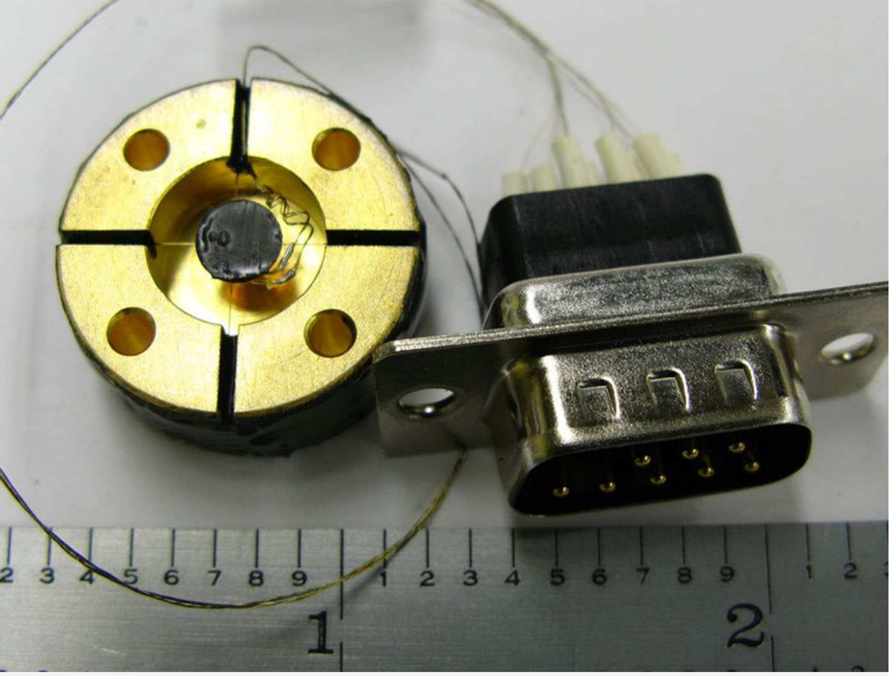


National Aeronautics and
Space Administration

Sensors

A Low Cost, Low Temperature Radiometer for Thermal Measurements

In situ sensing for long wavelength infrared radiation

Many present and future NASA missions require high performance, large scale cryogenic systems, such as the sunshields and cold instruments for the James Webb Space Telescope (JWST). Testing these systems is problematic both from the size, and the low heat loads allowed. The heat loads can be greatly influenced by non-ideal black-body characteristics of the test chamber and by stray heat from warmer parts of the system and ground support equipment. Previously, stray thermal energy was not directly measured but inferred from deviations in the expected results, which lead to errors in thermal modeling and in lack of knowledge of the thermal performance of the item under test. Technologists at NASA Goddard Space Flight Center have developed a radiometer to help identify the sources of stray heat and to make non-contact thermal emission measurements of materials such as vapor-deposited aluminum on Kapton and multilayer insulation blankets, as well as background measurements of non-ideal chamber effects such as light leaks and radiation bounces.

BENEFITS

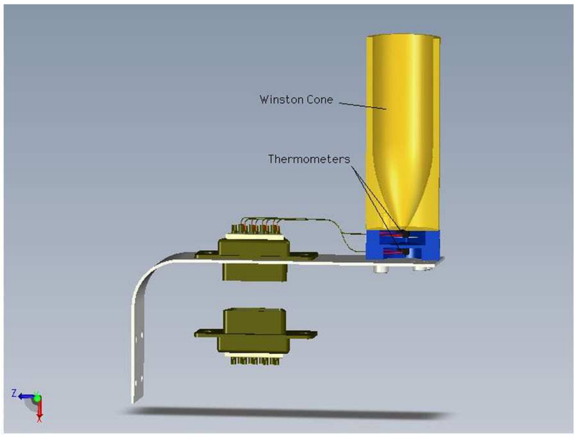
- Low cost
- Compact size
- Easy to calibrate
- Capable of high resolution sensitivity measurements (better than 0.01 microwatt per cm sq.)

technology solution

THE TECHNOLOGY

The radiometer is a simpler, much cheaper, and more flexible version of infrared detectors that have been in use for very high-resolution astronomical observations. Its form is similar to bolometers which have long been used for sensitive astronomical infrared measurements. By relaxing the sensitivity and response times, the radiometers can be made much less costly.

The device is composed of a non-imaging concentrator, known as a Winston cone, and a pair of thermometers that all reside at low temperature. The radiometer was designed to help identify the sources of stray heat and to make non-contacting thermal emission measurements of materials like vapor deposited aluminum on Kapton. The Winston cone is made from ordinary Aliminum alloy (e.g. 6061-T6) with an entrance aperture of about 17 mm wide and an exit aperture of about 3 mm in diameter. Light entering the Winston cone exits through this aperture into a cavity in which is suspended a small thermometer. This thermometer will be coated with a stainless-steel-powder-loaded epoxy to achieve relatively high emissivity. This coating has the property of nearly wavelength independent absorption over the wavelength range from a few microns to over 100 microns. On the back and outside the cavity a second, matching thermometer is located. Using the two thermometers together provides a calibratable readout that is insensitive to absolute temperature to first order.



Cut-away drawing of the radiometer, electrical connector, and bracket. The length of the radiometer in this version is about 50 mm. Note the two thermometers (black) in the lower portion. For ease of drawing the upper portion of the Winston cone is shown as cylindrical rather than parabolic.

APPLICATIONS

The technology has several potential applications:

- In situ sensing for long wavelength infrared radiation
- Looking for heat leaks and reflected flux in low temperature thermal vacuum systems

PUBLICATIONS

Patent No: 8480296

Dipirro, M., Hait, T., Tuttle, J., & Canavan, E. (2009). A low-cost, low-temperature radiometer for thermal measurements. Proc. SPIE 7439. Astronomical and Space Optical Systems.

More Information

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