



Designation: E490 – 22

Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables¹

This standard is issued under the fixed designation E490; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These tables define the solar constant and zero air mass solar spectral irradiance for use in thermal analysis, thermal balance testing, and other tests of spacecraft and spacecraft components and materials. Typical applications include the calculation of solar absorptance from spectral reflectance data, the specification of solar UV exposure of materials during simulated space radiation testing, and the rating of photovoltaic cells deployed in space.

1.2 These tables are based upon data from experimental measurements made mostly from spacecraft, with minor contributions from observations made on high-altitude aircraft, or from the earth's surface.

1.3 These tables are representative of periods when the sun's activity is average or moderate. The sun's activity tends to modify its spectrum almost exclusively in the UV and extreme UV spectral regions (below 0.1 μm).

1.4 *Units*—The values stated in SI units are to be regarded as standard. Other units of measurement are included for information purposes only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

¹ These tables are under the jurisdiction of ASTM Committee E21 on Space Simulation and Applications of Space Technology and are the direct responsibility of Subcommittee E21.04 on Space Simulation Test Methods.

Current edition approved April 1, 2022. Published May 2022. Originally approved in 1973. Last previous edition approved in 2019 as E490 – 00a(2019). DOI: 10.1520/E0490-22

2. Referenced Documents

2.1 *ASTM Standards*:²

E349 Terminology Relating to Space Simulation
IEEE/ASTM SI 10 American National Standard for Metric Practice

3. Terminology

3.1 *air mass* (optical air mass) (AM), n —the ratio of the path length or radiation through the atmosphere (l_m) at any given angle, Z degrees, to the sea level path length toward the zenith (l_z).

$$AM = l_m/l_z \cong \sec Z, \text{ for } Z \leq 62^\circ \quad (1)$$

Symbol: AM1 (air mass one), AM2 (air mass two)

3.2 *air mass zero* (AM0), n —the absence of atmospheric attenuation of the solar irradiance at one astronomical unit from the sun.

3.3 *astronomical unit* (AU), n —a unit of length defined by the International Astronomical Union exactly as 149 597 870.7 km, representing the approximate mean distance between the earth and the sun.

3.4 *integrated irradiance*, n —spectral irradiance integrated over a specific wavelength interval from λ_1 to λ_2 , measured in $\text{W}\cdot\text{m}^{-2}$, Symbol:

$$E_{\lambda_1-\lambda_2} = \int_{\lambda_1}^{\lambda_2} E_\lambda d\lambda \quad (2)$$

3.5 *irradiance at a point on a surface* (E), n —quotient of the radiant flux incident on an element of the surface containing the point, by the area of that element, measured in $\text{W}\cdot\text{m}^{-2}$.

3.6 *irradiance, spectral* (E), n —the irradiance per unit wavelength interval at a specific wavelength, or as a function of wavelength measured in $\text{W}\cdot\text{m}^{-2} \cdot \mu\text{m}^{-1}$.

3.7 *solar constant*, n —the long-term mean total solar irradiance at normal incidence on a surface in free space at the earth's mean distance from the sun (1 AU).

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.8 *total solar irradiance, n* —the instantaneous integrated irradiance at normal incidence on a surface in free space at the earth’s mean distance from the sun (1 AU), considering all wavelengths from zero to infinity.

3.9 Additional definitions will be found in Terminology E349.

4. Solar Constant

4.1 The solar constant is $1361.1 \text{ W}\cdot\text{m}^{-2}$. This value is the long-term mean of the daily average Total Solar Irradiance (TSI) as measured with absolute cavity radiometers deployed on different satellites over the 1976–2017 period, after normalization to 1 AU. Corrections were considered for instrumental calibration and degradation issues or data breaks, as reported by Gueymard (1)³. During that period, the daily normalized TSI varied between 1357.1 and $1363.3 \text{ W}\cdot\text{m}^{-2}$, due to variations in solar activity. The standard deviation of the mean value is 0.5 %. The daily variation of TSI over four solar cycles is shown in Fig. 1. The solar constant value is $5.0 \text{ W}\cdot\text{m}^{-2}$ lower than in previous editions of this standard because the specific design of early radiometers induced a systematic error, which has been recently corrected, and because of a change in the absolute calibration reference (1).

4.2 The estimated absolute accuracy of absolute cavity radiometers in space is $\approx 0.2 \%$. Therefore, the accuracy of the solar constant is also estimated at $\approx 0.2 \%$.

³ The boldface numbers in parentheses refer to the list of references at the end of these tables.

4.3 The solar constant is an abstraction. It corresponds to periods of “average” or “moderate” solar activity. The latter’s variations affect TSI, as shown in Fig. 1, and also affect the spectrum differently depending on spectral range, with most relative impact to be expected at short wavelengths, below $0.4 \mu\text{m}$.

4.4 Table 1 summarizes the solar constant standard value at 1 AU in different units, and Table 2 provides its value at various planetary distances from the sun. These tables refer to the solar constant value defined above, for conditions of “moderate” solar activity. Variations in spectral distribution caused by solar activity are not considered in this standard.

5. Solar Spectral Irradiance at Air Mass Zero

5.1 The air mass zero solar spectral irradiance is based on data from satellites, space shuttle missions, high-altitude aircraft, rocket soundings, ground-based solar telescopes, and modeled spectral irradiance. The spectrum is a composite based on (1) the Woods “reference spectrum” below $0.28 \mu\text{m}$ (3), with modifications explained in (4); (2) 31 sources of data covering various wavelength ranges between 0.28 and $4 \mu\text{m}$, assembled using a consensus method after outlier rejection (5); and (3) the Gueymard 2004 spectrum beyond $4 \mu\text{m}$ (4).

5.2 Table 3 presents the solar spectral irradiance in tabular form for the range from 0.0005 to $1000 \mu\text{m}$. The first column gives the wavelength (λ) in μm ; the second gives the spectral irradiance (E_λ) at λ in $\text{W}\cdot\text{m}^{-2}\cdot\mu\text{m}^{-1}$; the third gives the total irradiance for the range from 0 to λ ($E_{0-\lambda}$) in $\text{W}\cdot\text{m}^{-2}$; and the fourth gives the percentage of the solar constant associated with wavelengths shorter than λ ($D_{0-\lambda}$).

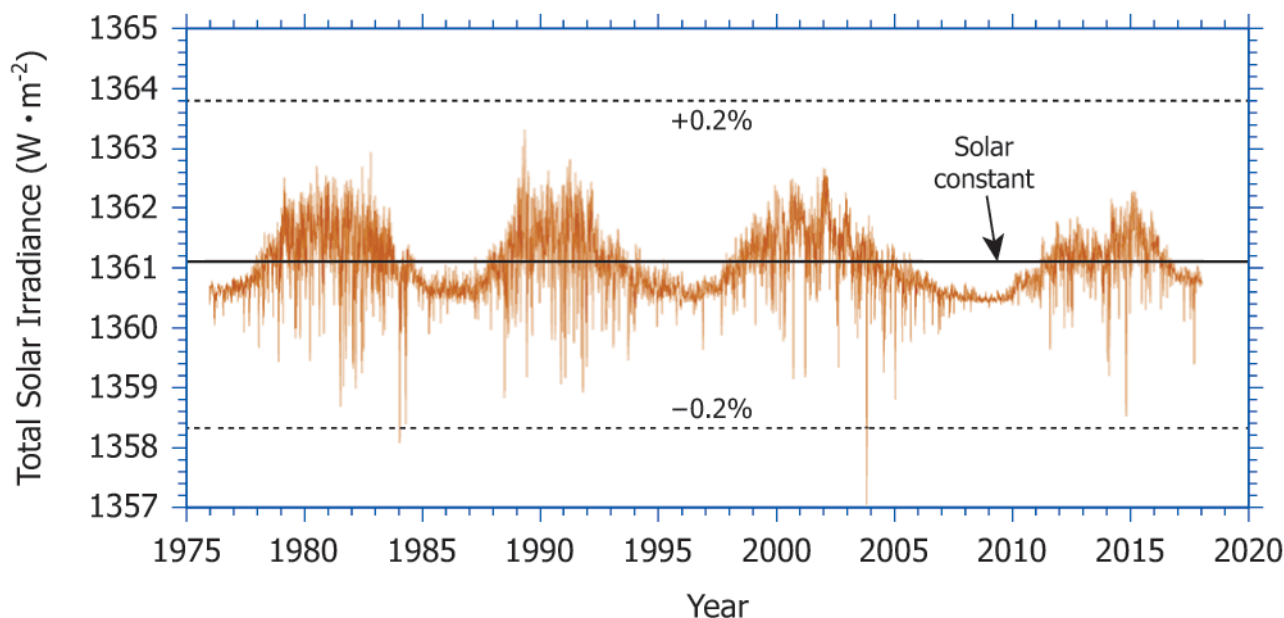


FIG. 1 Variation of Daily Total Solar Irradiance since 1976 Compared to the Solar Constant

TABLE 1 The Solar Constant in Alternative Units

Solar constant = 1361.1 W·m ⁻² [SI unit]
= 0.136 11 W·cm ⁻²
= 136.11 m W·cm ⁻²
= 1.3611 × 10 ⁶ erg·cm ⁻² ·s ⁻¹
= 126.45 W·ft ⁻²
= 1.9519 cal _{th} ·cm ⁻² ·min ⁻¹
= 0.03253 cal _{th} ·cm ⁻² ·s ⁻¹
= 432.1 Btu·ft ⁻² ·h ⁻¹
= 0.1200 Btu·ft ⁻² ·s ⁻¹
= 1.9519 Ly·min ⁻¹

The calorie (viz., the gram calorie) is the thermochemical calorie (cal_{th}) and is defined as 1 cal_{th} = 4.1840 J.

The Btu is the thermochemical British thermal unit and is defined by the relationship: 1 Btu/(°F·lb) = 1 cal_{th}/(°C·g).

The Langley (symbol Ly) is a legacy unit defined as 1 Ly = 1 cal_{th}·cm⁻² by NIST.

The Langley is no longer supported, per IEEE/ASTM SI 10-2010. It should only be used for historical data conversion into SI units.

TABLE 2 Solar Irradiance at the Planets and a Plutoid

Planet	Solar Irradiance, W·m ⁻²		
	Mean	Perihelion	Aphelion
Mercury	9083.4	14395	6249.1
Venus	2601.4	2637.3	2566.6
Earth	1361.1	1407.7	1316.7
Mars	586.27	713.23	490.43
Jupiter	50.270	55.528	45.725
Saturn	14.852	16.556	13.398
Uranus	3.6875	4.0446	3.3755
Neptune	1.4881	1.5248	1.4526
Pluto	0.863	1.53	0.552

All planetary solar irradiance values calculated with a 1/r² approximation using planetary distances compared to the Earth-Sun distance, defined as 1 AU.

Planetary distances were calculated using position data from the 2021

Astronomical Almanac (2).



TABLE 3 Solar Spectral Irradiance—Standard Curve

NOTE 1—Double lines indicate change in wavelength interval of integration. Each column continues to next page.

NOTE 2— λ = wavelength, μm , E_{λ} = solar spectral irradiance averaged over small bandwidth centered at λ , $\text{W}\cdot\text{m}^{-2}\cdot\mu\text{m}^{-1}$, $E_{0-\lambda}$ = integrated solar irradiance in the wavelength range from 0 to λ , $\text{W}\cdot\text{m}^{-2}$, and $D_{0-\lambda}$ = percentage of solar constant ($1361.1 \text{ W}\cdot\text{m}^{-2}$) associated with wavelengths shorter than λ .

λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$	λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$
0.0005	0.002	0	0	1.070	621.21	996.1	73.18
0.0015	0.122	6.2E-05	0.000005	1.071	627.71	996.7	73.23
0.0025	0.015	1.3E-04	0.000010	1.072	627.64	997.3	73.27
0.0035	0.025	1.5E-04	0.000011	1.073	618.02	997.9	73.32
0.0045	0.037	1.8E-04	0.000013	1.074	625.61	998.6	73.36
0.0055	0.046	2.2E-04	0.000016	1.075	617.15	999.2	73.41
0.0065	0.044	2.7E-04	0.000020	1.076	622.14	999.8	73.45
0.0075	0.031	3.1E-04	0.000022	1.077	623.93	1000.4	73.50
0.0085	0.028	3.4E-04	0.000025	1.078	618.09	1001.0	73.55
0.0095	0.017	3.6E-04	0.000026	1.079	613.01	1001.7	73.59
0.0105	0.007	3.7E-04	0.000027	1.080	620.45	1002.3	73.64
0.0115	0.003	3.7E-04	0.000028	1.081	608.37	1002.9	73.68
0.0125	0.002	3.8E-04	0.000028	1.082	601.90	1003.5	73.73
0.0135	0.002	3.8E-04	0.000028	1.083	602.35	1004.1	73.77
0.0145	0.021	3.9E-04	0.000029	1.084	611.11	1004.7	73.81
0.0155	0.016	4.1E-04	0.000030	1.085	612.53	1005.3	73.86
0.0165	0.034	4.3E-04	0.000032	1.086	611.15	1005.9	73.90
0.0175	0.501	7.0E-04	0.000052	1.087	595.56	1006.5	73.95
0.0185	0.288	1.10E-03	0.000081	1.088	602.77	1007.1	73.99
0.0195	0.204	1.34E-03	0.000099	1.089	601.29	1007.7	74.04
0.0205	0.196	1.54E-03	0.000113	1.090	604.56	1008.3	74.08
0.0215	0.094	1.69E-03	0.000124	1.091	605.91	1008.9	74.13
0.0225	0.103	1.78E-03	0.000131	1.092	598.59	1009.5	74.17
0.0235	0.023	1.85E-03	0.000136	1.093	589.96	1010.1	74.21
0.0245	0.048	1.88E-03	0.000138	1.094	562.86	1010.7	74.26
0.0255	0.117	1.97E-03	0.000144	1.095	583.03	1011.3	74.30
0.0265	0.040	2.04E-03	0.000150	1.096	583.87	1011.9	74.34
0.0275	0.085	2.11E-03	0.000155	1.097	585.48	1012.5	74.38
0.0285	0.086	2.19E-03	0.000161	1.098	577.64	1013.0	74.43
0.0295	0.044	2.26E-03	0.000166	1.099	590.05	1013.6	74.47
0.0305	0.625	2.59E-03	0.000190	1.100	591.28	1014.2	74.51
0.0315	0.119	2.96E-03	0.000218	1.101	587.76	1014.8	74.56
0.0325	0.159	3.10E-03	0.000228	1.102	578.38	1015.4	74.60
0.0335	0.157	3.26E-03	0.000240	1.103	587.65	1016.0	74.64
0.0345	0.069	3.37E-03	0.000248	1.104	587.24	1016.6	74.69
0.0355	0.059	3.44E-03	0.000253	1.105	584.91	1017.1	74.73
0.0365	0.080	3.51E-03	0.000258	1.106	584.70	1017.7	74.77
0.0375	0.014	3.55E-03	0.000261	1.107	584.10	1018.3	74.81
0.0385	0.006	3.56E-03	0.000262	1.108	582.78	1018.9	74.86
0.0395	0.006	3.57E-03	0.000262	1.109	583.02	1019.5	74.90
0.0405	0.010	3.58E-03	0.000263	1.110	581.62	1020.1	74.94
0.0415	0.018	3.59E-03	0.000264	1.111	578.64	1020.6	74.99
0.0425	0.005	3.60E-03	0.000265	1.112	576.96	1021.2	75.03
0.0435	0.011	3.61E-03	0.000265	1.113	575.63	1021.8	75.07
0.0445	0.004	3.62E-03	0.000266	1.114	577.64	1022.4	75.11
0.0455	0.005	3.62E-03	0.000266	1.115	574.31	1022.9	75.15
0.0465	0.017	3.63E-03	0.000267	1.116	574.47	1023.5	75.20
0.0475	0.007	3.65E-03	0.000268	1.117	575.39	1024.1	75.24
0.0485	0.012	3.66E-03	0.000269	1.118	572.57	1024.7	75.28
0.0495	0.040	3.68E-03	0.000270	1.119	568.33	1025.2	75.32
0.0505	0.017	3.71E-03	0.000273	1.120	567.71	1025.8	75.36
0.0515	0.006	3.72E-03	0.000273	1.121	566.96	1026.4	75.41
0.0525	0.010	3.73E-03	0.000274	1.122	568.20	1026.9	75.45
0.0535	0.007	3.74E-03	0.000275	1.123	567.47	1027.5	75.49
0.0545	0.005	3.74E-03	0.000275	1.124	565.51	1028.1	75.53
0.0555	0.022	3.76E-03	0.000276	1.125	553.85	1028.6	75.57
0.0565	0.007	3.77E-03	0.000277	1.126	555.77	1029.2	75.61
0.0575	0.007	3.78E-03	0.000278	1.127	560.09	1029.7	75.65
0.0585	0.037	3.80E-03	0.000279	1.128	560.33	1030.3	75.70
0.0595	0.008	3.82E-03	0.000281	1.129	555.96	1030.9	75.74
0.0605	0.031	3.84E-03	0.000282	1.130	553.80	1031.4	75.78
0.0615	0.010	3.86E-03	0.000284	1.131	556.21	1032.0	75.82
0.0625	0.042	3.89E-03	0.000286	1.132	555.44	1032.5	75.86
0.0635	0.011	3.91E-03	0.000288	1.133	550.26	1033.1	75.90
0.0645	0.002	3.92E-03	0.000288	1.134	552.95	1033.6	75.94
0.0655	0.002	3.92E-03	0.000288	1.135	554.54	1034.2	75.98
0.0665	0.002	3.92E-03	0.000288	1.136	552.99	1034.7	76.02
0.0675	0.002	3.93E-03	0.000288	1.137	549.94	1035.3	76.06



TABLE 3 Continued

λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$	λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$
0.0685	0.006	3.93E-03	0.000289	1.138	544.04	1035.8	76.10
0.0695	0.004	3.94E-03	0.000289	1.139	542.80	1036.4	76.14
0.0705	0.012	3.94E-03	0.000290	1.140	540.41	1036.9	76.18
0.0715	0.005	3.95E-03	0.000290	1.141	537.17	1037.5	76.22
0.0725	0.004	3.96E-03	0.000291	1.142	543.08	1038.0	76.26
0.0735	0.005	3.96E-03	0.000291	1.143	542.12	1038.5	76.30
0.0745	0.006	3.97E-03	0.000291	1.144	539.05	1039.1	76.34
0.0755	0.009	3.97E-03	0.000292	1.145	542.83	1039.6	76.38
0.0765	0.024	3.99E-03	0.000293	1.146	542.93	1040.2	76.42
0.0775	0.022	4.01E-03	0.000295	1.147	542.45	1040.7	76.46
0.0785	0.030	4.04E-03	0.000297	1.148	539.75	1041.3	76.50
0.0795	0.014	4.06E-03	0.000298	1.149	538.37	1041.8	76.54
0.0805	0.015	4.08E-03	0.000299	1.150	538.01	1042.3	76.58
0.0815	0.017	4.09E-03	0.000301	1.151	537.53	1042.9	76.62
0.0825	0.025	4.11E-03	0.000302	1.152	535.35	1043.4	76.66
0.0835	0.042	4.15E-03	0.000305	1.153	534.16	1043.9	76.70
0.0845	0.031	4.18E-03	0.000307	1.154	535.02	1044.5	76.74
0.0855	0.034	4.21E-03	0.000310	1.155	533.82	1045.0	76.78
0.0865	0.036	4.25E-03	0.000312	1.156	531.99	1045.5	76.82
0.0875	0.043	4.29E-03	0.000315	1.157	531.77	1046.1	76.85
0.0885	0.049	4.34E-03	0.000319	1.158	530.25	1046.6	76.89
0.0895	0.060	4.39E-03	0.000323	1.159	522.72	1047.1	76.93
0.0905	0.070	4.45E-03	0.000327	1.160	521.34	1047.7	76.97
0.0915	0.054	4.52E-03	0.000332	1.161	514.56	1048.2	77.01
0.0925	0.019	4.55E-03	0.000335	1.162	521.97	1048.7	77.05
0.0935	0.017	4.57E-03	0.000336	1.163	525.29	1049.2	77.08
0.0945	0.012	4.59E-03	0.000337	1.164	517.20	1049.7	77.12
0.0955	0.007	4.60E-03	0.000338	1.165	520.54	1050.3	77.16
0.0965	0.007	4.60E-03	0.000338	1.166	517.38	1050.8	77.20
0.0975	0.130	4.67E-03	0.000343	1.167	517.89	1051.3	77.24
0.0985	0.015	4.74E-03	0.000348	1.168	520.55	1051.8	77.28
0.0995	0.023	4.76E-03	0.000350	1.169	512.55	1052.3	77.31
0.1005	0.009	4.78E-03	0.000351	1.170	516.30	1052.8	77.35
0.1015	0.011	4.79E-03	0.000352	1.171	518.97	1053.4	77.39
0.1025	0.097	4.84E-03	0.000356	1.172	517.90	1053.9	77.43
0.1035	0.100	4.94E-03	0.000363	1.173	516.18	1054.4	77.47
0.1045	0.015	5.00E-03	0.000367	1.174	513.85	1054.9	77.50
0.1055	0.012	5.01E-03	0.000368	1.175	506.54	1055.4	77.54
0.1065	0.012	5.02E-03	0.000369	1.176	508.51	1055.9	77.58
0.1075	0.013	5.04E-03	0.000370	1.177	510.36	1056.4	77.62
0.1085	0.021	5.05E-03	0.000371	1.178	505.76	1056.9	77.65
0.1095	0.014	5.07E-03	0.000373	1.179	508.91	1057.5	77.69
0.1105	0.015	5.09E-03	0.000374	1.180	510.07	1058.0	77.73
0.1115	0.014	5.10E-03	0.000375	1.181	507.26	1058.5	77.76
0.1125	0.015	5.11E-03	0.000376	1.182	504.52	1059.0	77.80
0.1135	0.012	5.13E-03	0.000377	1.183	491.89	1059.5	77.84
0.1145	0.008	5.14E-03	0.000377	1.184	500.68	1060.0	77.88
0.1155	0.013	5.15E-03	0.000378	1.185	504.33	1060.5	77.91
0.1165	0.015	5.16E-03	0.000379	1.186	502.70	1061.0	77.95
0.1175	0.06	5.20E-03	0.000382	1.187	504.62	1061.5	77.99
0.1185	0.02	5.24E-03	0.000385	1.188	494.50	1062.0	78.02
0.1195	0.06	5.28E-03	0.000388	1.189	488.98	1062.5	78.06
0.1205	0.17	5.39E-03	0.000396	1.190	496.39	1063.0	78.09
0.1215	8.12	9.53E-03	0.000700	1.191	500.49	1063.5	78.13
0.1225	0.06	1.36E-02	0.001001	1.192	498.61	1064.0	78.17
0.1235	0.04	1.37E-02	0.001005	1.193	497.58	1064.5	78.20
0.1245	0.03	1.37E-02	0.001007	1.194	497.35	1065.0	78.24
0.1255	0.03	1.37E-02	0.001010	1.195	492.82	1065.5	78.28
0.1265	0.04	1.38E-02	0.001012	1.196	491.49	1065.9	78.31
0.1275	0.02	1.38E-02	0.001015	1.197	487.32	1066.4	78.35
0.1285	0.02	1.38E-02	0.001016	1.198	478.23	1066.9	78.39
0.1295	0.02	1.39E-02	0.001018	1.199	472.97	1067.4	78.42
0.1305	0.18	1.40E-02	0.001026	1.200	487.11	1067.9	78.46
0.1315	0.03	1.41E-02	0.001033	1.201	491.20	1068.4	78.49
0.1325	0.02	1.41E-02	0.001035	1.202	488.94	1068.9	78.53
0.1335	0.22	1.42E-02	0.001044	1.203	477.33	1069.3	78.56
0.1345	0.02	1.43E-02	0.001053	1.204	476.37	1069.8	78.60
0.1355	0.05	1.44E-02	0.001055	1.205	485.62	1070.3	78.63
0.1365	0.03	1.44E-02	0.001058	1.206	485.32	1070.8	78.67
0.1375	0.03	1.44E-02	0.001060	1.207	486.18	1071.3	78.70
0.1385	0.03	1.45E-02	0.001063	1.208	474.42	1071.7	78.74
0.1395	0.09	1.45E-02	0.001067	1.209	466.92	1072.2	78.77
0.1405	0.08	1.46E-02	0.001073	1.210	477.06	1072.7	78.81
0.1415	0.05	1.47E-02	0.001078	1.211	474.40	1073.2	78.84
0.1425	0.05	1.47E-02	0.001081	1.212	479.58	1073.6	78.88



TABLE 3 Continued

λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$	λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$
0.1435	0.06	1.48E-02	0.001085	1.213	479.92	1074.1	78.91
0.1445	0.06	1.48E-02	0.001089	1.214	479.01	1074.6	78.95
0.1455	0.06	1.49E-02	0.001094	1.215	479.94	1075.1	78.98
0.1465	0.07	1.50E-02	0.001098	1.216	478.96	1075.6	79.02
0.1475	0.09	1.50E-02	0.001105	1.217	477.84	1076.0	79.06
0.1485	0.09	1.51E-02	0.001111	1.218	476.61	1076.5	79.09
0.1495	0.08	1.52E-02	0.001118	1.219	474.49	1077.0	79.13
0.1505	0.09	1.53E-02	0.001125	1.220	474.94	1077.5	79.16
0.1515	0.10	1.54E-02	0.001132	1.221	474.05	1077.9	79.20
0.1525	0.13	1.55E-02	0.00114	1.222	472.02	1078.4	79.23
0.1535	0.14	1.57E-02	0.00115	1.223	471.02	1078.9	79.26
0.1545	0.25	1.59E-02	0.00116	1.224	470.92	1079.4	79.30
0.1555	0.21	1.61E-02	0.00118	1.225	469.66	1079.8	79.33
0.1565	0.21	1.63E-02	0.00120	1.226	469.63	1080.3	79.37
0.1575	0.19	1.65E-02	0.00121	1.227	463.92	1080.8	79.40
0.1585	0.18	1.67E-02	0.00123	1.228	466.29	1081.2	79.44
0.1595	0.18	1.69E-02	0.00124	1.229	468.21	1081.7	79.47
0.1605	0.21	1.71E-02	0.00125	1.230	465.10	1082.2	79.51
0.1615	0.24	1.73E-02	0.00127	1.231	464.65	1082.6	79.54
0.1625	0.28	1.75E-02	0.00129	1.232	462.49	1083.1	79.57
0.1635	0.30	1.78E-02	0.00131	1.233	463.69	1083.6	79.61
0.1645	0.34	1.82E-02	0.00133	1.234	462.58	1084.0	79.64
0.1655	0.53	1.86E-02	0.00137	1.235	460.20	1084.5	79.68
0.1665	0.37	1.90E-02	0.00140	1.236	460.44	1084.9	79.71
0.1675	0.44	1.94E-02	0.00143	1.237	461.46	1085.4	79.74
0.1685	0.49	1.99E-02	0.00146	1.238	461.39	1085.9	79.78
0.1695	0.64	2.05E-02	0.00150	1.239	456.92	1086.3	79.81
0.1705	0.74	2.12E-02	0.00155	1.240	455.20	1086.8	79.84
0.1715	0.74	2.19E-02	0.00161	1.241	457.32	1087.2	79.88
0.1725	0.80	2.27E-02	0.00166	1.242	455.72	1087.7	79.91
0.1735	0.80	2.35E-02	0.00172	1.243	451.67	1088.1	79.94
0.1745	0.98	2.43E-02	0.00179	1.244	453.06	1088.6	79.98
0.1755	1.21	2.54E-02	0.00187	1.245	455.64	1089.0	80.01
0.1765	1.31	2.67E-02	0.0020	1.246	451.42	1089.5	80.04
0.1775	1.58	2.81E-02	0.0021	1.247	451.21	1090.0	80.08
0.1785	1.76	2.98E-02	0.0022	1.248	451.33	1090.4	80.11
0.1795	1.72	3.16E-02	0.0023	1.249	451.20	1090.9	80.14
0.1805	2.06	3.35E-02	0.0025	1.250	450.52	1091.3	80.18
0.1815	2.48	3.57E-02	0.0026	1.251	447.73	1091.8	80.21
0.1825	2.31	3.81E-02	0.0028	1.252	445.13	1092.2	80.24
0.1835	2.47	4.05E-02	0.0030	1.253	444.66	1092.6	80.28
0.1845	2.11	4.28E-02	0.0031	1.254	445.13	1093.1	80.31
0.1855	2.42	4.51E-02	0.0033	1.255	444.28	1093.5	80.34
0.1865	2.77	4.77E-02	0.0035	1.256	444.30	1094.0	80.37
0.1875	3.21	5.07E-02	0.0037	1.257	441.54	1094.4	80.41
0.1885	3.40	5.40E-02	0.0040	1.258	441.57	1094.9	80.44
0.1895	3.83	5.76E-02	0.0042	1.259	441.16	1095.3	80.47
0.1905	3.97	6.15E-02	0.0045	1.260	441.81	1095.7	80.50
0.1915	4.36	6.56E-02	0.0048	1.261	440.33	1096.2	80.54
0.1925	4.66	7.02E-02	0.0052	1.262	437.51	1096.6	80.57
0.1935	3.53	7.43E-02	0.0055	1.263	440.78	1097.1	80.60
0.1945	5.90	7.90E-02	0.0058	1.264	436.36	1097.5	80.63
0.1955	5.75	8.48E-02	0.0062	1.265	435.98	1097.9	80.66
0.1965	6.51	9.09E-02	0.0067	1.266	437.07	1098.4	80.70
0.1975	6.60	9.75E-02	0.0072	1.267	433.05	1098.8	80.73
0.1985	6.66	0.104	0.0076	1.268	430.98	1099.2	80.76
0.1995	7.23	0.111	0.0082	1.269	432.07	1099.7	80.79
0.2000	7.11	0.115	0.0084	1.270	433.00	1100.1	80.82
0.2005	7.35	0.118	0.0087	1.271	433.51	1100.5	80.86
0.2010	8.07	0.122	0.0090	1.272	432.96	1101.0	80.89
0.2015	8.45	0.126	0.0093	1.273	431.30	1101.4	80.92
0.2020	8.77	0.131	0.0096	1.274	430.11	1101.8	80.95
0.2025	8.45	0.135	0.0099	1.275	430.37	1102.3	80.98
0.2030	9.19	0.139	0.0102	1.276	430.60	1102.7	81.01
0.2035	9.43	0.144	0.0106	1.277	429.79	1103.1	81.05
0.2040	9.92	0.149	0.0109	1.278	427.62	1103.6	81.08
0.2045	10.77	0.154	0.0113	1.279	425.69	1104.0	81.11
0.2050	10.93	0.159	0.0117	1.280	422.20	1104.4	81.14
0.2055	11.00	0.165	0.0121	1.281	407.81	1104.8	81.17
0.2060	11.06	0.170	0.0125	1.282	383.84	1105.2	81.20
0.2065	11.39	0.176	0.0129	1.283	402.80	1105.6	81.23
0.2070	12.51	0.182	0.0134	1.284	418.32	1106.0	81.26
0.2075	13.13	0.188	0.0138	1.285	420.69	1106.4	81.29
0.2080	13.75	0.195	0.0143	1.286	421.39	1106.9	81.32
0.2085	15.36	0.202	0.0149	1.287	422.29	1107.3	81.35



TABLE 3 Continued

λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$	λ	E_{λ}	$E_{0-\lambda}$	$D_{0-\lambda}$
0.2090	18.68	0.211	0.0155	1.288	419.76	1107.7	81.38
0.2095	21.92	0.221	0.0162	1.289	421.76	1108.1	81.41
0.2100	25.67	0.233	0.0171	1.290	417.63	1108.5	81.44
0.2105	28.85	0.247	0.0181	1.291	418.20	1109.0	81.47
0.2110	31.21	0.262	0.0192	1.292	417.99	1109.4	81.51
0.2115	34.48	0.278	0.0204	1.293	418.48	1109.8	81.54
0.2120	36.93	0.296	0.0217	1.294	416.51	1110.2	81.57
0.2125	29.28	0.312	0.0229	1.295	416.53	1110.6	81.60
0.2130	32.26	0.328	0.0241	1.296	416.07	1111.0	81.63
0.2135	32.66	0.344	0.0253	1.297	414.85	1111.5	81.66
0.2140	38.54	0.362	0.0266	1.298	412.50	1111.9	81.69
0.2145	42.52	0.382	0.0281	1.299	414.40	1112.3	81.72
0.2150	39.84	0.403	0.0296	1.300	413.08	1112.7	81.75
0.2155	37.64	0.422	0.0310	1.301	411.70	1113.1	81.78
0.2160	34.89	0.440	0.0323	1.302	409.54	1113.5	81.81
0.2165	33.80	0.457	0.0336	1.303	408.29	1113.9	81.84
0.2170	34.02	0.474	0.0348	1.304	407.81	1114.3	81.87
0.2175	34.45	0.491	0.0361	1.305	408.89	1114.8	81.90
0.2180	43.96	0.511	0.0375	1.306	410.02	1115.2	81.93
0.2185	46.62	0.534	0.0392	1.307	407.25	1115.6	81.96
0.2190	46.78	0.557	0.0409	1.308	406.36	1116.0	81.99
0.2195	49.60	0.581	0.0427	1.309	407.02	1116.4	82.02
0.2200	51.10	0.606	0.0445	1.310	405.46	1116.8	82.05
0.2205	51.29	0.632	0.0464	1.311	404.37	1117.2	82.08
0.2210	37.53	0.654	0.0481	1.312	397.83	1117.6	82.11
0.2215	40.58	0.674	0.0495	1.313	395.11	1118.0	82.14
0.2220	44.93	0.695	0.0511	1.314	403.31	1118.4	82.17
0.2225	51.20	0.719	0.0528	1.315	392.7	1118.8	82.20
0.2230	58.35	0.746	0.0548	1.316	392.34	1119.2	82.23
0.2235	66.87	0.778	0.0571	1.317	399.61	1119.6	82.25
0.2240	63.86	0.810	0.0595	1.318	397.58	1120.0	82.28
0.2245	60.43	0.841	0.0618	1.319	399.53	1120.4	82.31
0.2250	57.40	0.871	0.0640	1.320	398.21	1120.8	82.34
0.2255	52.27	0.898	0.0660	1.321	396.28	1121.2	82.37
0.2260	47.00	0.923	0.0678	1.322	395.80	1121.6	82.40
0.2265	38.33	0.944	0.0694	1.323	395.42	1122.0	82.43
0.2270	35.84	0.963	0.0708	1.324	395.90	1122.4	82.46
0.2275	37.88	0.981	0.0721	1.325	394.36	1122.8	82.49
0.2280	49.00	1.003	0.0737	1.326	393.37	1123.2	82.52
0.2285	54.53	1.029	0.0756	1.327	391.25	1123.5	82.55
0.2290	49.34	1.055	0.0775	1.328	391.38	1123.9	82.57
0.2295	49.41	1.080	0.0793	1.329	384.24	1124.3	82.60
0.2300	43.03	1.103	0.0810	1.330	387.10	1124.7	82.63
0.2305	55.93	1.128	0.0828	1.331	389.19	1125.1	82.66
0.2310	53.32	1.155	0.0848	1.332	383.87	1125.5	82.69
0.2315	50.62	1.181	0.0868	1.333	387.58	1125.9	82.72
0.2320	51.20	1.206	0.0886	1.334	389.14	1126.3	82.75
0.2325	55.01	1.233	0.0906	1.335	387.42	1126.6	82.77
0.2330	49.55	1.259	0.0925	1.336	386.25	1127.0	82.80
0.2335	45.58	1.283	0.0942	1.337	385.92	1127.4	82.83
0.2340	41.04	1.304	0.0958	1.338	383.54	1127.8	82.86
0.2345	34.95	1.323	0.0972	1.339	379.35	1128.2	82.89
0.2350	44.28	1.343	0.0987	1.340	378.77	1128.6	82.91
0.2355	55.82	1.368	0.101	1.341	382.08	1128.9	82.94
0.2360	48.75	1.394	0.102	1.342	381.65	1129.3	82.97
0.2365	47.40	1.418	0.104	1.343	381.43	1129.7	83.00
0.2370	50.98	1.443	0.106	1.344	381.48	1130.1	83.03
0.2375	49.34	1.468	0.108	1.345	380.35	1130.5	83.05
0.2380	44.12	1.491	0.110	1.346	378.41	1130.8	83.08
0.2385	39.04	1.512	0.111	1.347	378.76	1131.2	83.11
0.2390	45.62	1.533	0.113	1.348	378.65	1131.6	83.14
0.2395	43.62	1.556	0.114	1.349	377.04	1132.0	83.17
0.2400	43.18	1.577	0.116	1.350	372.84	1132.4	83.19
0.2405	39.77	1.598	0.117	1.351	374.66	1132.7	83.22
0.2410	40.58	1.618	0.119	1.352	376.25	1133.1	83.25
0.2415	49.70	1.641	0.121	1.353	375.45	1133.5	83.28
0.2420	64.24	1.669	0.123	1.354	374.28	1133.9	83.30
0.2425	70.66	1.703	0.125	1.355	368.81	1134.2	83.33
0.2430	70.83	1.738	0.128	1.356	368.01	1134.6	83.36
0.2435	64.87	1.772	0.130	1.357	366.14	1135.0	83.38
0.2440	66.44	1.805	0.133	1.358	371.01	1135.3	83.41
0.2445	63.27	1.838	0.135	1.359	370.39	1135.7	83.44
0.2450	54.78	1.867	0.137	1.360	365.57	1136.1	83.47
0.2455	49.87	1.893	0.139	1.361	369.61	1136.4	83.49
0.2460	49.86	1.918	0.141	1.362	369.91	1136.8	83.52