stage come from the same source but the flows of non-premixed methane and oxygen gas are split off to a secondary mixing apparatus and can be mixed in a near-stoichiometric to highly lean mixture ratio. The primary augmenter is a component that has channels venting this mixed gas to impinge on each other in the center of the augmenter, perpendicular to the flow from the catalyst. The total cross-sectional area of these channels is on a similar order as that of the catalyst. The augmenter has internal channels that act as a manifold to distribute equally the gas to the inward-venting channels. This stage creates a stable flame kernel as its flows, which are on the order of 0.01 g/s, are ignited by the combustion products of the catalyst. This stage is designed to produce combustion products in the flame kernel that exceed the autothermal ignition temperature of oxygen and methane.

While these combined components will mix and produce a near stoichiometric flame with a temperature high enough to ignite the reactants in most combustion devices, the overall mass flow rate and energy is still relatively low. For the extreme conditions of igniting a cryogenic propellant chemical rocket, this total may not be enough to maintain a flame in the adverse environment. To enable this operation, another gas phase stage called the secondary augmenter is added in series with the first two components. As more heat release is required, the mass flow rate is increased by an order of magnitude to more than 0.1 g/s for this stage. The flows are kept separate, however, until injected where they impinge and mix within this secondary augmenter. Again, the flows are distributed via a manifold system then injected through ports that are sized more than an order of magnitude larger than the total port area of the first two components. The mixture is kept fuel rich so that the temperature is regulated below the melting point of the components. With the ignition of this stage, a large stable torch is produced to ignite the cryogens.

The hardware is designed so that the total size of the device was similar to that of a traditional spark plug. Likewise, the outlet of the igniter mimics that of a spark plug in order to have it act as a direct replacement in combustion devices. In tests it functioned as such, lighting chambers with propellant flows an order of magnitude larger. Operation was demonstrated with back pressures as low as 0.01 atmospheres up to approximately 10 atmospheres and in theory, these bounds could be wider. Ignition was demonstrated with reactant temperatures near chilled-in cryogenic conditions. This igniter serves as a low-energy alternative to spark ignition and can operate as an ignition source for a variety of commercial combustion devices.

This work was done by Steven J. Schneider and Matthew C. Deans of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18565-1.

Stage Cylindrical Immersive Display

This collaborative design environment enables design engineers to be immersed in a car or airplane, for example, to evaluate the designs of components.

NASA's Jet Propulsion Laboratory, Pasadena, California

Panoramic images with a wide field of view intend to provide a better understanding of an environment by placing objects of the environment on one seamless image. However, understanding the sizes and relative positions of the objects in a panorama is not intuitive and prone to errors because the field of view is unnatural to human perception. Scientists are often faced with the difficult task of interpreting the sizes and relative positions of objects in an environment when viewing an image of the environment on computer monitors or prints. A panorama can display an object that appears to be to the right of the viewer when it is, in fact, behind the viewer. This misinterpretation can be very costly, especially when the environment is remote and/or only accessible by unmanned vehicles.

A 270° cylindrical display has been developed that surrounds the viewer with carefully calibrated panoramic imagery that correctly engages their natural kinesthetic senses and provides a more accurate awareness of the environment. The cylindrical immersive display offers a more natural window to the environment than a standard cubic CAVE (Cave Automatic Virtual Environment), and the geometry allows multiple collocated users to simultaneously view data and share important decision-making tasks.

A CAVE is an immersive virtual reality environment that allows one or more users to absorb themselves in a virtual environment. A common CAVE setup is a room-sized cube where the cube sides act as projection planes. By nature, all cubic CAVEs face a problem with edge matching at edges and corners of the display. Modern immersive displays have found ways to minimize seams by creating very tight edges, and rely on the user to ignore the seam. One significant deficiency of flat-walled CAVEs is that the sense of orientation and perspective within the scene is broken across adjacent walls. On any single wall, parallel lines properly converge at their vanishing point as they should, and the sense of perspective within the scene contained on only one wall has integrity. Unfortunately, parallel lines that lie on adjacent walls do not necessarily remain parallel. This results in inaccuracies in the scene that can distract the viewer and subtract from the immersive experience of the CAVE.

The cylindrical display overcomes the problem of distorted edges. Its smooth surface is perfectly equidistant from the viewer when he or she is positioned near the center. This eliminates the artifacts of a flat-walled CAVE where the viewing surface varies in distance from the viewer wherever he or she may stand within it. The display is a curved rear-projected screen comprising three-quarters of a 12-ft-diameter (≈3.7-m-diameter) cylinder. The projection surface is a high-contrast, unity gain, flexible screen material. The screen is about 6.5 ft (≈2 m) tall, and the height of the actual image displayed on the screen is approximately 5 ft (≈1.5 m). A single consumer video card outputs to three short-throw projectors that are mounted behind the screen. Each projector illuminates 90° of the screen and overlaps slightly with an adjacent projector. The resolution of the entire cylindrical display is about 3,500×1,024 pixels. The projectors are edge-blended and calibrated into a seamless display using Scalable Display Technologies' camera-based calibration.

This system, known as Stage, is designed to address two critical visualization problems. First, people viewing imagery from surface spacecraft often incorrectly estimate the size of objects in the environment because imagery on a standard computer screen does not occupy the correct portion of their visual field. Second, people viewing panoramic images frequently fail to understand the relative positions of objects in the environment because the panoramic image is rolled out flat and presented in front of them instead of wrapping around them. These fundamental errors have well-documented and dramatic