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ACTIVE CAVITY RADIOMETER (ACR)
(N008)

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The objective of the Active Cavity Radiometer (ACR) experiment on the ATLAS mission is the measurement of the total solar irradiance with state-of-the-art accuracy and precision. This experiment is part of an ongoing program of space flight observations to study short- and long-term variations in the total solar output of optical energy. Precise observations of solar total irradiance provide information on the solar cycle and other long-term trends in solar output that are of climatological significance as well as short-term solar physics phenomena such as radiation anisotropy, active region structure, "missing flux" due to sunspots, bolometry of solar flares, global oscillations, coronal holes, and large-scale convective flows.

The interaction of solar radiation with the Earth's atmosphere, oceans, and land masses provides the primary driving force for the formation of weather systems and the determination of climate. Small changes in the solar luminosity could have far-reaching implications: systematic changes of only 0.5 percent per century could explain the entire range of past climate from tropical to ice age conditions.

The determination of the total energy flux is one of the most basic measurements of astrophysics. Its average value gives the solar luminosity, and variations around the average can arise from intrinsic variations in energy generation or transport within the solar interior, or solar atmospheric phenomena of several kinds.

The principal role of the ATLAS ACR observations will be in support of extended solar irradiance experiments on free-flying satellites. Annual in-flight comparison of observations by both ATLAS and free-flying experiments is an important part of sustaining the long-term precision of the climatological solar irradiance data base at the required ±0.1 percent level.

A second important role for ATLAS solar irradiance measurements will be establishment of the radiation scale at the solar total flux level in the International System of Units (SI). Two types of pyrheliometers, the ACR and SOLCON (see the E021 description), will be directly intercompared during the ATLAS 1 mission. Addition of other sensors is planned for future reflights. Comparisons of solar observations by different pyrheliometers in the shuttle space environment will provide the most definitive experiment for determining their accuracy in defining the radiation scale at the solar total flux level.

The ACR instrument on the ATLAS 1 mission consists of three independent, self-calibrating cavity pyrheliometers (Fig. II-1). Their active cavity radiometer (Type V) sensors are the most recent in a series developed at the Jet Propulsion Laboratory for defining solar radiation measurements in the International System of Units (SI).

The name Active Cavity Radiometer characterizes the mode of operation of these pyrheliometers. A servo system maintains the temperature of the primary (solar viewing) cavity 0.5 K above that of the reference cavity by controlling the electrical power supplied to its heater. As the shutter alternately blocks or admits solar irradiance to the cavity through its 10 deg field-of-view, the servo system adjusts the power accordingly, and the difference between shutter open and closed is proportional to the solar irradiance. The constant of proportionality is determined from accurate measurements of the electrical properties of the cavity heater, the area of the precisely machined aperture through which the solar irradiance enters the cavity, and the absorptance of the cavity for the solar flux. Each of the three ACR V sensors is an independent, electrically self-calibrated pyrheliometer, with an effective thermal time constant of 1 sec.

The spectral bandpass of the ACR sensors is determined by the efficiency of the specular black absorber on the inner face of the primary cavity. The specular finish guarantees multiple interactions between the incident radiation and the cavity absorbing surface. Reflectance measurements made by the National Bureau of Standards indicate an effective cavity absorptance for the ACR V of 0.999880 ± 0.000020 in visible light. Uniform response for the cavity with an effective absorbance near this value is predicted from the vacuum UV to the mid-IR.

Separate shutters on each sensor facilitate their operation with different frequencies for all possible combinations in either automatic or manual modes. The three sensors are used in various combinations to provide periodic cross references on the system's performance. This phased use of the three channels is designed to sustain maximum precision and accuracy of the ACR's observations for the duration of the mission.

The ACR system is modular in design for maximum flexibility as a reflyable solar irradiance experiment. In Figure II-2 the basic system components are shown as the electronics, sensor, shutter, and ACR (detector) modules. Up to six detector modules of the configuration shown in Figure II-1 can be flown using the four cylindrical mounting bays and adding two more to the rectangular bay of the sensor module. Three ACR V's will be flown on the ATLAS 1 mission. The fourth cylindrical bay will house a Sun position sensor designed to measure the relative angle between the instrument axis and the solar vector. In future reflights, as the complement of sensors increases, the Sun sensor will be mounted externally on the sensor module's alignment pad.

Analysis indicates the ACR V is capable of defining the radiation scale with ±0.1 percent SI uncertainty. Determination of the actual level of performance in flight will be the object of a series of in-flight intercomparison experiments that began with Spacelab 1. The single sample irradiance precision will be ±0.012 percent. The 1σ uncertainty for a single measurement cycle ($\sim$2 min) is expected to be less than ±10 ppm.

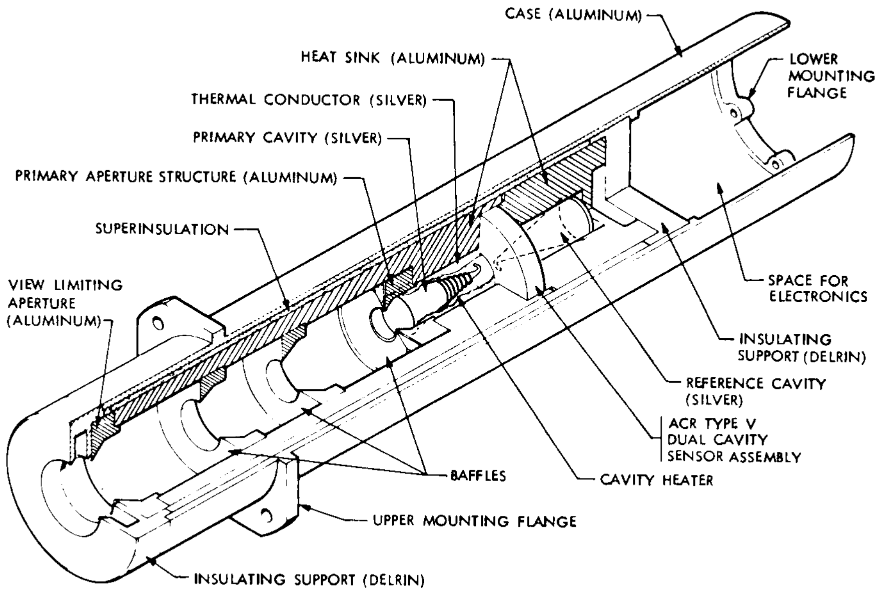

Figure II-1. Schematic of Jet Propulsion Laboratory's ACR Module (Type V).

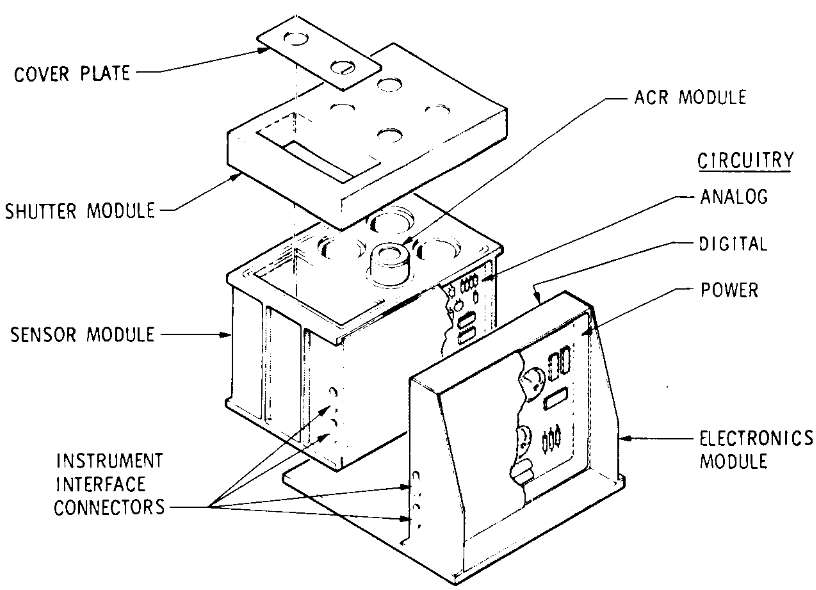

Figure II-2. Exploded view of Jet Propulsion Laboratory's ACR for ATLAS 1.