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Atlas of Atomic Spectral Lines of Plutonium Emitted by an Inductively Coupled Plasma

by

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ATLAS OF ATOMIC SPECTRAL LINES OF PLUTONIUM
EMITTED BY AN INDUCTIVELY COUPLED PLASMA

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ABSTRACT

Optical emission spectra from high-purity Pu-242 were generated with a glovebox-enclosed inductively coupled plasma (ICP) source. Spectra covering the 2280-7008 Angstrom wavelength range are presented along with general commentary on ICP-Pu spectroscopy.

INTRODUCTION

Plutonium (Pu) is a highly toxic, fissionable element that is used for both electrical power generation and for the fabrication of nuclear weapons. Because Pu is produced in large quantities during the normal operation of nuclear power reactors, it is essential, for both public health and for nuclear safeguards programs, to develop accurate, sensitive, and rapid analytical methods for the determination of Pu wherever it occurs in the nuclear fuel cycle.

This atlas of the optical emission spectra of Pu as produced by an ICP excitation source was prepared as part of a study on the possible use of emission spectroscopy for monitoring Pu concentrations and isotope ratios in all aspects of the nuclear fuel cycle [1]. (Ref. 1 is included in this report as Appendix II.)

The first papers concerned with the analytical applications of inductively coupled plasma - atomic emission spectrometry (ICP-AES) to the determination of Pu solution concentration were those of KARNOWSKI and BERG [2], who reported on the use of a glovebox housed ICP source for the study of Pu and other hazardous radionuclei, and MAINKA, MULLER, and GEYER [3], who reported the detection limits for 13 Pu lines between 294 and 346 nm. EDELSON and FASSEL [4] presented a design for an ICP facility devoted to the study of alpha-emitting radionuclei along with a Pu-242 ICP-AES spectrum.

APPARATUS and PROCEDURES

Apparatus: The data presented herein were collected with an ICP apparatus specially adapted for glovebox operation [5]. The ICP operating conditions employed are listed in Table 1.

TABLE 1. ICP OPERATING CONDITIONS

Forward R.F. Power	900W
Reflected Power	<5W
Argon Flow Rates	
Outer Gas	17 l/min
Intermediate Gas	For ignition only
Nebulizer Gas	0.95 l/min
Sample Uptake Rate	0.25 ml/min
Observation Height	15 mm above load coil
Integration Time	1.0 s x 160 measurements (Photodiode array detector)

Some of the operating conditions were dictated by the limitations of glovebox operation rather than by spectroscopic considerations. For example, the power applied at the ICP torch was restricted to 900W forward power to minimize the heat input to a nearby air filtration device, and the torch-to-slit distance was set at ~1.7 m to permit the further isolation of the enclosed ICP in a separately ventilated room. A concentric nebulizer with a nominal solution uptake rate of ~0.3 to 0.4 ml/minute was chosen for this work. A peristaltic pump was used to further limit the flow to 0.25 ml/min and thereby reduce the amount of liquid waste generated during ICP operation.

The instrumentation used is described in Table 2 and a schematic diagram of the experimental lay-out is shown in Fig. 1 of Appendix II.

TABLE 2. INSTRUMENTATION

A. POWER and NEBULIZER SYSTEM

Generator	Type HFS 3000D (Plasma-Therm)
Nebulizer	TR-50-CO.5 (Meinhard)
Torch	T 1.5 (Plasma-Therm)
Spray Chamber	- (Plasma-Therm)
Peristaltic Pump	Minipuls 2 (Gilson Med. Elec)
Mass Flow Controllers	(3-channel) (MKS)

B. SPECTROMETER

Grating	1.50 m, f/14 THR1500 (Jobin-Yvon)
	2400 groove/mm (Jobin-Yvon)
	(Master holographic grating)
Entrance Slit	0.015 mm
Filter	Schott #GG 400 for 500-700nm

C. SIGNAL DETECTION ELECTRONICS

OMA	Model 1450 (EG&G/PAR)
PDA Detector	Model 1453 (EG&G/PAR)

D. COMPUTER SYSTEM

CPU	11/73 (Digital Equipment)
Graphics Terminal	Model 550 (Visual Technology)
Operating System	RT-11 V.5.1c (Digital Equipment)
Software	Ames Laboratory

Reagents: A sample of specially purified Pu-242 was obtained from the New Brunswick Laboratory of the U.S. Department of Energy. The sample had been purified by column chromatography to remove Am impurities and was supplied to us as the nitrate for easy dissolution. The stated isotopic purity was 99.932%. The sample was dissolved in deionized water and a small amount of doubly distilled nitric acid to provide a final concentration of 400 μg Pu/ml.

Procedure:

A photodiode array, optical multichannel analyzer (PDA-OMA), was used to record the optical emission spectrum of Pu-242 from 200 to 700 nm. This device was mounted on the photographic exit port of the high-resolution monochromator, and because this port was located perpendicular to the usual optical path, a mirror was used to divert the dispersed radiation to the PDA. With this mirror in place, the monochromator could be used only in the single-pass mode. In this configuration, with a 2400 grooves/mm grating, the resolution of the system was ca. 6 pm (at 300 nm) and the spectral coverage was ca. 6 nm [1].

To conserve sample, successive 6 nm wavelength segments were recorded without interrupting the delivery of Pu solution to the plasma. At the end of recording runs covering a wide wavelength range, the slit was covered and the detector array diode dark current was recorded. The dark current was then subtracted from each Pu spectrum segment to produce the detector dark-current corrected spectrum, which contained contributions from other plasma constituents, such as Ar, C, Si, O, N, H, and OH. A quadratic fitting function was used to calibrate the Pu line wavelengths [1]. The wavelength of lines in calibrated OMA spectra could be reliably estimated to within 5 pm (0.05 Å).

RESULTS AND DISCUSSION

Appendix I consists of 114 wavelength-vs.-intensity plots of the Pu-242 OMA data, corrected for detector dark current. These plots cover the spectral region extending from 2280 to 7008 Å. No Pu emission lines were detected in the region from 1980 to 2280 Å.

Tabular data on the pages facing the wavelength-vs.-intensity plots list the stronger lines, which are marked on the plots with either a dot or an element symbol (for lines not due to Pu emission). The first column of the tables gives the wavelength in Angstrom units, which are generally accurate to within 0.05 Å for the Pu lines. The second column lists the intensities, in counts, which have been corrected for detector dark current. The reported intensity values have not been corrected to account for the expected variation of instrument sensitivity to spectral wavelength. An attempt was made to estimate this variation by recording the spectrum of a quartz-halogen lamp over the 2500 - 7000 Å range and dividing the resultant spectrum by the expected "black-body" emission intensity from this source. The results are shown in Fig. 1, which must be understood to represent only an approximation of the actual instrument response function.

The spectral plots of Pu-242 presented in Appendix I are uncomplicated by either isotopic splitting or hyperfine splitting, which must be taken into account in the spectroscopy of Pu isotopic mixtures or the study of odd-weight Pu isotopes [1].

Few Pu lines were found in the spectral region from 1980 to 2480 Å, possibly because of the poor response of the photodiode array at those wavelengths. To compensate for the poor sensitivity, the entrance slit

Fig. 1. Approximate variation of monochromator-OMA sensitivity with wavelength. Measured using a 1000W quartz-halogen source (Model FEL, [Q1000/4CL], General Electric) operated at 8A, with a specified color temperature of 3200K. Curve shown is the average of measurements with two different lamps.

of the monochromator was opened to 0.050 mm, and the number of one-second integrations was doubled to 320. In addition, these spectra were smoothed with a running, three-point averaging procedure to increase their signal-to-noise ratio. The intensity values in the accompanying tables were measured prior to the smoothing procedure, and consequently, the tabular intensities for the regions from 2330 to 2480Å may not agree with the spectral intensities shown in the smoothed plots.

The detection limits of several of the most prominent Pu lines are listed in Table 3 of Appendix II.

REFERENCES

1. M.C. EDELSON, E.L. DeKALB, R.K. WINGE, and V.A. FASSEL, Spectrochim. Acta, 41B, 475 (1986).
2. K.D. KARNOWSKI and R. BERG, LaborPraxis, 5, 574 (1981).
3. E. MAINKA, H.G MULLER, and F. GEYER, Versuche zur Pu-Bestimmung mit Hilfe der ICP-Methode, KfK-3578, pp. 175 -188, Kernforschungszentrum Karlsruhe, Karlsruhe, FRG (July 1983).
4. M.C. EDELSON and V.A. FASSEL, A New Facility for High Resolution Inductively Coupled Plasma - Atomic Multielement Emission Spectroscopy of Radioactive Materials, in Analytical Spectroscopy, Ed. W.S. LYON, pp. 227-233, Elsevier, Amsterdam (1984).
5. M.C. EDELSON and E.L. DeKALB, The Ames Laboratory Facility for the Emission Spectroscopic Study of Alpha-Emitting Radionuclei: The Design and Operating History, in Use and Development of Enclosed Plasma Spectroscopic Sources, Ed. M.C. Edelson and J. Leland Daniel, ASTM Special Technical Publication No. 951, to be published in 1987.

APPENDIX I

FIGURES 1-114

ICP-OMA spectra of a ~0.4 mg/ml Pu-242 solution. The spectra are corrected for OMA diode dark current contributions, are unsmoothed and represent the summation of 160 one-second integrations (see text for special recording conditions for low wavelength spectra). (1 nm = 10 Å).

$\lambda(\text{\AA})$	I
2331.0452	538.
2338.5256	640.
2340.4287	782.
2359.3928	846.
2362.6738	1364.
2363.3301	965.
2366.9392	1108.
2368.9077	957.
2373.4355	1066.
2374.6167	1018.
2375.2729	1003.
2376.1917	819.
2386.1934	1192.
2391.4302	1064.
2396.9944	1431.
2404.5222	1137.
2421.0181	1187.
2425.8621	1345.
2427.4331	1375.
2431.9500	1342.

$\lambda(\text{\AA})$	I
2431.8455	807.
2436.2849	930.
2439.5469	873.
2457.7761	1254.
2458.9460	1259.
2461.0247	1259.
2463.0378	1269.
2464.5308	2400.
2468.3586	1064.
2469.9150	2550.
2470.3689	1317.
2474.9050	1939.
2475.3584	1265.
2481.8960	1929.
2481.6643	1332.
2481.9243	1908.
2484.6550	1734.
2485.2402	1299.
2486.7356	2065.
2488.5557	1536.
2490.8960	1650.
2497.5254	2469.
2498.3704	2312.
2500.6448	1608.
2501.6194	1306.
2502.2043	4681.
2502.9841	1117.
2509.0264	2936.
2510.1958	1257.
2512.1445	4640.
2516.1067	2659.
2519.5491	1662.
2519.8738	1790.
2523.1855	2549.
2523.8350	2027.
2526.1077	1315.
2528.5100	2543.
2530.2629	1198.

$\lambda(\text{\AA})$	I
2538.5027	1036.
2542.7112	1273.
2544.1995	1446.
2544.9111	978.
2545.6228	1120.
2546.0757	1081.
2553.0574	2213.
2553.7678	906.
2553.9617	954.
2555.2534	1037.
2556.6094	1129.
2560.4819	1030.
2564.9966	1563.
2567.8967	1847.
2569.0566	1013.
2569.4431	1225.
2571.1821	1892.
2573.9504	1306.
2575.4951	935.
2576.2029	2406.
2577.3608	1028.
2581.0906	1718.
2581.1736	1937.
2583.5688	1439.
2584.0217	4902.
2588.7437	2303.
2593.3318	1984.
2593.8484	1739.
2594.8818	2032.
2597.1414	5489.
2604.8159	2615.
2606.8777	1370.
2610.6125	4553.
2612.7361	1452.
2614.9233	1571.
2616.2092	1337.
2618.2664	2189.
2618.5234	8306.
2620.0012	1338.
2622.8274	1934.
2623.5334	2005.
2624.5605	1753.
2626.8708	2440.
2628.0896	2184.
2630.7188	1233.
2631.5520	2526.

$\lambda(\text{\AA})$	I
2631.5505	3125.
2633.8826	1827.
2637.4434	2150.
2637.8315	2651.
2638.1550	1843.
2639.0608	1954.
2640.8718	1736.
2644.8145	2030.
2650.9475	1683.
2652.3020	3136.
2652.5601	1729.
2655.5901	4393.
2656.2988	2723.
2658.4890	3681.
2661.2576	3578.
2662.4160	2497.
2664.0886	1698.
2664.9246	2819.
2668.3958	1708.
2669.8735	2611.
2675.9714	2798.
2678.0237	2371.
2683.2959	3733.
2685.0317	2698.
2688.6318	2259.
2689.6602	2565.
2689.8530	2529.
2693.5161	5323.
2695.1865	2355.
2695.5720	5173.
2697.6277	4954.
2703.7290	3652.
2706.8108	2398.
2709.6353	2983.
2711.4324	2716.
2711.7532	2341.
2712.3950	2822.
2715.7957	4351.
2716.7581	2914.
2718.8108	2739.
2719.6445	3267.
2722.7871	3444.
2726.6985	2752.
2730.5444	3332.

$\lambda(\text{\AA})$	I
2730.5454	3707.
2737.7834	3250.
2739.3206	6182.
2741.8186	5459.
2743.6760	3363.
2744.1243	6067.
2745.2771	3614.
2750.4648	5635.
2751.6177	3307.
2758.2783	3529.
2761.1602	5913.
2763.2734	3533.
2766.1553	3295.
2766.4753	4326.
2767.1157	3436.
2768.3325	3375.
2769.2290	8019.
2772.1748	3338.
2772.3027	11804.
2773.3274	7104.
2773.4553	5182.
2776.4009	9175.
2776.8491	3732.
2777.2974	4037.
2778.8342	4514.
2781.4595	23570.
2781.4675	27735.
2783.9583	10582.
2784.5332	68421.
2787.3430	17858.
2791.0464	9361.
2794.5579	10436.
2795.4517	35300.
2795.8987	17647.
2798.2605	7324.
2804.1326	7236.
2805.4727	6833.
2806.1108	38885.
2807.0681	22215.
2808.5996	6923.
2809.2375	16029.
2810.8965	6933.
2811.2156	8661.
2811.4070	6798.
2815.7454	18131.
2818.3608	9861.
2821.4861	7839.
2824.5476	15505.
2826.2693	9520.
2830.2866	7832.

$\lambda(\text{\AA})$	I
2836.3035	10006.
2838.6729	12905.
2840.3965	12997.
2846.3291	15658.
2847.0305	10946.
2852.8293	10473.
2856.0767	9553.
2859.0042	11969.
2860.0220	36630.
2860.2764	14257.
2862.1846	11066.
2866.5706	14030.
2867.1423	38224.
2867.8413	9166.
2869.0483	38627.
2869.3022	10854.
2872.6040	9200.
2874.9524	15310.
2875.5234	10682.
2876.4116	13919.
2877.5532	10587.
2878.0605	10047.
2885.1401	18420.
2891.7454	14758.
2894.5393	39480.
2895.7458	21241.
2897.9683	57503.
2898.9207	18482.
2899.3652	19257.
2899.7461	32980.
2904.1904	24791.
2904.8889	29306.
2910.3484	37310.
2910.6658	17933.
2913.5854	17940.
2915.1089	28551.
2918.0286	29003.
2918.7900	20209.
2923.1689	24747.
2923.6768	15126.
2925.4534	73969.
2926.0247	26768.
2926.6592	43858.
2928.2454	46890.
2929.7048	17686.
2930.9739	29371.

$\lambda(\text{\AA})$	I
2930.9709	29178.
2933.2534	25726.
2933.5703	29750.
2938.8962	24835.
2939.0864	66237.
2941.3689	67710.
2945.2361	38396.
2945.9968	37803.
2950.0542	94465.
2951.5754	35653.
2951.7656	105529.
2952.0193	28310.
2954.4282	120833.
2964.6335	152194.
2969.0071	48654.
2970.4648	24514.
2972.4929	114312.
2973.4436	39792.
2978.0703	45089.
2978.5139	83418.
2980.2883	77253.
2980.2898	88515.
2981.2996	17978.
2986.9788	23547.
2988.2407	82797.
2991.3323	44165.
2991.6477	35538.
2994.0449	194623.
2996.4421	131440.
2998.5239	28945.
3000.6052	198018.
3004.8311	31542.
3008.9932	61551.
3013.4702	23100.
3017.9468	25723.
3019.2708	33174.
3023.4312	52329.
3028.8518	33920.
3029.4192	26028.
3029.9233	49210.

$\lambda(\text{\AA})$	I
3032.1987	33349.
3033.9036	15636.
3038.3853	29124.
3042.6123	46951.
3043.1169	27642.
3044.6306	23954.
3045.1350	31412.
3046.1438	17155.
3046.7744	16542.
3047.4048	25798.
3056.6680	19058.
3057.4866	25705.
3060.3201	45529.
3061.6421	37911.
3065.1038	20029.
3069.3188	54633.
3070.7651	43043.
3073.6577	27401.
3074.6633	24850.
3076.0464	15333.
3080.2844	16311.
3083.2412	25254.
3087.5806	17232.
3088.1462	25763.
3091.3521	18402.
3091.9805	24660.
3094.1169	49254.
3096.3154	22981.
3101.4019	17967.
3104.1011	28572.
3105.0425	52133.
3106.0464	40297.
3111.8171	34806.
3115.2654	18339.
3116.8950	30469.
3117.9604	30929.
3120.8425	20137.
3123.8491	26303.
3129.2332	51741.

$\lambda(\text{\AA})$	I
3132.1821	18314.
3133.1863	24053.
3133.8767	22087.
3137.5156	49679.
3138.5193	26371.
3139.8367	13695.
3142.0317	17765.
3144.8533	16757.
3145.8564	19665.
3156.0710	12712.
3158.0127	20658.
3159.2026	108282.
3159.9541	18519.
3161.7700	45560.
3162.2710	13748.
3163.1475	55835.
3164.3369	16422.
3164.9629	19504.
3169.2185	15186.
3174.5364	27663.
3175.1619	44964.
3175.5996	13141.
3178.7888	15315.
3179.4141	25740.
3182.1697	24099.
3184.2930	24064.
3185.1047	40767.
3187.6025	25866.
3189.2261	22193.
3191.4741	23938.
3194.5337	42670.
3198.4673	88643.
3200.2156	28745.
3200.9648	27127.
3201.2771	26913.
3201.6516	25121.
3202.7754	17073.
3204.4612	33292.
3206.7712	36409.
3207.7075	20845.
3208.6440	18897.
3216.1353	22703.
3220.9419	39848.
3221.5662	16463.
3224.8743	36519.
3229.8677	18634.

$\lambda(\text{\AA})$	I
3231.8579	55666.
3232.6057	45132.
3241.3894	77609.
3242.9458	64775.
3243.2568	27912.
3245.1863	118255.
3246.3064	66937.
3247.5508	19822.
3252.7126	16691.
3253.8315	18135.
3256.5664	22831.
3260.5425	36704.
3261.0393	13806.
3265.7578	21383.
3271.0940	19197.
3273.0786	38848.
3273.5747	22185.
3275.1248	31810.
3276.1787	14779.
3279.2773	50965.
3283.8472	23717.
3286.3909	31921.
3287.6313	12197.
3287.8796	23963.
3289.9885	57478.
3290.2988	29360.
3298.4226	51143.
3302.4526	13984.
3303.1965	13025.
3307.7212	19365.
3312.6169	49705.
3313.5464	15527.
3315.3433	36525.
3316.0867	19850.
3316.9541	12782.
3317.5735	18024.
3323.8296	23561.
3324.8206	11315.
3329.4648	41994.

$\lambda(\text{\AA})$	I
3332.8779	17566.
3337.7080	73636.
3339.7510	18313.
3340.1223	12554.
3343.2783	11143.
3347.8557	11078.
3350.3291	46757.
3351.3184	23592.
3351.8127	33982.
3356.2007	11450.
3356.5715	20889.
3358.8574	15672.
3359.3516	14344.
3361.3279	14760.
3362.2542	18558.
3370.2163	32214.
3370.6482	39046.
3374.6575	13208.
3376.8157	11421.
3376.9390	20738.
3377.3706	30852.
3381.1699	19689.
3381.9783	18637.
3391.4673	43584.
3392.2715	22286.
3398.2009	39241.
3401.1592	255182.
3401.9597	16610.
3404.6050	19242.
3408.0452	14321.
3413.2554	21203.
3418.8796	117694.
3421.3811	20049.
3424.3054	24383.
3424.6099	24434.
3425.4011	66723.
3425.7053	20082.
3426.2527	43258.

$\lambda(\text{\AA})$	I
3442.5442	12503.
3444.0830	19651.
3449.0674	49791.
3455.2791	46732.
3460.7495	22689.
3462.6541	27478.
3465.1729	188238.
3469.2258	98058.
3470.9448	12430.
3473.7068	193418.
3481.8225	11750.
3483.1743	43794.
3484.2803	4215.
3488.7021	6780.
3490.1143	4313.
3491.2190	7933.
3495.8210	3910.
3497.2317	20415.
3497.5996	10546.
3498.7034	3693.
3499.3779	5143.
3501.0945	3553.
3504.0361	4040.
3504.8328	9580.
3515.3022	3839.
3516.6479	15425.
3517.6880	4015.
3521.8459	4162.
3527.2234	4398.
3528.6892	5160.
3528.9946	3876.

$\lambda(\text{\AA})$	I
3533.0627	42405.
3533.3076	19642.
3539.1812	19119.
3539.9758	25627.
3540.7095	20967.
3546.8193	9757.
3546.9414	10294.
3550.2375	15684.
3551.4580	5838.
3551.7019	5645.
3556.5803	8810.
3556.7632	15946.
3559.3223	10047.
3563.5242	7277.
3565.2891	13492.
3567.8442	39600.
3568.6958	13327.
3573.7407	6391.
3575.1987	5772.
3577.2026	10147.
3577.9919	5666.
3579.2058	6847.
3581.7007	14480.
3585.8660	248601.
3588.0078	13506.
3591.7373	14585.
3600.0361	20143.
3600.7673	26698.
3602.7166	21358.
3604.0557	46841.
3606.0029	16824.
3608.8604	49428.
3609.8325	21339.
3610.4399	18504.
3610.8044	24330.
3610.9866	19637.
3614.0823	16960.
3615.7808	35643.
3621.4148	24424.
3625.6489	14065.
3627.5828	111473.
3628.7302	14263.

$\lambda(\text{\AA})$	I
3632.2009	325543.
3635.9033	43920.
3636.4495	48813.
3639.7849	19155.
3647.9636	34744.
3648.9321	24097.
3649.2346	29004.
3651.4131	87586.
3652.2600	26701.
3659.4529	124246.
3660.7212	16972.
3662.7739	19988.
3663.8000	19308.
3672.1223	24661.
3674.8333	35935.
3679.6492	36040.
3680.4990	19758.
3682.9224	35977.
3688.1287	17807.
3690.3665	50762.
3691.2734	29790.
3695.3223	41697.
3698.5222	15103.
3699.1860	103367.
3699.4878	48112.
3701.1167	120117.
3702.3833	19204.
3709.1921	151981.
3710.9980	26398.
3717.0723	28646.
3717.9136	14520.
3718.1538	52634.
3720.2563	109077.
3721.6375	63346.
3726.1377	162573.
3726.7974	146493.
3727.5767	16221.

$\lambda(\text{\AA})$	I
3732.0491	128630.
3732.6492	14983.
3736.2483	16875.
3737.5679	20970.
3739.3672	64212.
3739.8469	11765.
3743.0854	78751.
3744.1050	21343.
3744.8845	15939.
3747.5828	20581.
3752.3193	14573.
3753.6382	19599.
3755.2566	34337.
3758.5535	27189.
3763.2283	25245.
3767.4231	18780.
3770.2991	70017.
3771.0781	13666.
3773.5942	104098.
3775.6311	47887.
3788.8425	45644.
3789.2021	13074.
3789.8618	34000.
3792.2595	12551.
3799.3875	13953.
3799.6270	15064.
3799.8064	12564.
3803.5767	93325.
3805.9692	13090.
3807.2249	25155.
3807.4641	40668.
3807.8228	17870.
3809.1379	72324.
3809.6162	16893.
3810.2139	204092.
3811.7676	42241.
3812.3052	165114.
3814.8735	70078.
3823.9443	73426.
3825.8525	21467.

$\lambda(\text{\AA})$	I
3830.2241	15783.
3830.9424	28019.
3835.4890	16767.
3835.9673	39773.
3836.6851	16021.
3836.9241	15663.
3838.8372	35418.
3841.5266	20612.
3846.1860	16641.
3850.0664	21444.
3851.0215	20181.
3851.2004	54714.
3851.8567	16309.
3852.6323	62365.
3853.1096	26802.
3856.9268	29776.
3858.3577	33449.
3862.4697	18809.
3864.7930	32046.
3865.0908	45217.
3868.9014	15416.
3872.4719	25394.
3874.1970	75158.
3876.9922	35723.
3878.5972	26422.
3882.8115	53545.
3886.5530	68131.
3887.3843	50501.
3888.2156	21985.
3891.8965	45021.
3892.9058	39244.
3895.2205	15159.
3895.7546	21617.
3904.1208	48383.
3906.1377	27773.
3907.2646	253629.
3909.1030	19083.
3910.2891	58563.
3912.6016	114681.
3913.5500	84204.
3914.3208	14690.
3921.6704	17852.
3927.9504	31469.
3929.3130	19219.

$\lambda(\text{\AA})$	I
3931.2209	26294.
3934.0029	34780.
3935.6594	22464.
3947.0688	37065.
3949.0178	19039.
3949.2542	31179.
3950.3760	17090.
3953.0325	115133.
3959.0503	73912.
3962.7056	59085.
3963.5896	44833.
3967.1838	20663.
3971.4829	41229.
3971.6006	26845.
3972.2480	172117.
3974.6023	20223.
3975.4263	239656.
3975.9558	35486.
3979.7522	19416.
3980.5222	43562.
3985.6121	191228.
3988.5090	36759.
3989.7498	32438.
3989.8679	120928.
3990.0452	56017.
3991.5806	46024.
3992.2302	49506.
3993.9417	21245.
3996.1243	49078.
4003.4875	16921.
4004.6643	21554.
4013.2422	22381.
4015.8818	26647.
4016.9958	16010.
4021.6821	123278.
4023.5549	30769.
4024.6079	40924.
4026.9468	15614.
4028.9336	22233.

$\lambda(\text{\AA})$	I
4028.9358	24628.
4031.1687	16620.
4033.0481	18881.
4033.2830	18585.
4035.0442	14345.
4035.7488	23302.
4038.9758	13931.
4039.5037	40756.
4041.4387	16849.
4044.4277	21075.
4045.5996	19895.
4048.8789	67873.
4053.2678	13733.
4054.7883	40601.
4056.6594	55287.
4059.3474	24070.
4064.8364	93189.
4066.9951	14929.
4073.0002	15186.
4074.1655	14950.
4074.1667	25904.
4074.4033	18375.
4077.0029	17330.
4078.1833	37955.
4078.7141	18439.
4080.3057	16289.
4088.8843	14217.
4097.8828	27286.
4099.5132	14212.
4099.9209	19820.
4100.9678	48784.
4103.8726	17847.
4104.6851	15155.
4106.0186	45954.
4112.3813	17590.
4112.9009	19289.
4113.1318	41367.
4115.7256	25946.
4116.1289	32330.
4116.4741	31264.
4117.1074	18816.

$\lambda(\text{\AA})$	I
4121.5693	35165.
4123.5981	24706.
4123.8882	11840.
4124.0039	17418.
4125.8013	13650.
4128.4702	23599.
4129.9209	42206.
4130.9077	9426.
4135.1479	15624.
4138.4033	14137.
4141.1367	51065.
4147.7158	14394.
4149.5861	27698.
4149.9302	9991.
4156.1123	11914.
4158.6807	93302.
4159.4399	19373.
4159.9072	9737.
4164.2085	11873.
4167.8745	19394.
4169.5029	11711.
4173.1069	11487.
4174.6753	11616.
4178.2759	70707.
4181.9321	17940.
4182.2222	11818.
4187.5562	11414.
4189.1206	11974.
4189.9316	58760.
4190.1636	80950.
4190.9165	28744.
4195.0269	14892.
4196.2422	71096.
4198.3823	36065.
4200.7529	97619.
4203.0068	18422.
4205.6064	32625.
4206.5884	10344.
4208.0894	26765.
4208.7822	35532.

$\lambda(\text{\AA})$	I
4208.6821	37244.
4211.9272	12862.
4212.1592	23164.
4215.2285	16512.
4216.3281	33468.
4217.5435	13263.
4218.9897	56958.
4222.2275	12735.
4223.0366	9136.
4224.9434	17694.
4229.7935	77477.
4230.9473	26003.
4236.5977	17240.
4247.2446	31642.
4249.7729	58208.
4249.9453	14984.
4251.6685	14589.
4251.9556	9166.
4254.7368	66354.
4256.0063	39783.
4256.5830	24836.
4257.7368	31452.
4258.0825	21896.
4259.3511	38221.
4266.3208	25135.
4267.1265	19696.
4272.1870	41623.
4273.3364	184920.
4274.3706	16617.
4275.0024	15731.
4278.0454	23509.
4278.3320	66088.
4278.7339	55783.
4280.3403	88324.
4281.1431	16429.
4281.7739	19046.
4283.7808	29195.
4289.1074	100013.
4297.7988	39311.
4298.1987	36882.

$\lambda(\text{\AA})$	I
4298.2002	43756.
4299.6890	9358.
4300.1470	38344.
4304.8408	10851.
4307.2441	23295.
4313.4214	10818.
4314.2788	58456.
4314.5649	34365.
4316.5654	51966.
4317.0225	14374.
4318.8516	27836.
4320.9082	9365.
4321.7651	17551.
4326.2197	30775.
4329.3022	11039.
4329.5879	15213.
4330.6152	73886.
4330.8433	25566.
4333.5820	37357.
4335.2368	12285.
4335.9780	40454.
4337.2329	138005.
4340.4829	11511.
4343.8853	21921.
4345.1455	14820.
4346.0620	15418.
4346.6348	10704.
4352.7554	188501.
4355.6689	18807.
4355.8975	19094.
4358.0664	80736.
4361.3745	17717.
4371.5630	35520.
4379.8506	100565.
4380.0205	14547.
4381.3242	42133.
4383.5903	55060.
4384.6660	16363.
4385.3452	172991.
4386.1943	14501.

$\lambda(\text{\AA})$	I
4392.7988	12680.
4392.9697	47734.
4393.5957	15482.
4393.9370	110424.
4394.2217	14113.
4396.4971	153093.
4398.2598	13724.
4398.6006	18983.
4403.9985	51034.
4404.3960	15085.
4404.9067	58773.
4406.7803	170464.
4419.4775	77896.
4420.3267	17944.
4421.7412	15126.
4421.8545	24338.
4423.4385	11341.
4433.0459	31810.
4433.0034	26240.
4435.4922	20957.
4437.0757	14017.
4437.4150	7149.
4440.3550	30191.
4441.6548	128737.
4447.1357	7204.
4448.2656	39250.
4448.3784	10390.
4456.7349	78117.
4466.7192	7220.
4467.5649	15921.
4468.4668	50242.
4469.0869	16660.
4472.8628	244232.
4474.6094	11587.
4475.6797	17709.
4477.4819	16192.
4477.6509	6609.

$\lambda(\text{\AA})$	I
4480.7939	21481.
4481.0742	14100.
4481.2988	40752.
4485.3379	20417.
4490.3301	14072.
4491.7319	23624.
4492.1245	16353.
4493.8071	188387.
4496.7788	34027.
4500.7588	19996.
4501.9922	12011.
4504.9067	296410.
4507.5967	53419.
4510.5664	53436.
4510.7344	15943.
4512.8638	42965.
4521.1533	46607.
4521.6577	13751.
4527.6445	33191.
4531.0566	7084.
4535.9219	7394.
4536.2017	421993.
4537.4873	9208.
4545.3672	11655.
4549.3330	8015.
4550.8965	7460.
4551.2314	8418.
4551.5664	21917.
4561.1108	9542.
4567.4697	13095.

$\lambda(\text{\AA})$	I
4574.1196	6886.
4574.7378	10236.
4576.0303	7040.
4577.0410	6900.
4577.7705	5793.
4578.2754	26225.
4579.8452	84494.
4584.0430	4628.
4585.0488	11796.
4585.3281	8695.
4586.8911	5725.
4588.6758	14609.
4590.9600	6555.
4591.6831	9208.
4594.1294	34204.
4596.2393	5949.
4599.7866	6484.
4600.0635	12944.
4600.7827	4948.
4604.1543	5859.
4606.8579	19646.
4607.1885	23746.
4610.6021	13656.
4612.6357	5322.
4615.5044	15491.
4618.0107	16208.
4618.9565	9999.
4625.1260	20434.
4627.0132	9034.
4627.3457	32932.
4627.5122	90532.
4630.1733	6697.
4630.8940	57595.
4637.0361	13609.
4638.4731	6408.
4638.6387	6478.
4639.3018	46883.
4639.5776	8889.
4641.7856	11705.
4642.8340	5526.
4643.8813	14165.
4646.1411	14750.
4656.4229	9172.
4656.5874	8108.
4657.4102	56899.

$\lambda(\text{\AA})$	I
4657.4121	49401.
4660.8936	13313.
4662.2744	10160.
4664.2065	115323.
4668.5107	9234.
4671.1577	23444.
4673.2524	22295.
4674.9053	16210.
4689.5381	60809.
4690.9663	18393.
4692.1196	38539.
4693.9858	23339.
4698.8135	35828.
4701.3350	84913.
4702.3828	7111.
4702.9878	9543.
4709.0903	24560.
4711.3979	8208.
4713.7598	16929.
4715.7363	39876.
4716.0659	8403.
4722.6509	16449.
4722.8154	44545.
4726.3794	25837.
4730.7637	7017.
4731.2568	60537.
4731.4756	5577.
4734.2690	6588.
4734.5430	5273.
4738.7578	14669.
4739.1953	18204.
4739.6333	8068.
4741.9307	5818.
4742.3135	13266.
4744.3916	12794.

$\lambda(\text{\AA})$	I
4747.8940	4093.
4748.6606	4415.
4748.8247	7192.
4749.3716	8047.
4752.1064	4833.
4752.9268	5423.
4755.1128	7192.
4762.3726	5877.
4763.4082	13647.
4767.1685	207328.
4768.5845	9485.
4768.8022	4475.
4768.9653	4067.
4773.6992	4149.
4774.7866	4595.
4776.0913	5267.
4780.8164	8690.
4784.2886	5479.
4785.2646	4824.
4787.1616	8084.
4790.0327	3679.
4790.8989	5593.
4791.4946	5916.
4799.1538	3472.
4802.0361	27070.
4804.8076	7391.
4808.9331	42217.
4810.7769	11835.
4811.7529	10121.
4813.5410	3613.
4815.3823	20341.
4816.1943	4625.
4817.8184	11102.
4818.3594	4932.
4819.9819	5439.
4822.9546	7988.
4823.1704	103318.
4828.9458	3818.
4829.5928	22761.
4831.4795	6315.
4832.5034	6350.
4834.7651	3684.

$\lambda(\text{\AA})$	I
4840.5610	18948.
4842.2412	30358.
4842.6743	9923.
4845.0576	6380.
4845.5991	9787.
4850.2534	31365.
4851.1187	7192.
4851.5513	15228.
4852.0381	7863.
4852.3628	21544.
4854.0386	18378.
4861.3843	43876.
4862.7876	4943.
4863.1113	5718.
4864.8374	12184.
4865.0532	17782.
4869.9590	23063.
4872.0601	8992.
4874.1060	18259.
4876.2056	9222.
4876.4204	8254.
4878.8418	6553.
4880.1323	18426.
4880.6162	22513.
4880.9927	5596.
4884.2349	23162.
4886.0225	10604.
4886.7266	17825.
4887.2681	16819.
4887.9717	5950.
4888.3501	16281.
4891.9722	11076.
4894.2402	41239.
4894.7256	12501.
4898.7153	15780.
4899.7388	11962.
4901.9995	8281.
4903.7739	10360.
4906.8896	31655.
4908.2852	20137.
4910.4844	4743.
4910.8057	16411.
4911.9849	6583.
4917.0688	29403.
4918.1909	30517.
4919.8467	15024.
4924.7007	12269.
4926.7246	19928.

$\lambda(\text{\AA})$	I
4926.7456	18777.
4927.6060	7277.
4928.4658	19357.
4930.6680	10910.
4934.2100	4842.
4935.1216	24397.
4935.7114	4281.
4935.8184	8508.
4938.1226	9377.
4939.5684	3895.
4941.0132	10567.
4941.7622	9689.
4942.9390	4645.
4945.5044	43306.
4949.4551	6366.
4954.3594	5732.
4955.6377	25104.
4957.6064	36908.
4959.3086	17311.
4963.3467	9022.
4964.8330	3851.
4967.0610	4887.
4970.3994	5693.
4974.5269	6527.
4975.9663	5182.
4977.9907	5576.
4979.4292	18403.
4979.7485	8567.
4980.7070	39652.
4982.5166	31127.
4983.2080	5344.
4984.4316	62163.
4986.6650	16961.
4987.5684	6610.
4993.0391	15678.
4997.6006	6072.
4999.8271	7035.
5000.2510	5806.
5001.5752	5035.
5002.8462	35459.
5004.3286	10636.
5004.5400	6814.
5006.5508	8358.
5007.7144	8700.
5009.7764	7180.
5012.8413	10614.
5013.8975	6033.
5014.9004	5056.

$\lambda(\text{\AA})$	I
5019.4189	4100.
5020.3672	3546.
5022.0010	3162.
5023.0024	6179.
5023.3184	44221.
5024.6890	4359.
5026.0596	6522.
5031.0698	2895.
5032.0195	3126.
5032.6523	7634.
5035.8716	3698.
5037.8774	11067.
5038.0889	9204.
5038.8809	2987.
5045.1660	7975.
5045.5356	7512.
5047.0684	18731.
5048.0723	3515.
5048.7065	2714.
5049.9224	5889.
5050.9268	3786.
5054.0996	2891.
5054.2583	5051.
5057.1680	13422.
5060.4487	3823.
5065.3735	10471.
5072.5146	1924.
5074.2466	14416.
5075.0332	2016.
5077.5508	4456.
5078.4419	2554.
5078.6519	14190.
5079.1758	1880.
5084.0488	7470.
5084.3633	2394.
5085.3584	1856.
5086.1963	21546.
5087.1909	3600.
5088.3950	3411.
5089.2847	2941.
5090.0693	19957.
5093.1558	1981.
5093.9927	2031.
5097.2339	2547.
5097.5474	1751.
5099.1147	2164.
5100.4209	1825.
5100.8911	2930.
5101.9355	3107.

$\lambda(\text{\AA})$	I
5106.9844	2300.
5108.7183	11169.
5109.0859	3545.
5110.6089	2575.
5111.0811	1875.
5111.9209	2567.
5116.6406	2162.
5118.3169	1619.
5118.6313	1779.
5121.4585	3934.
5122.2954	2243.
5128.3589	1607.
5130.6040	1892.
5132.5347	1799.
5132.9521	18859.
5135.7153	1414.
5136.4448	2136.
5138.1636	1542.
5139.9858	2252.
5142.6392	2186.
5143.6792	1353.
5146.5898	11016.
5147.7324	2015.
5149.3418	5477.
5151.2622	3583.
5151.1880	2112.
5151.5039	1898.
5153.9795	7524.
5159.1807	2726.
5160.1245	6888.
5162.3247	7548.
5162.6909	16292.
5168.1768	3334.
5169.8447	5246.
5176.0322	3891.
5178.1069	2250.
5178.7285	4841.
5179.4019	7491.
5179.7124	4118.
5180.0229	5056.
5180.2300	1745.
5187.9741	6902.
5188.4888	3386.
5191.1636	2802.
5192.7041	1672.
5193.5254	2118.
5193.8330	7392.
5193.9360	5891.
5194.1411	4183.

$\lambda(\text{\AA})$	I
5204.1489	3364.
5205.2749	6707.
5206.9131	3458.
5207.2207	2722.
5207.6304	4316.
5209.6304	24255.
5210.5024	3962.
5213.1221	3491.
5214.5620	4627.
5215.3853	5218.
5215.8999	2463.
5216.8784	3168.
5217.1875	2061.
5218.4243	11276.
5219.1460	8720.
5221.3647	8030.
5221.9331	9120.
5224.1553	2668.
5226.0181	3037.
5227.9858	5778.
5230.4751	5746.
5233.1230	2278.
5233.7988	2063.
5235.5151	2263.
5235.7231	13312.
5236.0352	3244.
5246.1763	5891.
5247.1660	5308.
5247.9468	2032.
5249.2466	2283.
5250.9077	4518.
5252.4619	5841.
5252.9277	2716.
5253.2383	4196.
5254.2202	3077.
5254.6333	2184.
5258.9082	5048.
5260.9097	2103.
5263.5195	9622.
5263.6729	4007.
5266.0703	3017.
5267.0889	3646.
5267.7500	9640.
5267.9531	7195.
5273.0200	9714.
5276.8003	2455.
5276.9512	8292.
5281.8628	2975.
5281.9629	3098.
5282.7119	2323.
5284.5566	1976.
5284.7061	2354.

$\lambda(\text{\AA})$	I
5287.5776	2727.
5288.3955	6242.
5290.7969	1906.
5292.6855	11048.
5293.5527	1415.
5296.8164	1481.
5297.0713	3375.
5298.2939	5607.
5299.6689	11092.
5300.3818	3751.
5304.1460	6652.
5304.7559	1661.
5305.7725	2153.
5306.6870	1446.
5307.4995	1434.
5316.7778	18236.
5319.9653	2695.
5320.5215	3186.
5321.0776	12841.
5322.0381	1951.
5326.3809	2255.
5328.3984	25585.
5336.4634	3370.
5337.1768	2609.
5340.3848	1993.
5341.8096	22917.
5344.7583	6885.
5345.1138	5480.
5346.4346	4077.
5348.2114	2096.
5348.8711	2235.
5349.8857	2276.
5350.0376	2220.
5350.5957	6768.
5351.1533	3297.
5353.1299	1445.
5353.3325	2617.
5358.5952	1875.
5361.1221	2469.
5361.6270	2792.
5362.1318	1893.
5364.3525	2147.
5367.9321	3447.
5369.1411	2075.
5370.6011	3362.
5371.0542	2129.
5371.2051	1425.
5371.4565	1415.

$\lambda(\text{\AA})$	I
5378.4429	1415.
5378.6948	1450.
5378.9971	9043.
5381.0620	1433.
5382.0693	5134.
5382.8745	4799.
5383.2271	1294.
5386.5986	1257.
5387.4033	3028.
5387.9062	4848.
5388.7109	1446.
5391.2241	3579.
5391.8271	2180.
5396.3481	3985.
5398.0049	1447.
5398.4063	4589.
5405.0269	1133.
5405.8789	1506.
5408.4844	17782.
5410.1372	1503.
5410.5879	1174.
5413.3408	1849.
5416.8428	1976.
5417.3931	3596.
5417.6929	1141.
5418.3931	6451.
5420.2925	1226.
5421.1685	2476.
5421.5205	1992.
5423.0298	9914.
5426.1953	3255.
5428.2524	6213.
5431.8096	9182.
5435.3101	4459.
5436.6084	2123.
5439.1528	2744.
5443.0869	2148.
5444.0815	2113.
5444.2808	3120.
5447.3604	3027.
5447.7080	4678.
5448.7993	9510.
5449.9893	5983.
5451.7725	5275.
5452.3174	2802.
5452.4160	6940.
5456.8159	2353.
5457.8525	2559.
5458.2969	3643.
5461.6978	5227.
5462.4858	5857.
5462.9287	2092.

$\lambda(\text{\AA})$	I
5469.7100	3114.
5469.9609	1689.
5471.5132	1626.
5472.4639	2484.
5476.3599	16662.
5477.3071	1532.
5477.7559	5643.
5482.2822	1624.
5486.1011	2352.
5494.1489	1787.
5496.1162	14496.
5496.7061	2513.
5497.2954	2865.
5498.6206	1711.
5501.2671	2697.
5502.7842	2237.
5503.0283	2494.
5504.6411	2683.
5504.9341	1956.
5505.6660	1951.
5506.3003	3177.
5507.0317	2930.
5507.3242	7296.
5508.2012	3775.
5509.4668	1622.
5510.9941	2249.
5515.7354	3018.
5516.5176	1626.
5518.1802	1547.
5518.5225	6635.
5519.2070	2619.
5519.9409	1683.
5523.6104	3449.
5525.0293	1764.
5525.3721	2047.
5528.0156	4073.
5529.4849	5727.
5530.5620	1470.
5530.8071	6173.
5531.0518	1691.
5534.1870	3244.
5538.3042	1481.
5539.2358	1386.
5545.3174	4197.
5547.1333	11327.
5547.5747	2569.
5548.1147	1582.
5549.6855	1561.
5550.6675	1825.
5552.3369	3391.
5552.7788	1623.

$\lambda(\text{\AA})$	I
5558.7041	9170.
5559.1499	12481.
5559.6943	2656.
5562.0669	2663.
5563.3506	1526.
5563.5972	2825.
5565.2734	5245.
5566.1108	1503.
5566.4062	11740.
5567.2427	2875.
5568.2754	2572.
5568.6191	2537.
5570.5347	1580.
5572.5938	5820.
5574.2583	1479.
5574.5518	2056.
5577.2886	3316.
5580.2139	1460.
5587.2080	1429.
5589.5308	5089.
5590.5937	2117.
5592.6211	1536.
5597.7227	4425.
5602.8628	2025.
5606.7324	14200.
5607.1240	3195.
5609.4224	1946.
5610.9858	3338.
5611.8159	1952.
5616.8867	1980.
5617.8604	4559.
5618.7363	1986.
5623.5469	2365.
5623.8867	2818.
5625.7783	8924.
5628.0562	12523.
5629.2178	4474.
5630.5728	3194.
5630.7178	3524.
5630.9111	5022.
5631.5400	3055.
5633.5210	6939.
5633.7627	2600.
5635.4521	17281.
5637.3813	2910.
5637.7666	11590.

$\lambda(\text{\AA})$	I
5645.2998	1603.
5647.7422	2810.
5647.9863	3948.
5648.8638	1982.
5650.4224	1660.
5650.8115	7660.
5654.3081	1844.
5654.7446	2334.
5656.5840	3148.
5657.2129	3572.
5658.2275	1990.
5659.0479	1860.
5659.3857	1709.
5661.3135	10155.
5665.6846	2233.
5668.8433	2459.
5668.9863	1955.
5670.7524	2275.
5673.5142	1509.
5674.5127	2320.
5675.6519	2807.
5675.8892	2364.
5681.3291	7813.
5681.8477	2403.
5687.3477	4870.
5688.8462	2018.
5690.9058	3009.
5693.4175	1901.
5694.4604	2193.
5694.9819	1835.
5695.9312	1567.
5698.0669	2472.
5698.8267	1752.
5699.2544	3201.
5699.9668	3242.
5701.2979	1689.
5703.0098	32946.
5704.8179	2521.
5705.9126	2104.
5708.4375	6813.
5711.3462	2037.
5716.5986	10742.
5718.6069	2073.
5719.8506	1579.
5725.6460	1672.
5726.0293	6046.
5727.6123	3671.
5729.8198	1824.
5733.4712	2131.
5734.1440	1610.

$\lambda(\text{\AA})$	I
5739.5757	5928.
5740.0996	5024.
5743.7671	1490.
5749.0488	2319.
5749.3340	1693.
5749.9521	58857.
5751.4258	4233.
5751.9961	4100.
5754.0396	2123.
5754.9419	2273.
5756.6519	1568.
5764.7642	2303.
5765.5225	1656.
5767.6548	4537.
5767.9863	40001.
5769.2178	1386.
5770.2593	2096.
5770.4014	1899.
5772.2949	2817.
5773.1465	1626.
5773.2886	1423.
5785.3486	3136.
5787.3896	15332.
5788.0537	1760.
5792.9326	2476.
5795.4390	5294.
5798.9321	2162.
5803.5024	1868.
5803.6909	12470.
5804.0674	2023.
5806.9351	5191.
5812.5176	2604.
5812.7520	2238.
5812.9863	2390.
5815.7944	2430.
5816.9165	2805.
5817.1499	1939.
5818.3184	42200.

$\lambda(\text{\AA})$	I
5828.8711	2246.
5834.3135	4382.
5835.2632	2799.
5836.7803	2053.
5838.7651	7934.
5840.4619	2118.
5845.4761	4889.
5845.7559	6570.
5847.5259	8068.
5851.4658	2915.
5852.5732	5526.
5854.0010	2107.
5854.7363	4113.
5855.3794	4367.
5855.8379	4106.
5856.9370	75124.
5860.3135	3525.
5866.9619	2394.
5875.9043	1808.
5876.7026	7620.
5877.1250	1934.
5877.5000	1905.
5880.1694	11357.
5880.7305	1938.
5881.0107	24216.
5882.6919	3733.
5888.7373	10558.
5889.1543	10427.
5893.1313	14949.
5894.8374	4309.
5898.1025	6407.
5898.6533	2461.
5900.7158	3608.
5902.6367	5481.
5903.0937	7546.
5903.4131	7326.
5903.6416	6210.
5904.9644	1889.
5905.2378	2103.
5909.2842	3133.
5911.8662	8939.
5912.0474	10044.

$\lambda(\text{\AA})$	I
5912.2354	1742.
5912.4155	2873.
5919.3691	3949.
5920.1851	3803.
5920.4570	2778.
5922.5444	20285.
5925.1362	2555.
5925.8647	3354.
5928.9668	6504.
5931.9395	1898.
5932.7642	17510.
5935.0576	2284.
5935.9761	2738.
5936.6196	2287.
5937.7700	1693.
5939.4277	1794.
5942.7046	4146.
5943.0283	1611.
5944.0923	3424.
5947.8926	2286.
5949.2393	1975.
5951.6118	2013.
5952.5435	6734.
5957.6807	1739.
5957.9146	2015.
5960.9756	1394.
5962.7925	2148.
5963.4282	9741.
5971.8516	1989.
5973.6133	1930.
5978.4834	17581.
5979.0239	8286.
5979.4741	12327.
5979.7891	2977.
5981.4087	8060.
5983.4312	8038.
5987.3804	2838.
5987.6494	1398.
5987.9634	1483.
5988.0977	3792.
5991.3662	3908.
5997.6191	1703.
5997.8867	1748.
5998.0649	2964.
5998.2881	1479.
5999.0010	2538.
5999.6250	2298.
6000.3818	1476.
6001.0498	1733.
6002.1177	6143.
6002.3403	2399.

$\lambda(\text{\AA})$	I
5987.4600	2481.
5988.1855	3693.
5988.3213	1700.
5991.4941	4727.
5997.7891	1695.
5998.0605	1667.
5998.2417	2935.
5998.4678	1478.
5999.1465	2270.
5999.8252	2136.
6000.5493	1567.
6001.2729	1957.
6002.3584	7051.
6002.5396	2095.
6006.3818	12311.
6007.4663	20697.
6012.5698	3117.
6013.3823	4433.
6013.8335	1458.
6018.1191	4713.
6018.8403	7055.
6024.7319	2904.
6025.2690	3461.
6029.4355	2645.
6030.0630	3678.
6032.1719	41615.
6034.3726	1797.
6037.6997	4933.
6039.9956	1768.
6041.0767	2871.
6042.6538	1645.
6043.3301	15922.
6044.0068	3725.
6045.4507	3416.
6050.2847	31779.
6052.8638	3539.
6053.1812	3481.

$\lambda(\text{\AA})$	I
6059.4614	4865.
6060.3110	17286.
6060.8926	1871.
6062.9937	1596.
6064.7812	1396.
6064.9155	1034.
6065.2729	1525.
6066.9707	1369.
6070.9902	1037.
6071.7046	4402.
6077.7739	1740.
6079.0674	1822.
6079.6025	5951.
6080.3159	1330.
6089.1401	1683.
6090.2534	1337.
6090.6099	2081.
6091.0107	1245.
6091.5449	1330.
6092.4355	2287.
6092.3071	2134.
6097.9468	1961.
6098.8667	2791.
6100.5771	2668.
6101.1479	1939.
6104.3120	3351.
6105.6323	6590.
6106.2051	2385.
6106.7339	2682.
6107.0864	2749.
6107.2187	1781.
6108.4092	1658.
6108.9829	4278.
6110.0425	2298.
6110.8823	2462.
6112.4297	4866.
6114.1558	1913.
6115.3965	2532.
6119.3472	1985.
6122.1050	1558.
6123.1743	4716.
6125.0469	2684.

$\lambda(\text{\AA})$	I
6127.9507	1836.
6129.6416	1716.
6135.4961	2731.
6135.7173	9539.
6139.8228	1580.
6140.3516	2038.
6143.1670	1633.
6144.0015	4092.
6144.1768	1515.
6144.6157	1864.
6145.7119	7045.
6145.8438	6351.
6146.6758	1980.
6151.1777	5435.
6152.5723	1418.
6153.1387	4747.
6155.5303	2238.
6155.8779	1459.
6156.2251	3889.
6157.0063	6110.
6158.3936	8396.
6159.8657	1659.
6161.3359	3287.
6163.9482	1493.
6164.1655	1917.
6166.5571	1542.
6169.6060	5532.
6169.7363	1525.
6170.1724	4079.
6170.7393	3128.
6173.0967	4632.
6174.4072	1564.
6176.2441	1380.
6176.3755	2067.
6182.8208	1624.
6183.0845	18300.
6183.4800	1443.
6183.6997	1850.
6185.8545	26909.
6188.7168	2284.
6189.7310	2626.
6190.1279	2173.
6192.8647	2912.
6196.0488	1288.
6196.1816	1400.

$\lambda(\text{\AA})$	I
6196.0718	1144.
6196.5513	1050.
6200.6899	1732.
6201.1689	837.
6203.2563	3271.
6203.4302	1584.
6203.9512	924.
6204.3857	1046.
6204.7769	832.
6206.3394	4209.
6208.1611	3007.
6209.9375	1461.
6210.6738	2129.
6211.1064	1811.
6212.7075	4420.
6213.6152	1376.
6215.1274	881.
6216.0776	3538.
6218.9248	2460.
6219.0972	6378.
6231.1270	862.
6232.5728	3431.
6233.2681	1406.
6237.1274	3564.
6238.5542	2474.
6239.0723	3999.
6240.1514	1107.
6243.1646	1469.
6244.1094	4337.
6248.0068	1071.
6248.2207	1145.
6248.6050	1092.
6251.8447	2362.
6252.7378	1450.
6253.1201	1108.
6257.1040	1375.
6258.1606	4596.
6260.1431	1189.
6261.4062	1212.
6261.9106	1193.
6264.6812	1770.

$\lambda(\text{\AA})$	I
6268.2192	1903.
6268.5645	1141.
6269.4692	879.
6270.6748	878.
6273.2134	1202.
6274.0298	814.
6276.3057	2016.
6276.7773	1115.
6279.3496	914.
6280.5488	1938.
6280.8057	8548.
6287.1714	831.
6287.3848	821.
6289.5151	1369.
6290.2393	3594.
6290.9199	4829.
6293.5562	1246.
6297.1216	4121.
6298.7739	30225.
6299.1553	2122.
6299.8750	875.
6300.3403	1344.
6304.4058	1365.
6304.7017	2555.
6305.1245	1653.
6307.8301	5187.
6315.8101	4923.
6320.7417	4326.
6321.7104	4953.
6322.5527	9690.
6323.3530	11219.
6325.7100	1307.
6326.6353	1481.
6327.9814	1354.
6329.2427	7077.
6330.1675	2217.
6332.5205	1493.
6334.6201	2492.
6334.9141	6070.

$\lambda(\text{\AA})$	I
6336.6836	1412.
6337.8613	3375.
6341.0542	847.
6341.4316	1020.
6343.1084	4090.
6343.4019	4827.
6346.4980	2607.
6350.2954	743.
6351.2119	1275.
6351.6699	1125.
6353.8330	1376.
6355.5776	1743.
6357.4443	1304.
6360.7153	3162.
6364.9263	1343.
6367.3560	786.
6367.9731	1090.
6368.1787	855.
6369.6172	5187.
6371.4878	1213.
6372.6514	934.
6373.6489	1521.
6376.2266	1002.
6377.3496	958.
6377.6406	1080.
6379.5132	1200.
6380.0542	5277.
6382.5103	867.
6384.7173	4030.
6385.3008	1054.
6387.2593	973.
6391.1372	1003.
6391.5542	1058.
6392.7227	1035.
6394.5586	1810.
6395.0596	990.
6396.2705	894.
6400.3228	1463.
6402.1201	853.
6405.1729	1170.
6405.5493	2280.

$\lambda(\text{\AA})$	I
6408.1680	2454.
6408.4902	2941.
6412.1660	1213.
6413.9482	1271.
6416.3437	27301.
6417.5640	1255.
6418.4194	1486.
6425.3311	2425.
6429.8154	1554.
6431.5908	1174.
6433.9902	1175.
6435.8560	2921.
6436.8110	1547.
6438.3491	1536.
6440.1816	1645.
6440.1890	1113.
6442.0630	3505.
6443.1431	29722.
6443.5581	1648.
6446.4541	1026.
6449.9932	1507.
6451.5093	1038.
6452.7764	1000.
6453.8774	1425.
6454.4072	1046.
6454.7329	2124.
6455.2212	1948.
6456.2773	2546.
6456.7642	2142.
6460.4824	1320.
6463.2954	1772.
6463.6963	1748.
6466.8120	1291.
6468.4824	2967.
6470.5044	3141.
6473.1880	1522.
6473.3062	1183.
6473.5029	1233.

$\lambda(\text{\AA})$	I
6477.4917	1151.
6477.9360	1087.
6480.2397	1263.
6481.3716	1036.
6483.0293	4258.
6484.5654	1117.
6486.3853	1247.
6486.6685	2205.
6487.5991	973.
6488.8530	4294.
6490.8354	930.
6492.3730	1023.
6495.4497	959.
6499.8228	1948.
6500.1064	983.
6503.8330	1037.
6506.0620	2008.
6510.8809	843.
6512.2231	1867.
6520.3433	2927.
6520.9453	7774.
6525.1450	845.
6527.5332	1309.
6528.2085	8306.
6531.1392	1407.
6535.1182	867.
6535.3535	2057.
6537.4702	2687.
6538.2524	2451.
6543.9331	2159.
6544.2046	2244.

$\lambda(\text{\AA})$	I
6537.3774	2892.
6538.1724	2493.
6543.8984	2125.
6544.1772	2061.
6547.5195	2162.
6549.3901	1779.
6555.1641	2902.
6560.5840	1870.
6561.6602	11308.
6562.8960	259739.
6565.4883	1805.
6565.6880	1958.

$\lambda(\text{\AA})$	I
6570.7090	8970.
6581.2739	2281.
6582.2964	1921.
6588.2251	3564.
6590.3804	2624.
6596.0532	2240.
6596.4438	2454.
6597.3032	3917.
6598.8257	3813.
6604.9697	4345.
6607.4648	2401.
6608.9453	3913.
6610.4639	3713.
6615.2095	5239.
6621.0327	13683.
6622.6226	2491.
6628.0435	2561.

$\lambda(\text{\AA})$	I
6628.1011	2978.
6632.7017	1421.
6633.7866	3191.
6634.1748	1339.
6634.5625	1663.
6638.9941	6327.
6643.5601	1521.
6648.5361	1561.
6654.5591	2156.
6655.5459	1421.
6661.0381	1718.
6663.1792	1578.
6664.3628	2014.
6669.4321	4090.
6672.8154	1187.
6677.4404	7853.
6678.8403	1322.
6682.4287	2344.
6684.5024	1335.
6687.9272	1468.

$\lambda(\text{\AA})$	I
6696.9536	1526.
6699.0415	1350.
6700.7485	1740.
6701.0137	1951.
6701.9990	2412.
6704.6875	1572.
6706.5405	1222.
6707.8633	2270.
6711.2979	1532.
6712.5791	10183.
6719.3643	1733.
6721.2500	1678.
6721.4766	3317.
6723.4014	2495.
6725.5156	1359.
6731.7144	1884.
6734.2871	1490.
6734.7788	3363.
6739.8535	1348.
6742.9243	6450.
6744.6309	8828.
6747.5908	1402.

$\lambda(\text{\AA})$	I
6750.7817	1573.
6752.9863	32161.
6753.5093	1646.
6754.3687	1371.
6754.5552	1532.
6756.3477	2429.
6757.6543	1694.
6759.4458	1388.
6759.6328	7509.
6766.6069	1503.
6766.7935	2718.
6768.2095	2045.
6775.8813	1825.
6776.1792	1413.

$\lambda(\text{\AA})$	I
6781.9014	1560.
6782.6089	3132.
6802.9414	6688.
6817.9971	2593.
6818.2900	1788.
6827.3247	1641.
6831.0161	3277.
6832.3843	3792.

$\lambda(\text{\AA})$	I
6838.1758	2735.
6838.5796	1085.
6839.4609	1038.
6840.9272	1465.
6841.5132	1043.
6841.7695	1061.
6845.0205	1755.
6846.5142	1039.
6849.9282	1929.
6850.7617	1071.
6852.1367	1091.
6855.4204	2422.
6857.3989	5554.
6861.1631	1822.
6862.4497	2041.
6865.4800	23904.
6868.2505	1226.
6868.7656	5871.
6871.3843	24324.
6876.1382	2055.
6879.5903	2264.
6887.0942	2126.
6887.7749	4997.
6888.1694	3053.
6890.5020	1641.
6897.7041	7288.

$\lambda(\text{\AA})$	I
6888.1147	2273.
6889.1484	887.
6889.5908	757.
6890.4741	1115.
6891.4292	954.
6896.4297	890.
6897.7349	5566.
6900.2256	954.
6901.5557	604.
6906.4106	802.
6916.6196	3311.
6920.8218	1096.
6922.8936	604.
6928.4468	3988.
6934.5757	2318.
6937.7051	8421.
6939.9312	655.
6940.8535	812.
6946.5649	738.

$\lambda(\text{\AA})$	I
6951.4766	2088.
6957.1924	3784.
6960.0176	768.
6960.4053	2088.
6961.2505	2395.
6961.6377	626.
6963.7109	669.
6965.6035	450395.
6968.3647	646.
6968.6787	836.
6968.9575	1015.
6973.0259	659.
6974.8618	849.

$\lambda(\text{\AA})$	I
6977.5571	527.
6984.6040	510.
6986.8511	733.
6987.1621	988.
6990.8286	447.
6991.9355	1924.
6992.5239	1425.
6993.0083	1750.
6994.5313	488.
6995.9160	418.
7001.5269	491.
7002.6704	1567.
7003.2939	841.
7004.4380	1232.

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