Cryogenic Radiometers and Absolute Radiometry Instrumentation

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Abstract

L-1 Standards and Technology, Inc. possesses significant expertise in absolute radiometry applicable for standards laboratories, test facilities and space-based measurements. Our cryogenic radiometers are used by 16 national laboratories around the world to provide the primary standard for radiometric power measurement scales from the deep-UV to the far-IR, and can be customized to perform specific measurements such as cryogenic blackbody calibrations, detector calibrations, laser power, synchrotron radiation, and hard radiation (gamma, x-ray, and particle). L-1 delivers complete solutions to exceed customers' goals for achieving true state-of-the-art absolute radiometric standards.

L-1 Standards and Technology, Inc. acquired the cryogenic radiometer line of Cambridge Research & Instrumentation, Inc. in 2001. This product line includes the LaserRad-II, CryoRad (ACR), and the CryoRad-II primary standard electrical-substitution radiometers. CRI was a pioneer in commercializing the field of primary optical power measurements, giving laboratories around the world access to state-of-the-art instruments for use as national standards. L-1 continues to manufacture these instruments, while introducing versions with even lower noise, wider dynamic range and longer helium hold times. The CryoRad-IIC delivered recently to NIST, has a noise floor of ~0.5 nW with a natural time constant of 2 s and a liquid helium hold-time of over 80 hours. The uncertainty in the optical power measurement scale at 1 mW for this radiometer is 0.005%.

L-1 is in the process of bringing two new cryogenic radiometer products to market. One is a significant upgrade of the existing cryogenic radiometer electronics called TC-04. The new electronics will replace the TC-02 system currently in use. The communication interface is 100MBaud Ethernet. The new system increases power resolution from 10 pW to 100 fW with a proportional decrease in measurement noise. All components will be temperature controlled to better than 0.1 K. The uncertainty of the power measurement scale will be <10 ppm from 25 mW to 1 μW. The 100fW resolution meets increasingly demanding measurements in the cryogenic infrared community. The new system also includes a number of software enhancements and measurement options. One significant changes will be the incorporation of a feed-forward control algorithm to the heater servos. This significantly reduces the measurement time, allowing more measurements to be performed between re-fills of liquid helium.

The second product is a 4 K mechanically-cooled cryogenic radiometer. This new radiometer does not replace the CryoRad-II series of radiometers, but to supplements our line to further meet the needs of the community. By providing a 4 K mechanically-cooled radiometer, users located where liquid helium is prohibitively expensive or supplies are unreliable, can achieve the highest level of measurement accuracy. A 4 K cryo-cooler is used instead of the more traditional 12 K - 15 K cryo-cooler to allow performance on par with the liquid helium cooled version. The measurement uncertainty at 1 mW will be the same as the CryoRad-II series. The natural time constant and noise floor will be similar to the CryoRad-II as well. This will give the user a state-of-the-art instrument that performs exceptionally well at 1 mW, but has the added advantage of a very low noise floor. By allowing low-uncertainty measurements at 1 μW, this new instrument is suitable for measurements anyplace that lower powers are the norm, such as monochromators, synchrotrons, UV and IR detectors, etc.

Custom projects are also a specialty of L-1. The 10CC infrared collimator for the LBIR facility at NIST. The 10CC is a cryogenic infrared collimator operating at <20 K, producing a highly collimated beam of infrared radiation.

L-1 has developed or is in the process of completing a range of support items for ambient calibration work such as trap detectors, ultra-precision ultra-stable amplifiers and temperature controllers, and cryogenic items such as blackbodies, mirrors, monochromators, mechanical motion, choppers, stepper motors, electronics, and detectors. Whether you need a single radiometer or detector, or a complete calibration system, L-1 can deliver a custom, state-of-the-art system to exceed your needs.

We will present results (i.e. noise, non-equivalence, time-constant, absorptance, responsivity, etc.) from several recent cryogenic radiometers that we have developed for a variety of applications. Their responsivity ranges from 2 K/mW to 210 K/mW at operating temperatures from 2.0 K to 9 K.