REVISED STANDARDS FOR THE SOLAR CONSTANT AND THE SOLAR SPECTRUM

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This paper presents the values of the solar constant and solar spectrum which are proposed as revised standards for science and technology. The proposal is now going through the review and approval process of the Standards Committee of ASTM and the International Commission on Illumination. These values have already been accepted by NASA's Space Vehicles Design Criteria Office.

The solar constant is the energy received from the Sun at the average Sun-Earth distance in the absence of the Earth's atmosphere. The zero-air-mass solar spectrum is the distribution of this energy as a function of wavelength. These parameters are important in many areas of solar physics, meteorology, geophysics, space technology, and other fields. In particular, they are important in the determination of the temperature equilibrium of satellites, the output of solar panels, radiation torques, and the surface degradation of space vehicles.

The value of the solar constant which had been in use for a long time, at least in the United States, was 2.00 cal-cm^{-2}-min^{-1} or 139.5 mW-cm^{-2}. It had been proposed by F. S. Johnson of NRL in 1954 and had been based on early ground-based Smithsonian data. Johnson had also proposed a solar spectral curve which became the standard (Figure 1). Values close to these had been proposed by Nicolet in Belgium, Allen in England, Makarova in the USSR, and others.

High altitude measurements made in recent years had produced converging evidence that 2.00 cal-cm^{-2}-min^{-1} was too high a value and that the spectrum required considerable change. In the range of wavelengths greater than 0.7 μm, the presence of highly variable and absorbent water vapor makes ground-based measurements highly unreliable. Hence, an *ad hoc* committee, of which I was the chairman, was formed to propose new standards. Members of the committee were Dr. Drummond of Eppley

Laboratory, Dr. Murcray of the University of Denver, Dr. Gast of AFCRL (retired)—all three of whom had done considerable work in this area—and Laue and Willson of JPL.

After a year's work, we proposed a revised value 1.94 cal-cm^{-2}-min^{-1} or 135.3 mW-cm^{-2}, which we felt would be accepted by the international scientific community with a high level of confidence (Table 1). This value is a weighted average of 8 values taken from experiments on the University of Denver baloon, the University of Leningrad balloon, and the Mars-Mariner Probe; from joint measurements by Eppley Laboratory and JPL, from experiments aboard the X-15, B-57B, and CV 990; and from four instruments, two angstroms, a cone, and a Hy-Cal which our GSFC group used on board NASA 711 Galileo in 1967. The new value is 3 percent lower than the Johnson value.

The standard solar spectral curve which we have proposed is based mainly on the GSFC experiment, with modifications based on the filter radiometer data of Eppley-JPL. We have built up a detailed spectral irradiance table for the range of 0.12 to 1000 μm. Of great interest is how the revised curve compares with those proposed earlier. The upper graph of Figure 2 shows the ratio of the values of spectral irradiance from the Johnson table to those from the revised table. In the visible spectrum, the Johnson values are higher by 5 to 10 percent. The lower graph shows a similar comparison with the Labs and Neckel curve. In the visible spectrum, the Labs and Neckel values are lower. In the IR spectrum, differences are greater. Figure 3 shows how the new curve compares with those of Nicolet (rather large differences), of Stair (small differences), and of the GSFC Galileo experiment. Corrections of the order of 1 or 2 percent were made to the earlier GSFC values in order to obtain the proposed new standard.

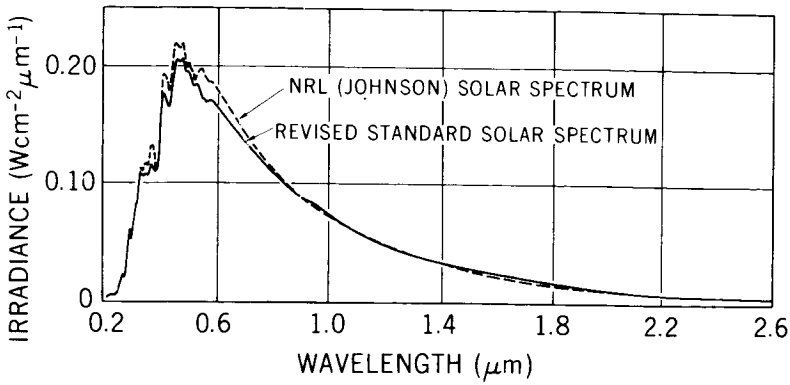

Figure 1–Solar spectral curves.

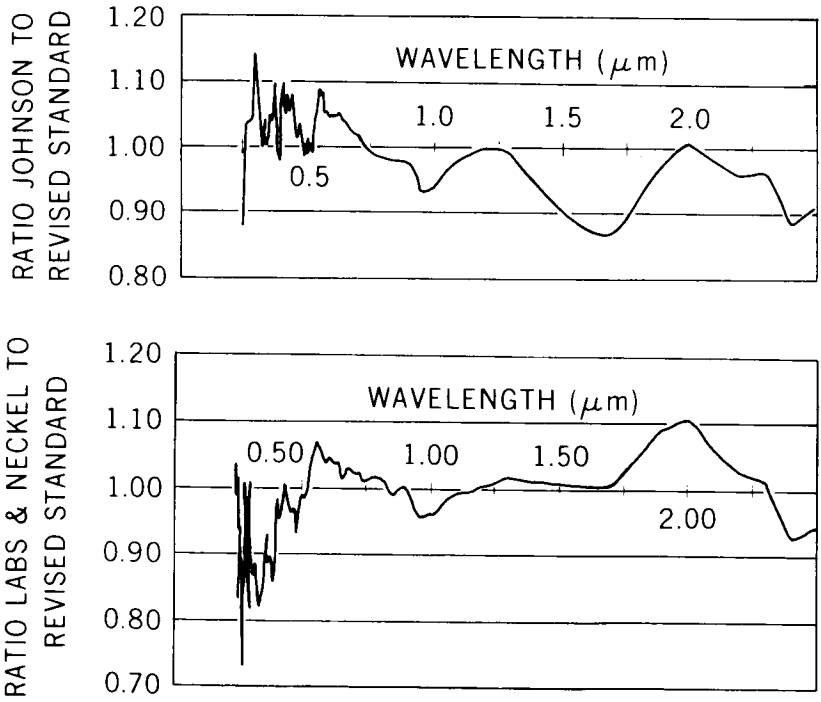

Figure 2–Comparison of revised standard with solar curves of Johnson and Labs and Neckel.

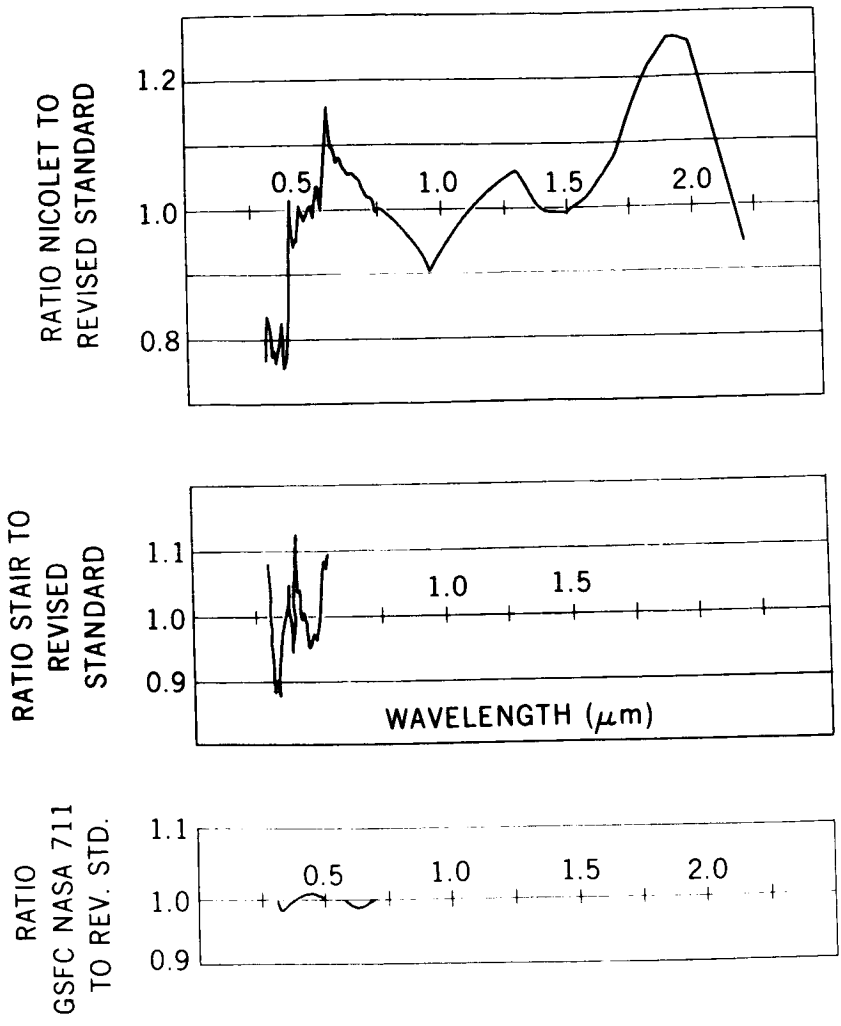

Figure 3–Comparison of revised standard with solar curves of Nicolet, Stair, and GSFC NASA 711.

Table 1—The solar constant.

NRL (JOHNSON) VALUE	139.5 mW cm^{-2} (2.00 cal cm^{-2} min^{-1})
VALUES FROM HIGH ALTITUDE	
• GSFC Å 6618	134.3 mW cm^{-2}
• GSFC Å 7635	134.9
• U OF LENINGRAD BALLOON	135.3
• U OF DENVER BALLOON	133.8
• GSFC HYCAL	135.2
• JPL MARINER CAVITY	135.3
• GSFC CONE	135.8
• EPPLEY-JPL X-15, CV990	136.0
REVISED STANDARD	135.3 mW cm^{-2} (1.94 cal $cm^{-2}min^{-1}$)