ING LA PALMA TECHNICAL NOTE NO.98

More Maps of Wavelength Calibration Lamps for the WHT ISIS

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CONTENTS

More Maps of Wavelength Calibration Lamps for the WHT ISIS

ING La Palma Technical Note 84 *gave identifications for lines produced by some of the calibration lamps and gratings available to ISIS (Intermediate dispersion Spectrograph and Imaging System) on the William Herschel Telescope at the Roque de Los Muchachos Observatory on the island of La Palma. This note gives identifications for the R158B, R158R and R1200R line gratings, with copper-argon and copper-neon lamps.*

In 1994/95 a further series of calibration lamp exposures were made by Rene Rutten using ISIS with the TEK1 CCD chip on the blue arm and TEK2 on the red arm. They were measured and reduced by Janet Sinclair. The lamps used were copper-argon and copper-neon. All the exposures were made with a slit width of 0.83arcseconds.

The following information is given in TABLE I.

Column 1: the wavelength range in Ångstroms for each frame.
Column 2: Exposure time in seconds.
Column 3: Order-sorting filter if used; no neutral density filters were used.
Column 4: Dispersion in Ångstroms per pixel.
Column 5: Number of lines used in the Figaro least squares fitting routine.
Column 6: RMS values using a quadratic solution
Column 7: RMS using a cubic solution
Column 8: RMS using a quintic solution

For each of the 4 configurations described in Table I line lists of the laboratory wavelengths used are given, followed by maps of these lines with identifications. More lines are given in the tables than are identified on the maps. These extra lines were found in the spectra, but were generally very weak. The figures given in brackets after the wavelengths in the line lists are the strengths of the lines given in the publication used. They should only be used as a rough guide as the relative values between different orders will vary and in particular will depend on the EHT setting on the lamp. The same published tables of laboratory wavelengths were used as in TN84; a reference list is given at the end of this note. A few lines in the list come from Line Spectra of the Elements. These are indicated with an asterisk in the line lists, as their line strengths are not on the same as the other publication.

The Figaro package, together with a Sun computer was used to examine the data. Where necessary the traces of cosmic rays were removed with `BCLEAN`. The Figaro package was also used for extracting the data, identifying the lines, giving an rms for the fitting of the wavelengths and for producing the maps. The intensity values given on the y-axes are per pixel. Blended lines are indicated on the maps by values in brackets and for these the wavelength is only given to an integer value.

Two lines were found which are possibly titanium in the copper-argon 1200 line spectra. These are identified in the line list, and indicated with brackets on the map.

Please send any comments or queries via e-mail to jes@ast.cam.ac.uk

References

The publication used was:

Tables of Spectral Lines of Neutral and Ionised Atoms, **1968**, Striganov, A.R. & Sventitskii, N.S., IFI/PLENUM New York-Washington.

Other publications consulted were:

Tables of Spectral Lines, **1970**, Zaidel, A.N., Prokof'ev, V.K., Raiskii, S.M., Slavnyi, V.A. & Shreider, E.Ya. IFI/PLENUM New York-London.

Wavelengths and Energy Levels of Ar I and Ar II in the region of 3400 – 9800 Angstroms. **1973**, Norlen, G., *Physica Scripta*, **8**, 249.

MIT Wavelength Tables. Vol 2. **1982**. Prepared by Phelps, F.M., The MIT Press, Cambridge, Massachusetts. London, England.

Line Spectra of the Elements. Handbook of Chemistry and Physics, eds. Weast, R.C. & Astle, M.J., Section E205, 62nd Edition, **1982**, CRC Press. Boca Raton, Florida.

TABLE I

Copper Argon lamp with **R158B** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
2885 – 5842	500	–	2.89	16	0.134	0.049	0.042
4981 – 7948	10	GG 395	2.90	22	0.105	0.103	0.100

Copper Argon lamp with **R158R** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
5185 – 8152	20	GG 395	2.90	25	0.146	0.122	0.122
8174 – 11161	3	RG 695	2.92	14	0.134	0.108	0.098

Copper Neon lamp with **R158B** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
2885 – 5841	500	–	2.89	11	0.175	0.167	0.157
4981 – 7948	10	GG 395	2.90	25	0.052	0.018	0.017

Copper Neon lamp with **R158R** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
5184 – 8152	4	GG 395	2.90	28	0.092	0.062	0.060
8174 – 11161	30	RG 695	2.92	23	0.218	0.184	0.177

Copper Argon lamp with **R1200R** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
5796 – 6203	400	GG 495	0.40	24	0.016	0.007	0.007
6195 – 6399	400	GG 495	0.40	11	0.023	0.013	0.013
6592 – 6998	10	GG 495	0.40	14	0.022	0.014	0.013
6998 – 7402	7	GG 485	0.39	13	0.029	0.022	0.022
7399 – 7600	2	GG 495	0.39	8	0.026	0.014	0.013
7800 – 8200	2	GG 495	0.39	7	0.005	0.003	0.001
8200 – 8598	5	GG 495	0.39	6	0.005	0.004	0.004
8603 – 8998	40	GG 495	0.39	11	0.012	0.007	0.007
9005 – 9397	5	GG 495	0.38	7	0.030	0.029	0.022
9406 – 9794	15	GG 495	0.38	5	0.024	0.024	–
9808 – 10192	500	RG 630	0.37	10	0.096	0.091	0.062
10211 – 10590	500	RG 630	0.37	9	0.342	0.315	0.272
10614 – 10987	500	RG 630	0.36	8	0.062	0.057	0.050

Copper Neon lamp with **R1200R** line grating

Range	Exp.	Filter	Disp.	Lines	quadratic	cubic	quintic
5796 – 6203	10	GG 495	0.40	12	0.021	0.008	0.008
6195 – 6602	7	GG 495	0.40	12	0.017	0.004	0.004
6592 – 6997	7	GG 495	0.40	7	0.024	0.019	0.017
6998 – 7403	6	GG 495	0.40	7	0.030	0.017	0.017
7399 – 7801	20	GG 495	0.39	6	0.006	0.004	0.002
7800 – 8200	300	GG 495	0.39	9	0.013	0.010	0.009
8200 – 8598	40	GG 495	0.39	9	0.016	0.004	0.003
8603 – 8998	100	GG 495	0.39	12	0.010	0.004	0.004
9005 – 9397	500	GG 495	0.38	10	0.021	0.014	0.007
9406 – 9795	500	GG 495	0.38	7	0.008	0.007	0.006
9809 – 10192	500	RG 630	0.37	11	0.023	0.021	0.020
10295 – 10562	500	RG 630	0.37	2	–	–	
10614 – 10988	500	RG 630	0.37	3	–	–	

Copper Argon lines: 1200 line Grating

5802.081 Ar I 40	6827.253 Ar I 30	8849.97 Ar I 150
5834.266 Ar I 60	6871.290 Ar I 150	8905.650 Ar II 6
5860.312 Ar I 60	6937.666 Ar I 100	8931.326 Ar II 5
5882.625 Ar I 100	6951.46 Ar I 20	8962.19 Ar I 40
5888.585 Ar I 300	6965.430 Ar I 400	8964.48 Ar I 10
5912.086 Ar I 500	7030.252 Ar I 100	8970.98 Ar I 2
5916.58 Ar I 5	7067.217 Ar I 400	9066.77 Ar I 40
5928.812 Ar I 200	7107.478 Ar I 200	9073.34 Ar I 50
5942.672 Ar I 40	7125.825 Ar I 30	9075.42 Ar I 60
5971.604 Ar I 5	7147.041 Ar I 30	9122.966 Ar I 500
5999.000 Ar I 20	7158.83 Ar I 30	9194.637 Ar I 150
6005.725 Ar I 4	7206.981 Ar I 100	9224.495 Ar I 1000
6013.679 Ar I 6	7229.93 Ar I 4	9291.58 Ar I 100
6025.152 Ar I 10	7272.935 Ar I 100	9354.218 Ar I 200
6032.129 Ar I 60	7311.724 Ar I 100	9459.09 Ar I 100
6043.225 Ar I 100	7316.007 Ar I 30	9478.39 Ar I 50
6052.723 Ar I 30	7353.316 Ar I 100	9535.640 Ar II 3
6059.373 Ar I 100	7372.119 Ar I 100	9657.784 Ar I 1500
6090.786 Ar I 10	7383.980 Ar I 400	9784.501 Ar I 1000
6098.805 Ar I 60	7412.334 Ar I 15	9849.460 Ar II 10
6105.635 Ar I 60	7425.290 Ar I 12	9854.065 Ar II 8
6114.929 Ar II 50	7435.33 Ar I 30	9906.394 Ar II 5
6145.443 Ar I 100	7436.25 Ar I 10	9927.35 Ti I 20
6155.239 Ar I 60	7471.168 Ar I 4	9941.33 Ti I 8
6170.176 Ar I 100	7484.24 Ar I 15	9951.88 Ar I 20
6172.290 Ar II 40	7503.869 Ar I 700	10029.70 Ar I 40
6173.098 Ar I 100	7514.651 Ar I 200	10052.10 Ar I 150
6212.504 Ar I 100	7589.320 Ar II 15	10069.04 Ar I 50
6215.942 Ar I 60	7635.106 Ar I 500	10163.45 Ar I 30
6243.125 Ar II 25	7670.04 Ar I 50	10254.04 Ar I 10
6243.396 Ar I 6	7704.81 Ar I 20	10299.077 Ar II 5
6296.876 Ar I 20	7723.760 Ar I 200	10309.15 Ar I 20
6307.660 Ar I 30	7724.206 Ar I 200	10319.62 Ar I 2
6369.578 Ar I 30	7798.55 Ar I 30	10332.76 Ar I 60
6384.719 Ar I 100	7868.20 Ar I 40	10470.051 Ar I 500
6416.308 Ar I 100	7891.078 Ar I 100	10478.10 Ar I 200
6441.908 Ar II 9	7948.175 Ar I 400	10506.47 Ar I 100
6443.858 Ar II 8	8006.157 Ar I 600	10529.32 Ar I 50
6466.550 Ar I 20	8014.785 Ar I 800	10673.55 Ar I 500
6483.076 Ar II 20	8103.692 Ar I 2000	10681.78 Ar I 200
6538.114 Ar I 30	8115.311 Ar I 5000	10683.40 Ar I 50
6571.37 Ar I 2	8178.84 Ar I 40	10700.98 Ar I 80
6598.684 Ar I 6	8178.96 Ar I 20	10759.13 Ar I 60
6604.854 Ar I 30	8264.522 Ar I 1500	10770.35 Ar I 15
6643.716 Ar II 100	8332.21 Ar I 20	10773.35 Ar I 30
6656.88 Ar I 6	8384.73 Ar I 60	10880.96 Ar I 150
6660.678 Ar I 100	8408.209 Ar I 3000	10950.74 Ar I 120
6664.053 Ar I 100	8424.647 Ar I 2500	
6666.356 Ar II 15	8521.443 Ar I 2000	
6677.282 Ar I 30	8605.779 Ar I 150	
6684.307 Ar II 50	8620.460 Ar I 100	
6698.875 Ar I 100	8667.944 Ar I 400	
6719.219 Ar I 100	8761.691 Ar I 200	
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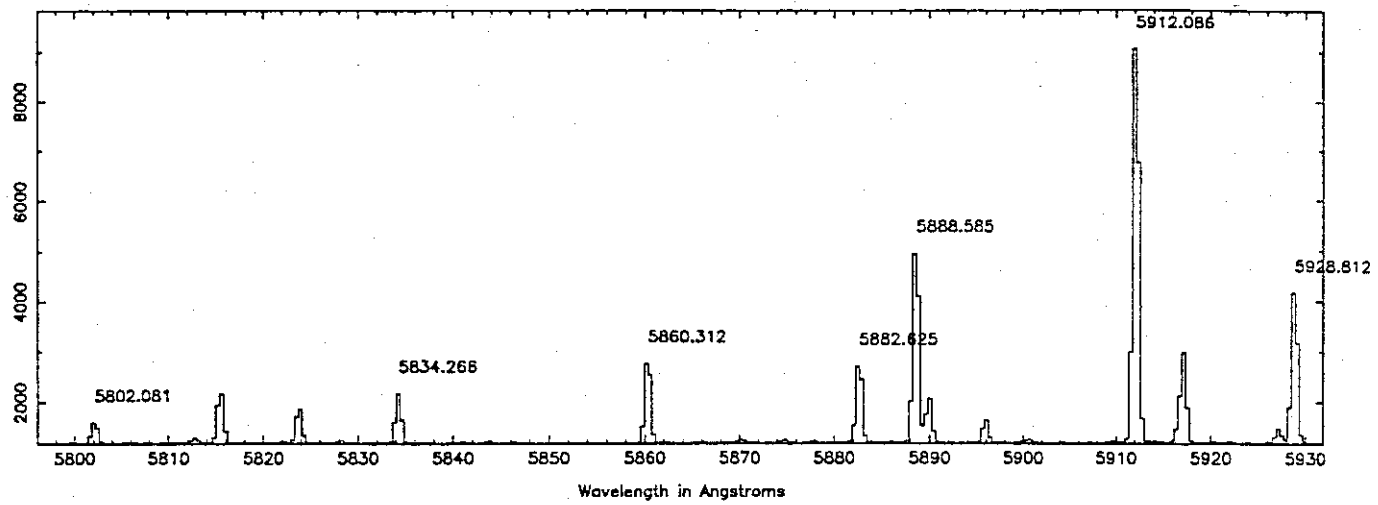
Cu–Ar (1200)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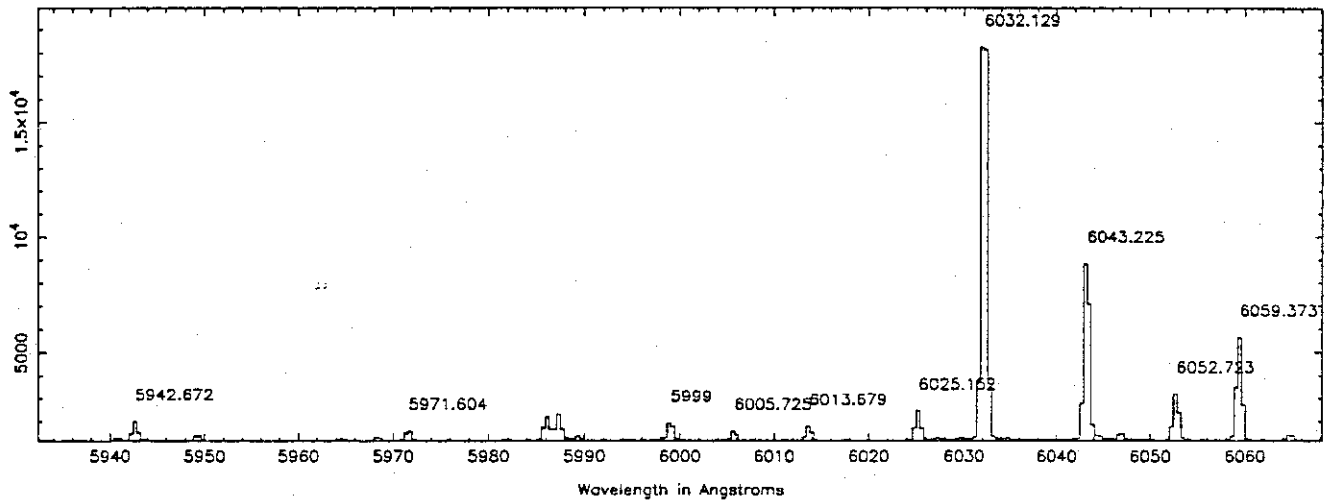
Wavelength in Angstroms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10⁴
1.5x10⁴
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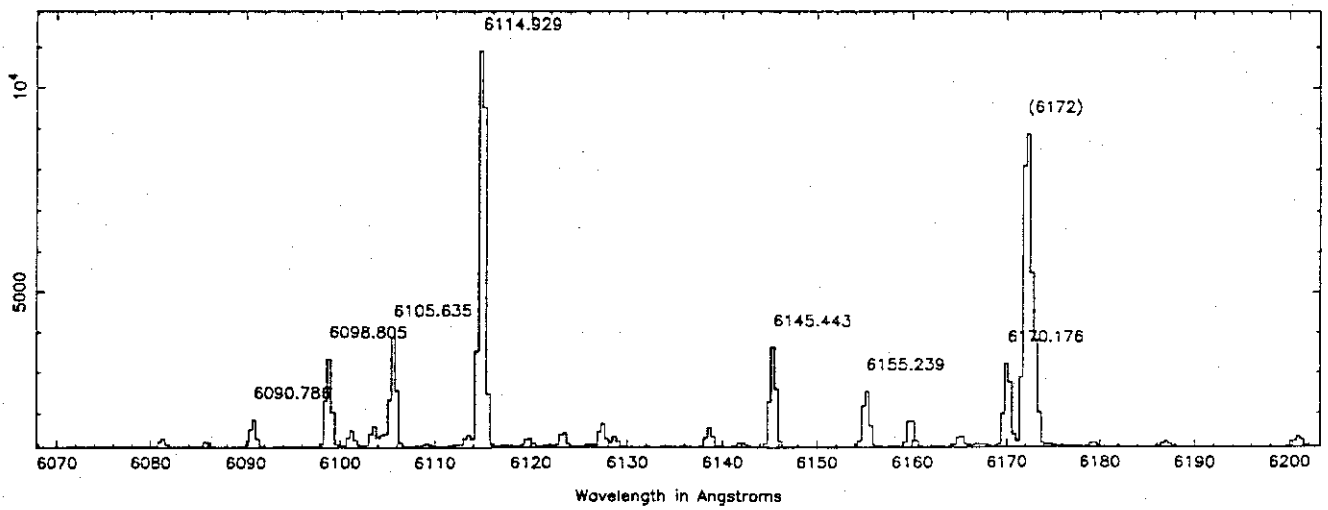
6050
6060
Wavelength in Angstroms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6090
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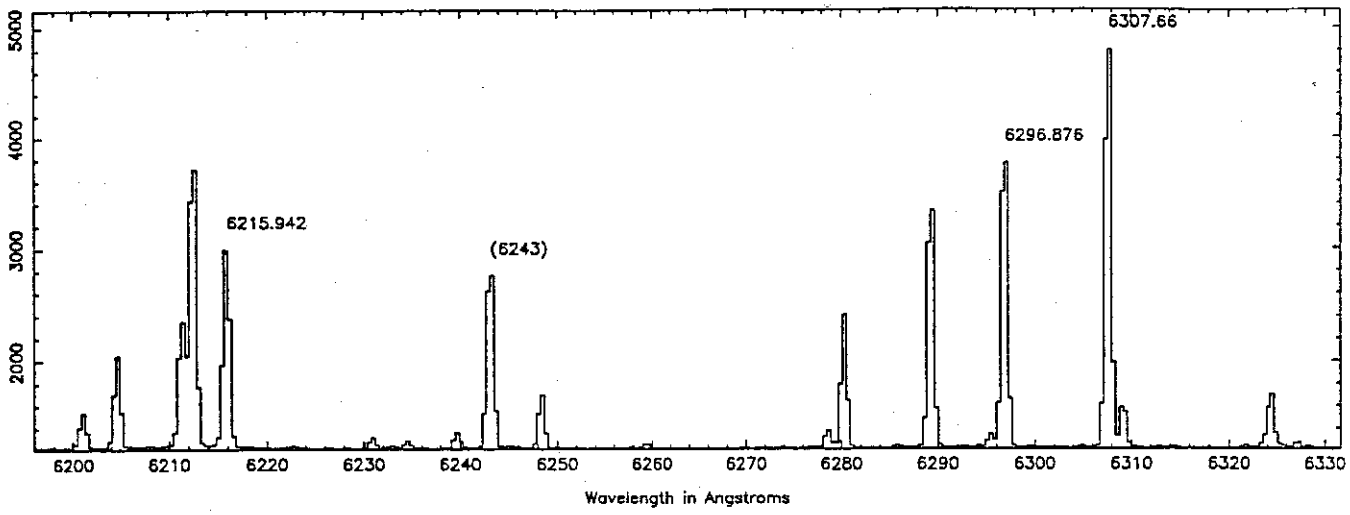
6190
6200
Wavelength in Angstroms

Cu–Ar (1200)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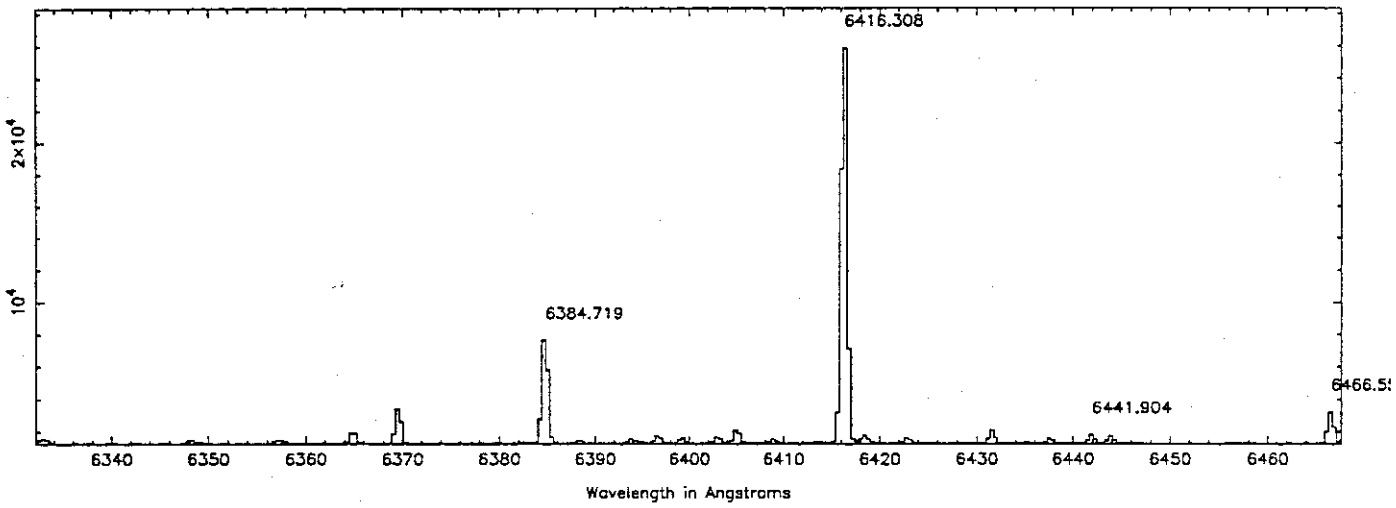
6320
6330
Wavelength in Angstroms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10⁴
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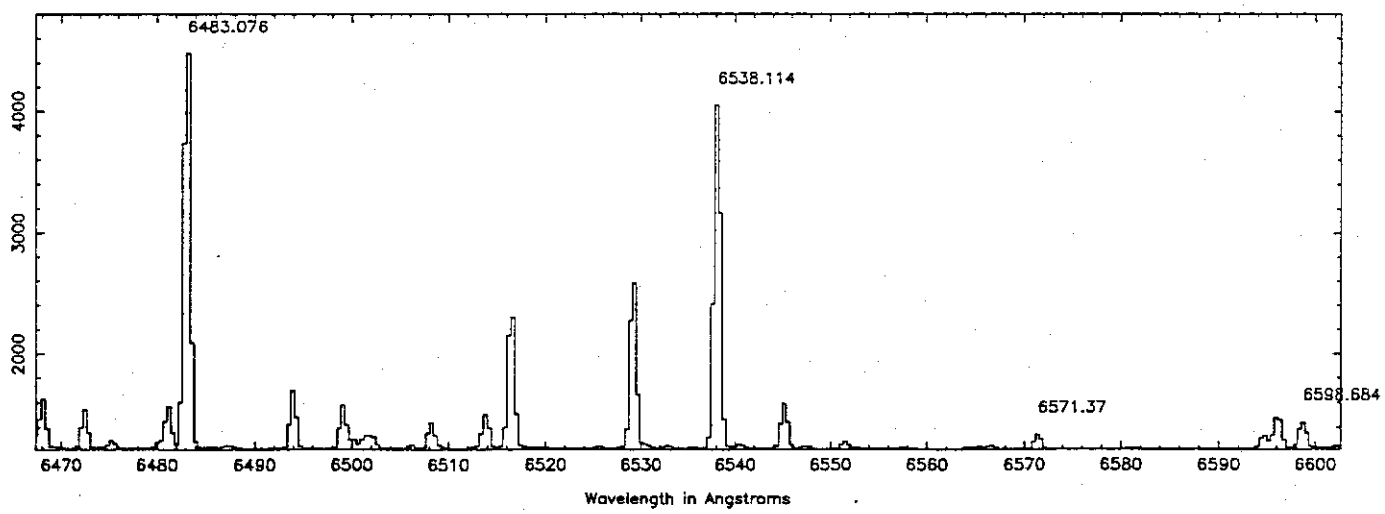
Wavelength in Angstroms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4000
3000
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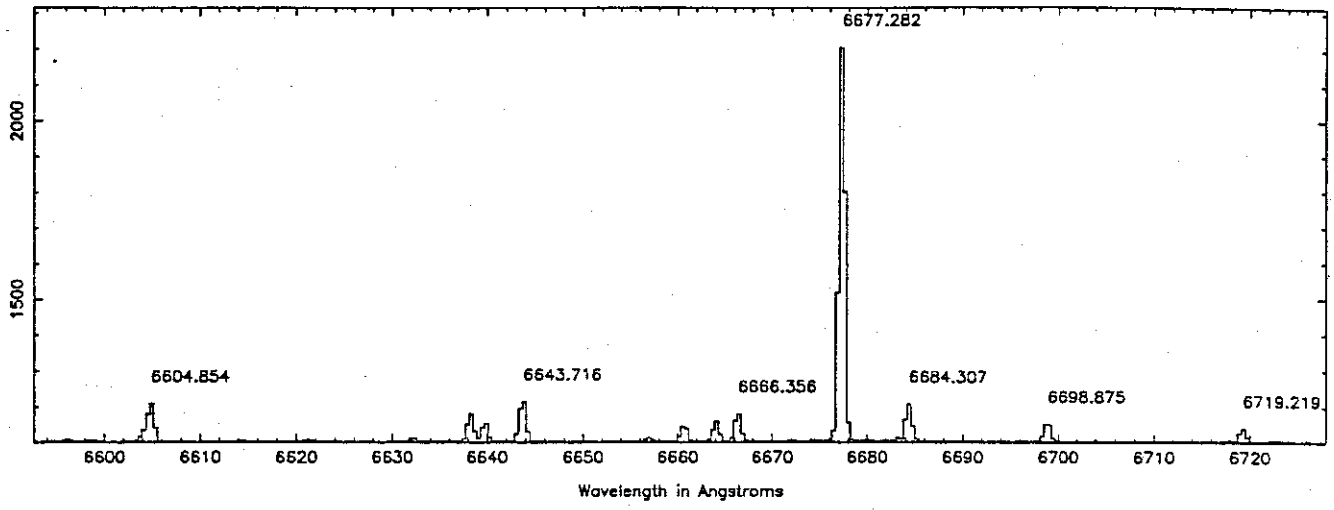
6590
6600
Wavelength in Angstroms

Cu–Ar (1200)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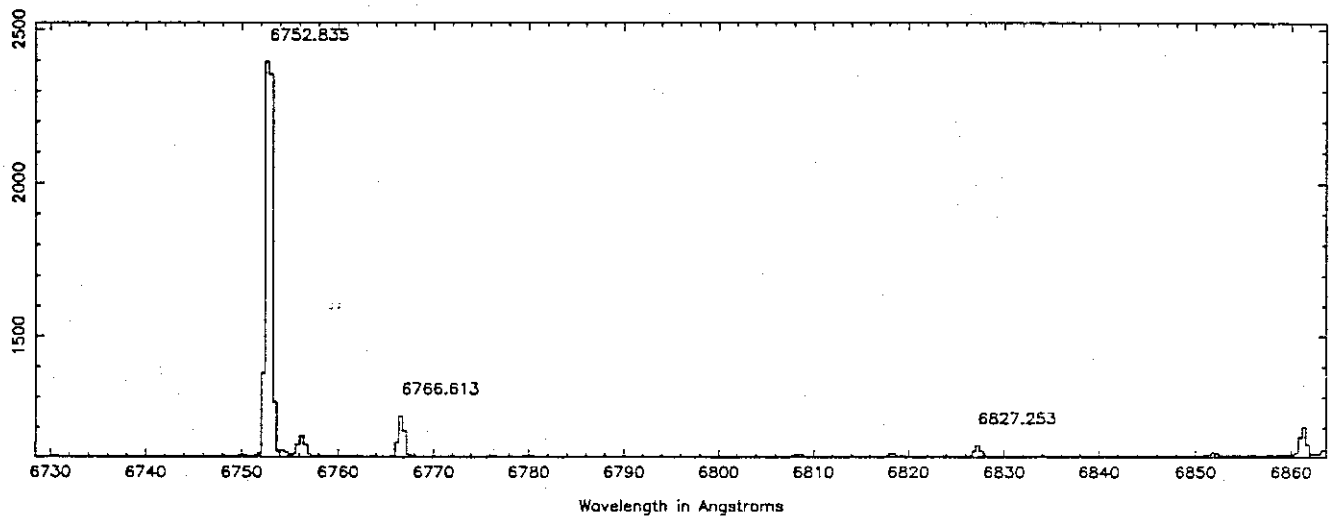
Wavelength in Angstroms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1500
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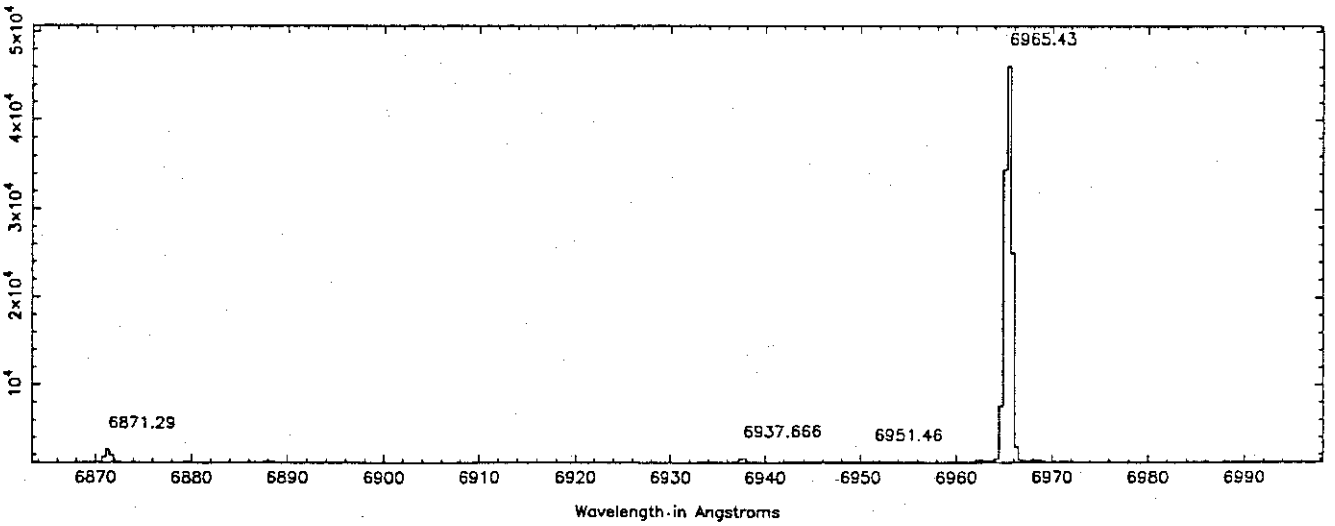
6860
Wavelength in Angstroms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10⁴
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6980
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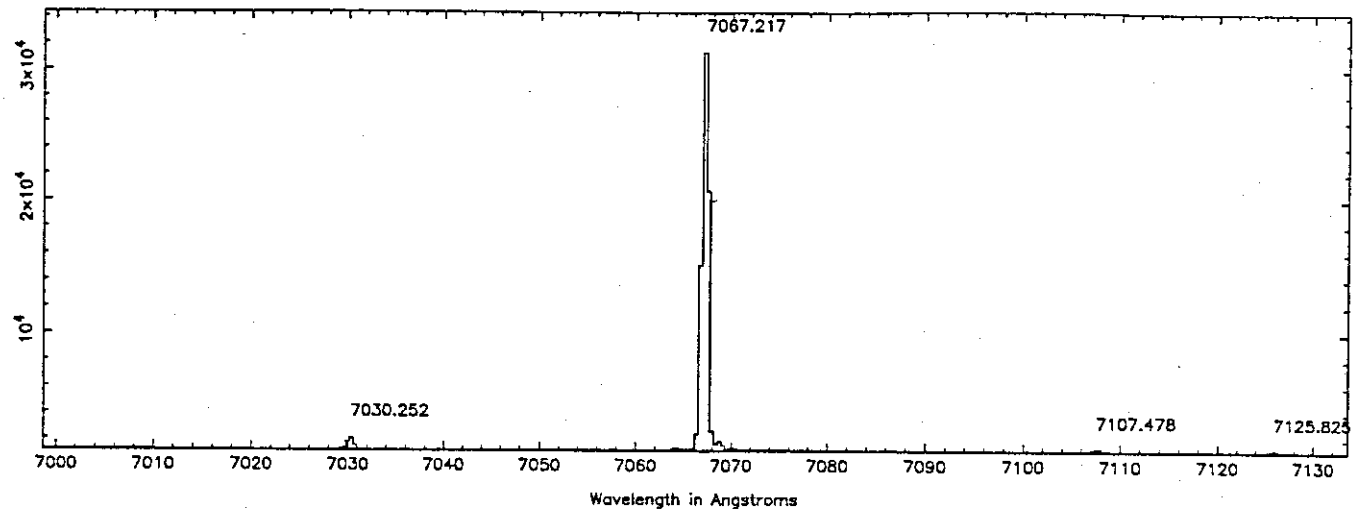
Wavelength in Angstroms

Cu–Ar (1200)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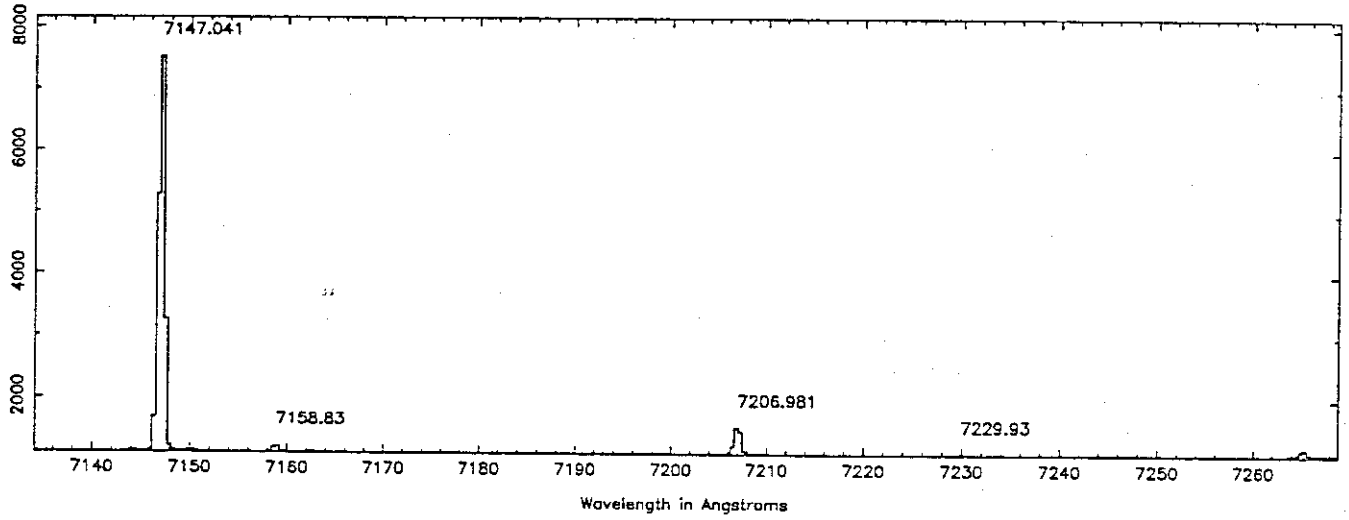
Wavelength in Angstroms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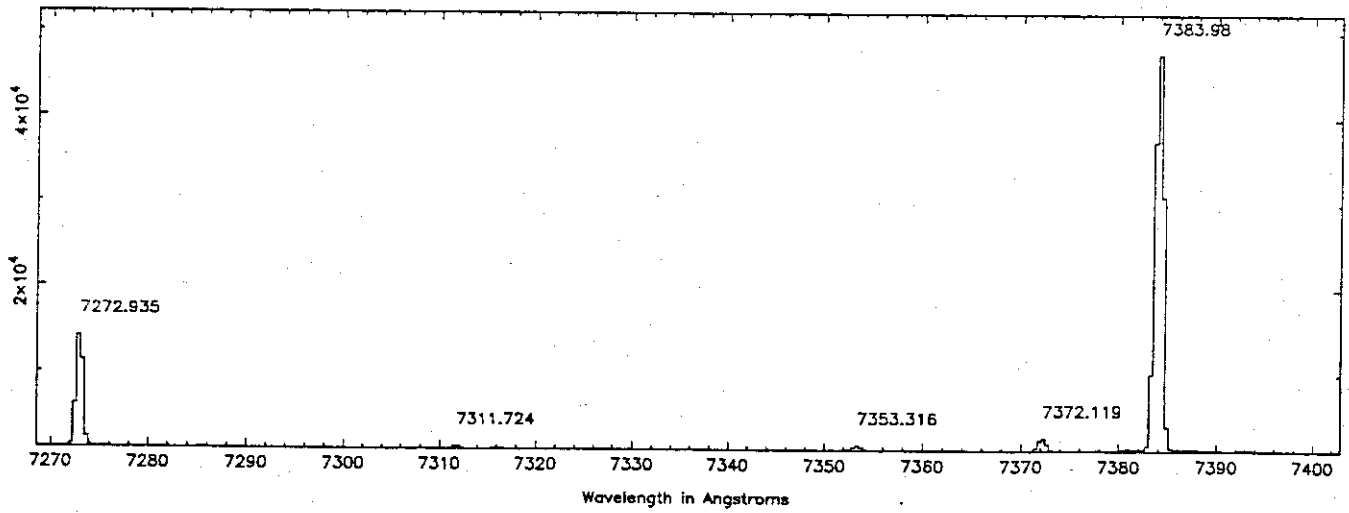
Wavelength in Angstroms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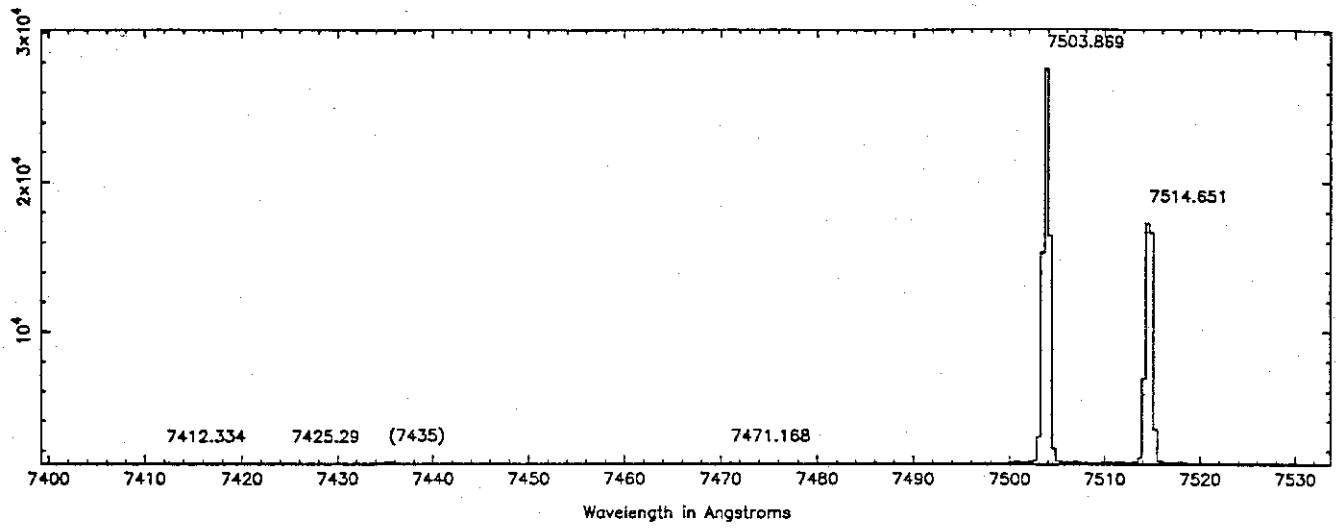
Wavelength in Angstroms

Cu–Ar (1200)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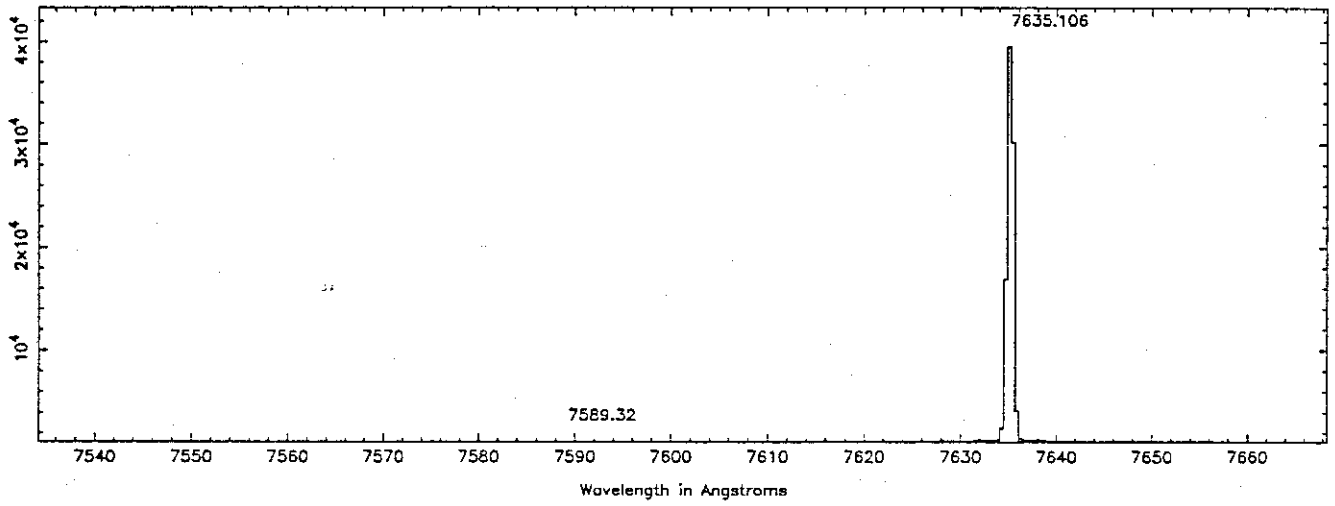
7425.29
(7435)
7471.168
Wavelength in Angstroms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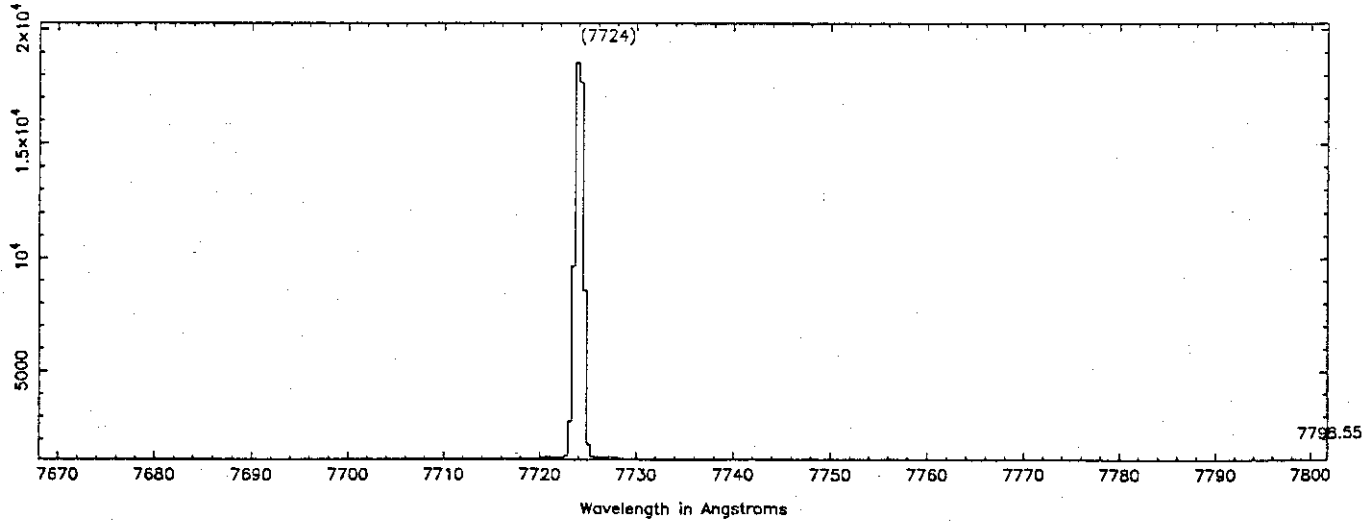
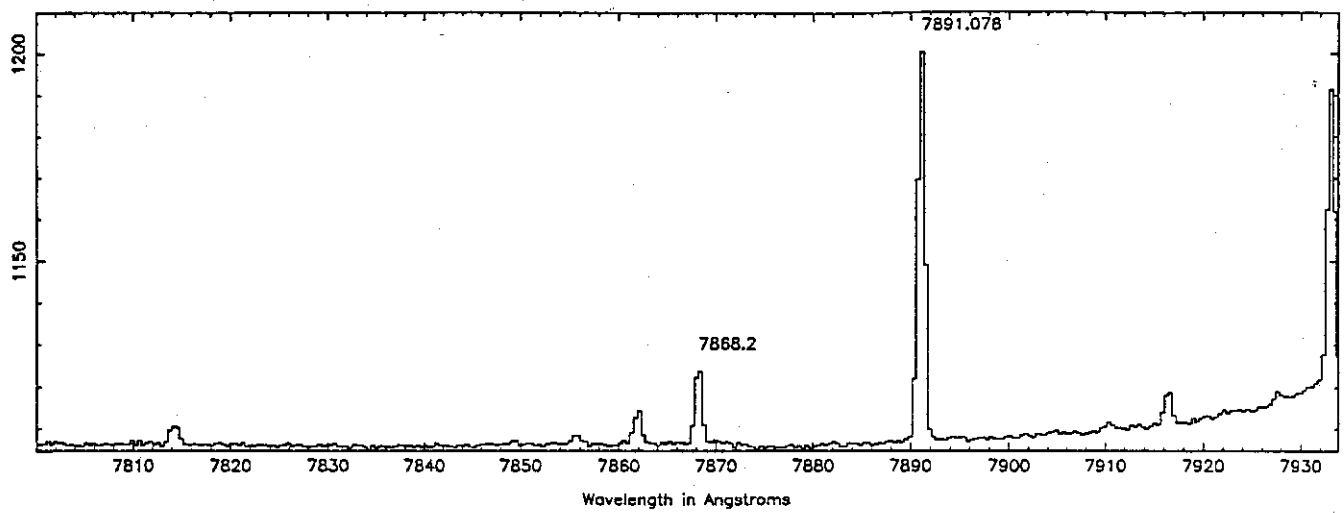
7589.32
Wavelength in Angstroms


(7724)
7798.55
Wavelength in Angstroms

Cu–Ar (1200)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1150
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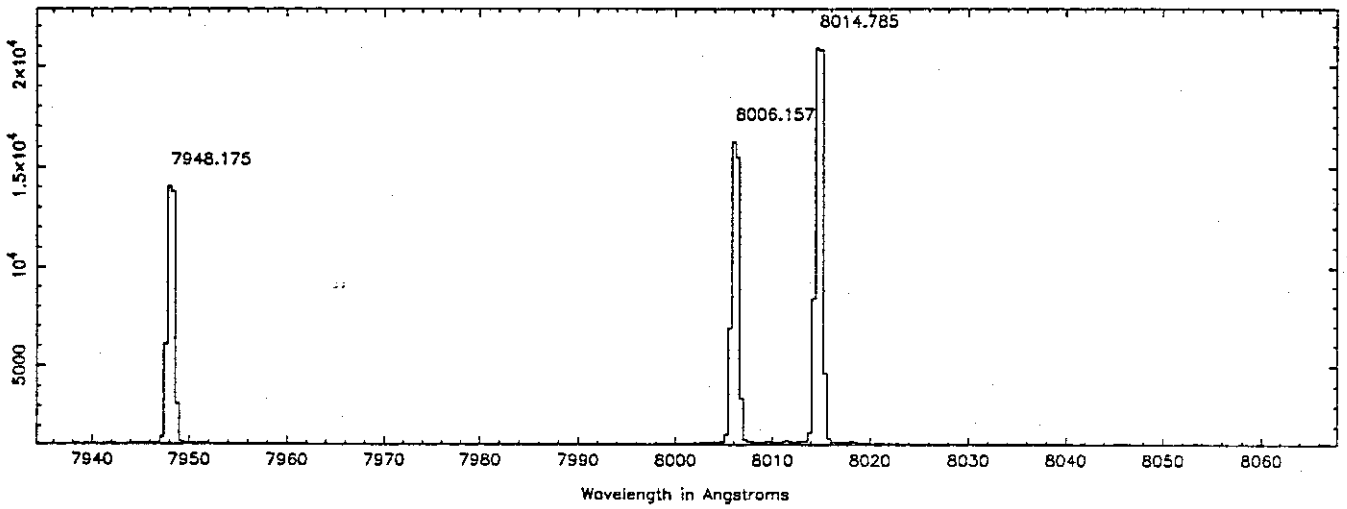
7900
7910
7920
7930
Wavelength in Angstroms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2×10⁴
1.5×10⁴
10⁴
5000
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7950
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8030
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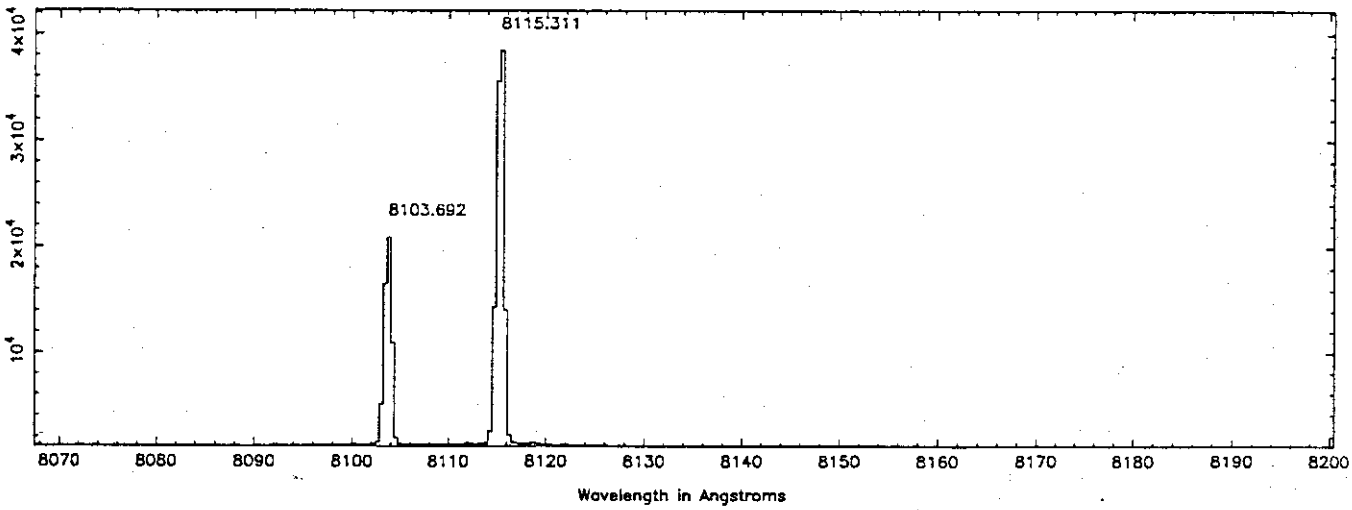
8050
8060
Wavelength in Angstroms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10⁴
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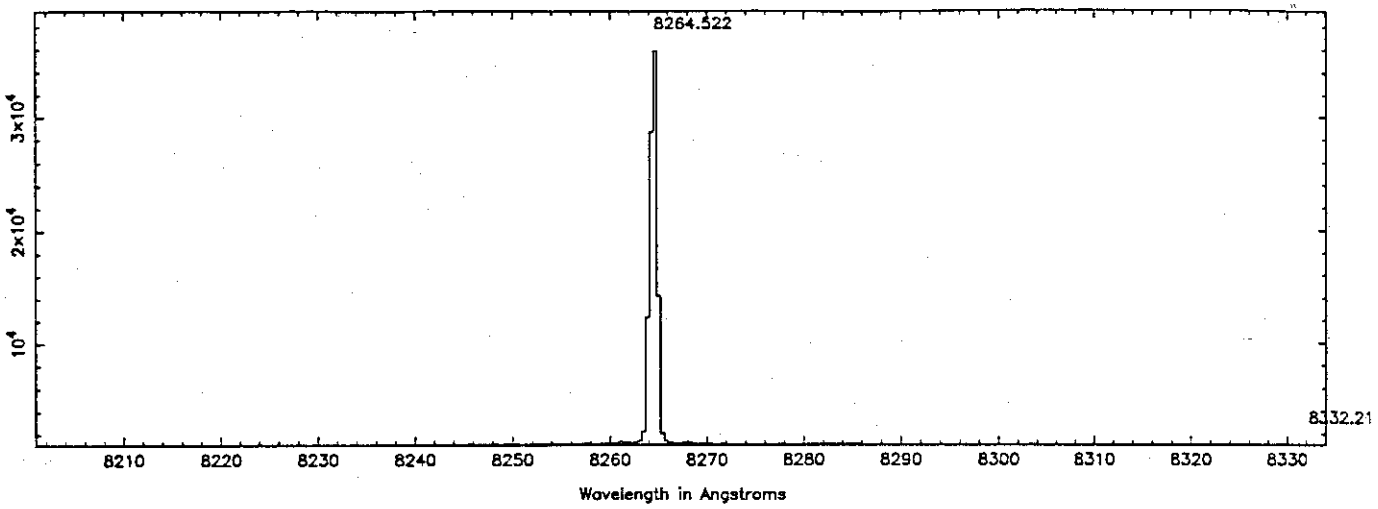
Wavelength in Angstroms

Cu–Ar (1200)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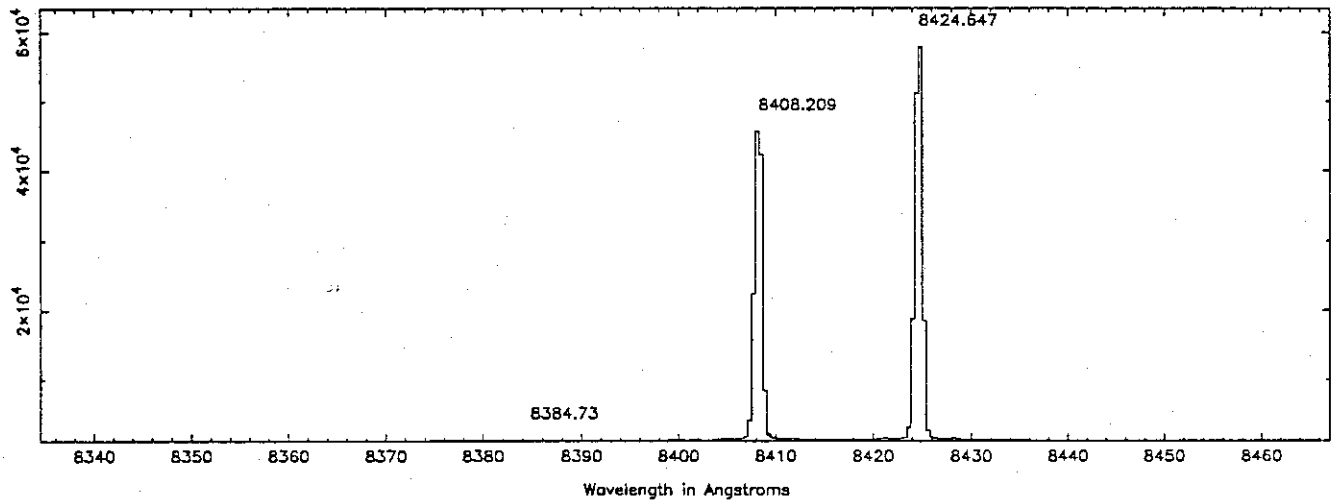
Wavelength in Angstroms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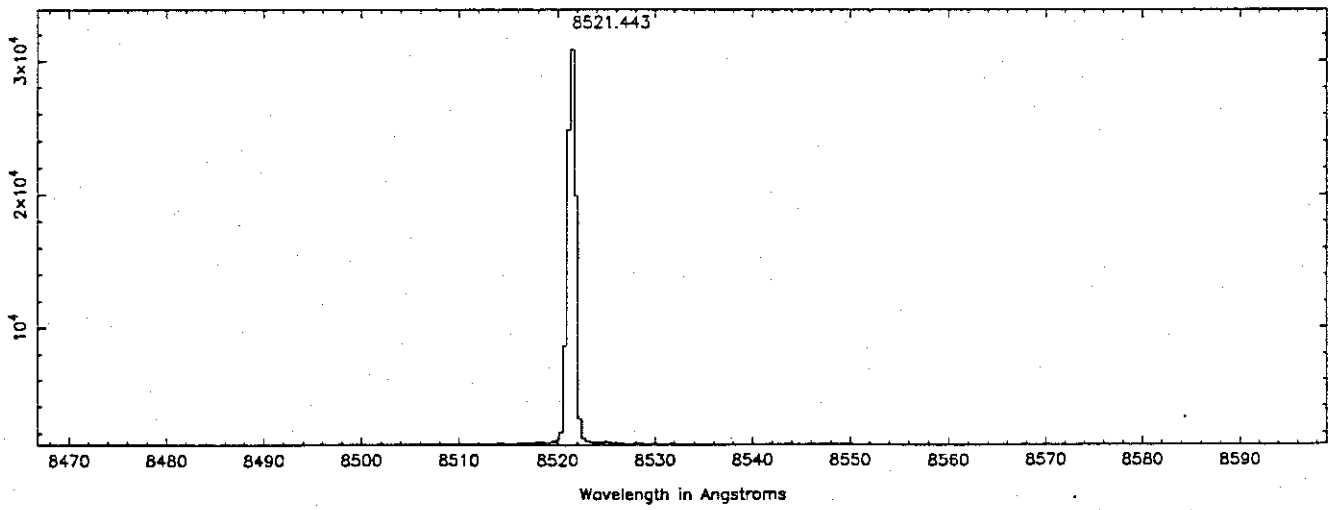
Wavelength in Angstroms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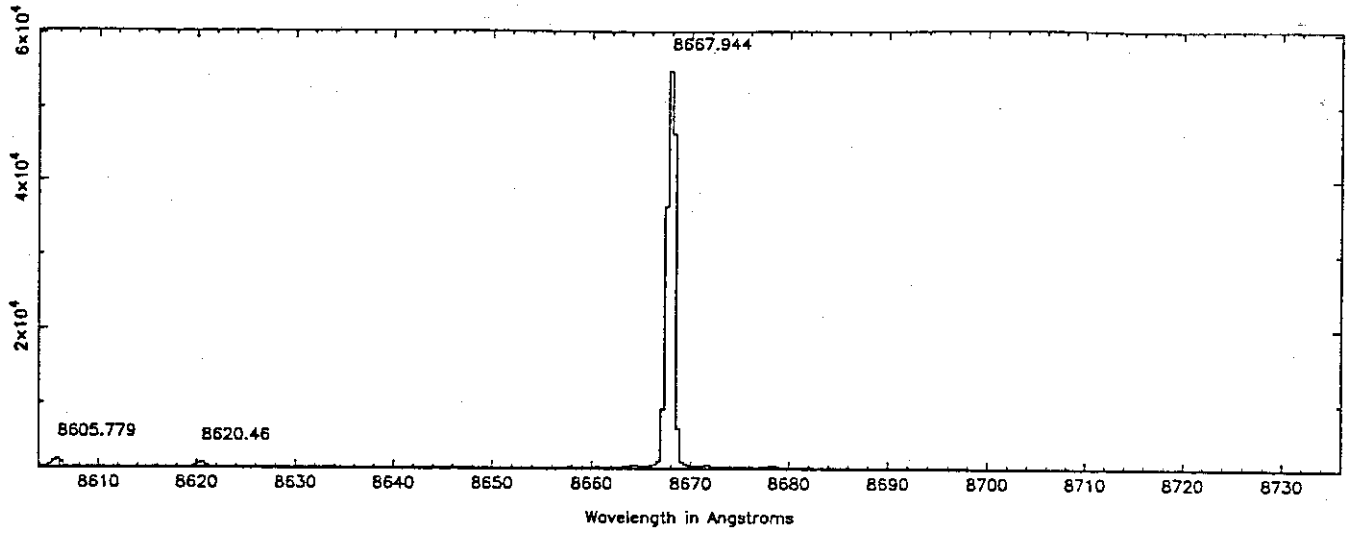
Wavelength in Angstroms

Cu–Ar (1200)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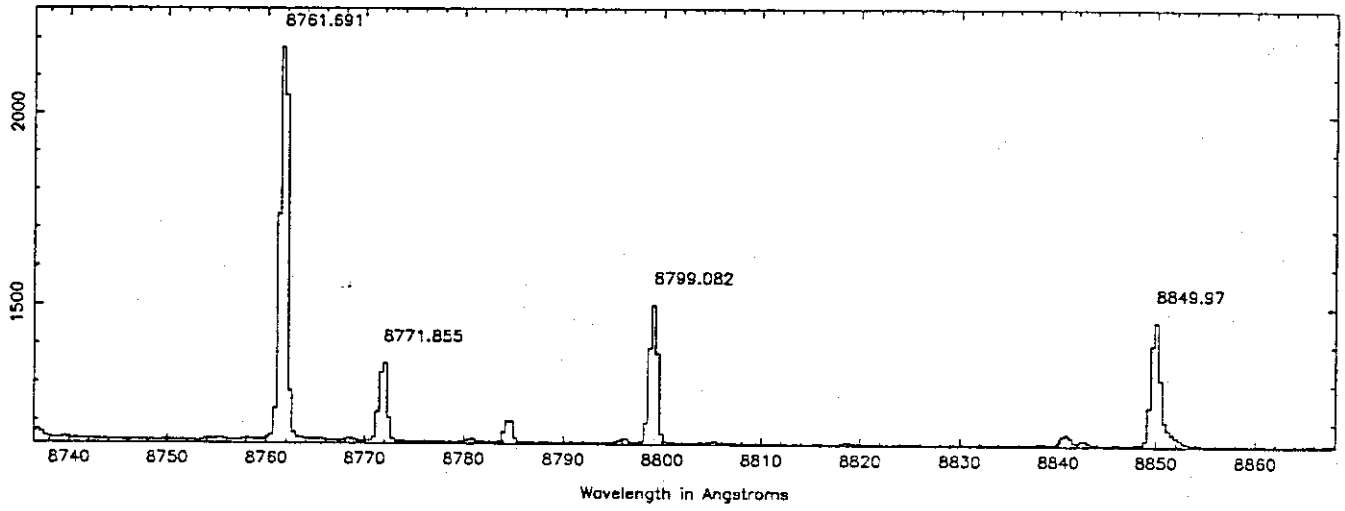
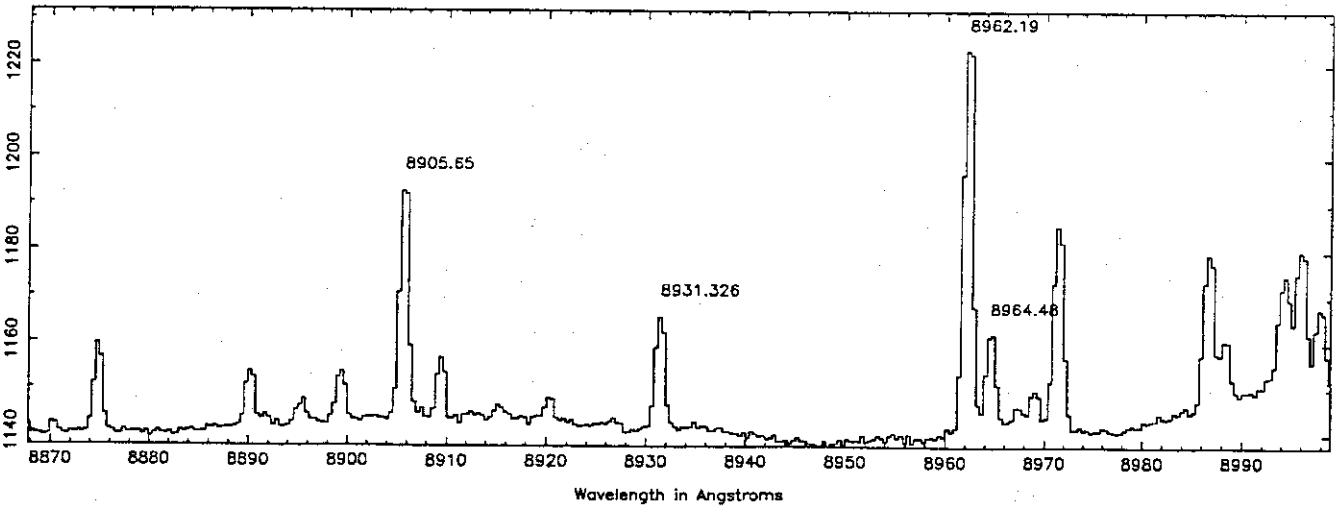
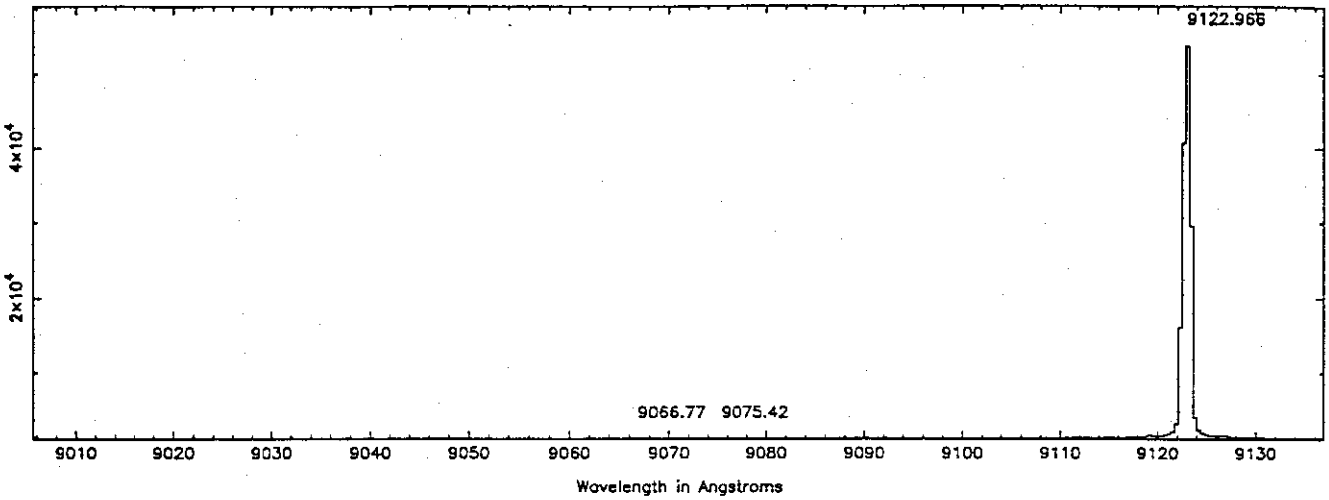
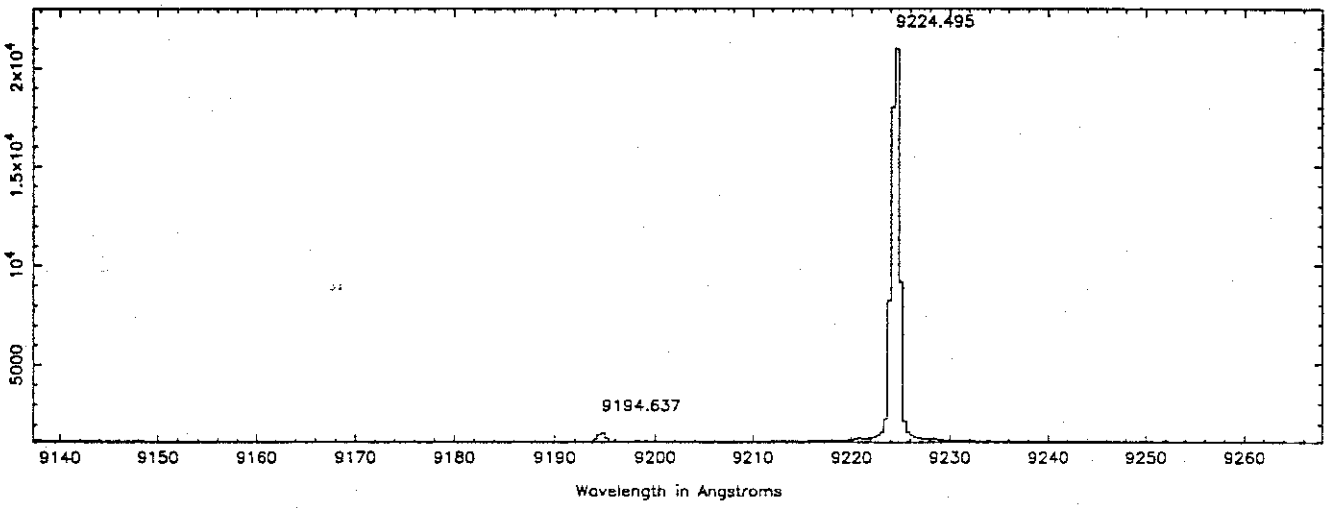
8605.779
8620.46
6x10⁴
4x10⁴
2x10⁴
8610 8620 8630 8640 8650 8660 8670 8680 8690 8700 8710 8720 8730
Wavelength in Angstroms

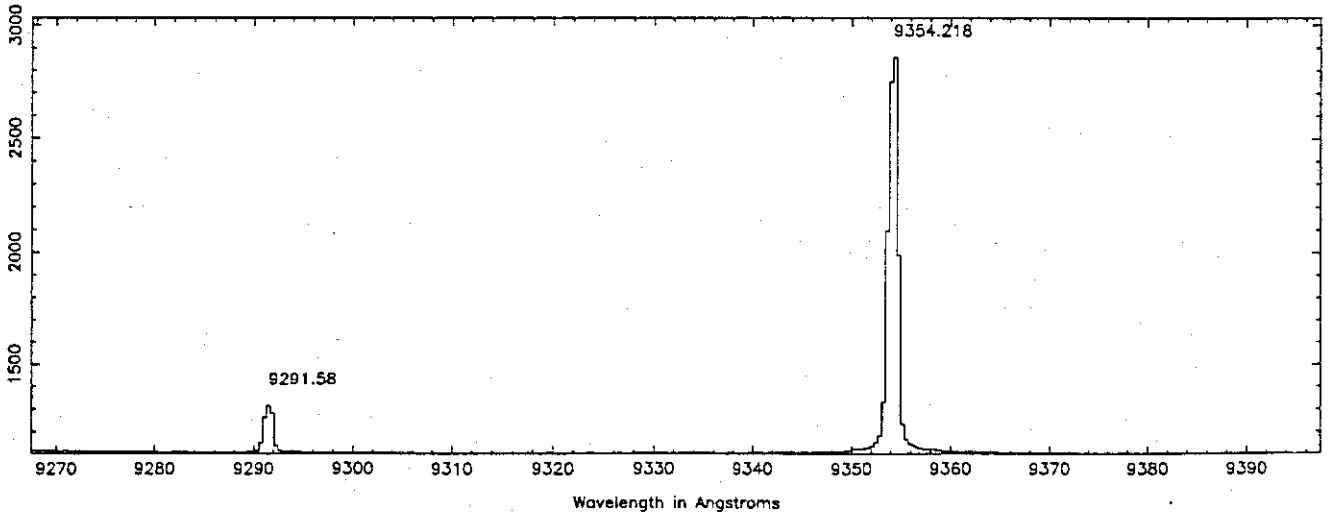

8761.691
8799.082
8771.855
8849.97
2000
1500
8740 8750 8760 8770 8780 8790 8800 8810 8820 8830 8840 8850 8860
Wavelength in Angstroms


8962.19
8905.65
8931.326
8964.46
1220
1200
1180
1160
1140
8870 8880 8890 8900 8910 8920 8930 8940 8950 8960 8970 8980 8990
Wavelength in Angstroms

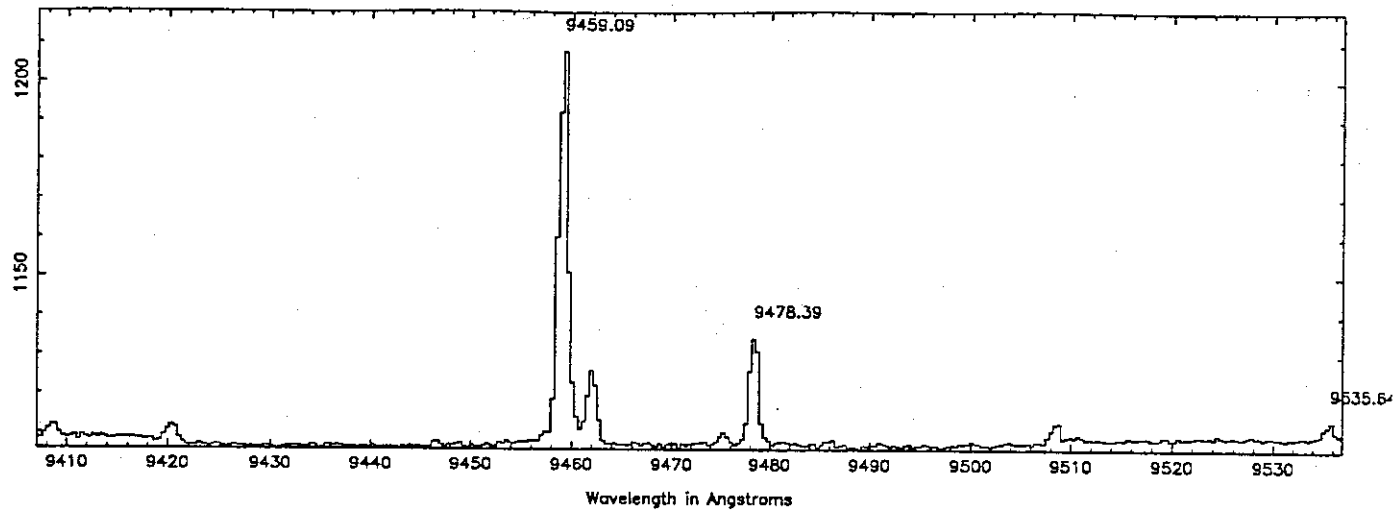
Cu–Ar (1200)

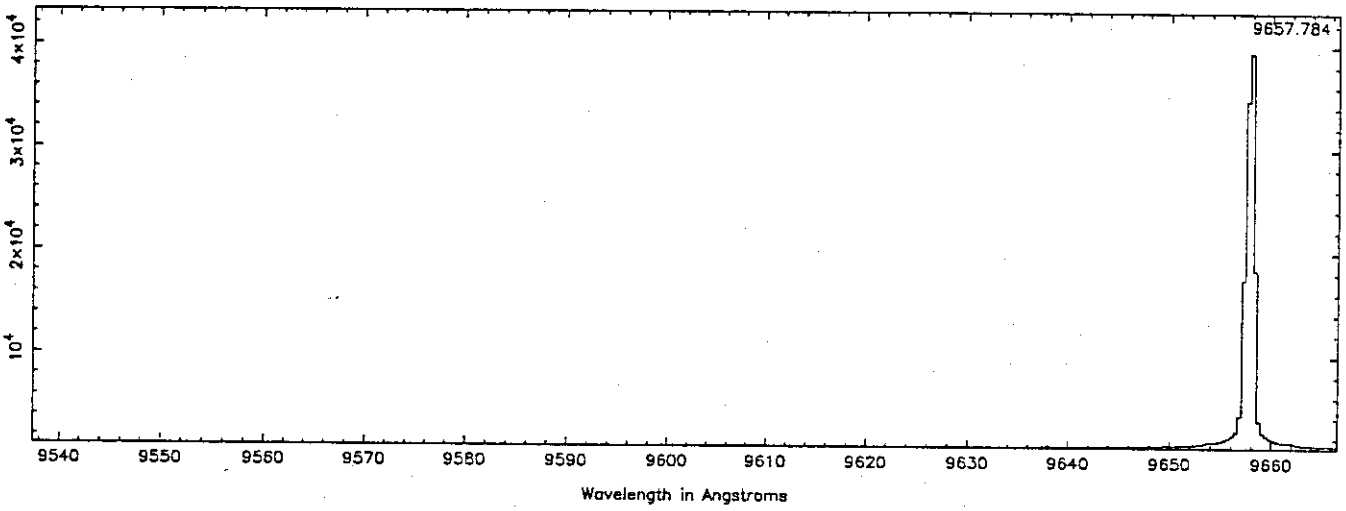

9122.966
9066.77
9075.42
4×10⁴
2×10⁴
9010
9020
9030
9040
9050
9060
9070
9080
9090
9100
9110
9120
9130
Wavelength in Angstroms

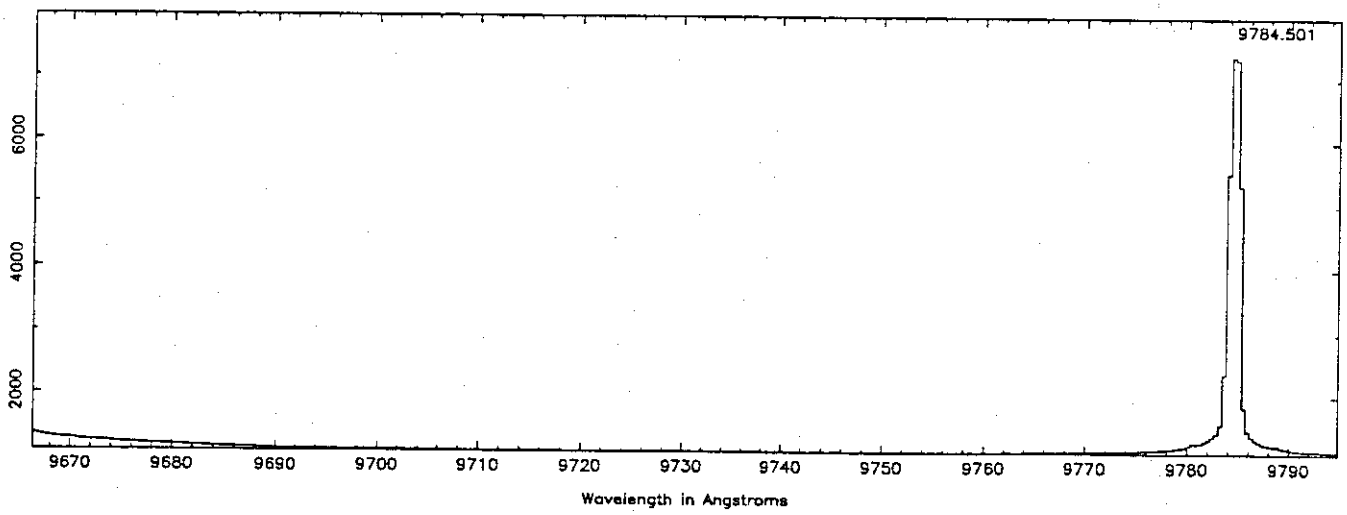

9224.495
9194.637
2×10⁴
1.5×10⁴
10⁴
5000
9140
9150
9160
9170
9180
9190
9200
9210
9220
9230
9240
9250
9260
Wavelength in Angstroms


9354.218
9291.58
3000
2500
2000
1500
9270
9280
9290
9300
9310
9320
9330
9340
9350
9360
9370
9380
9390
Wavelength in Angstroms

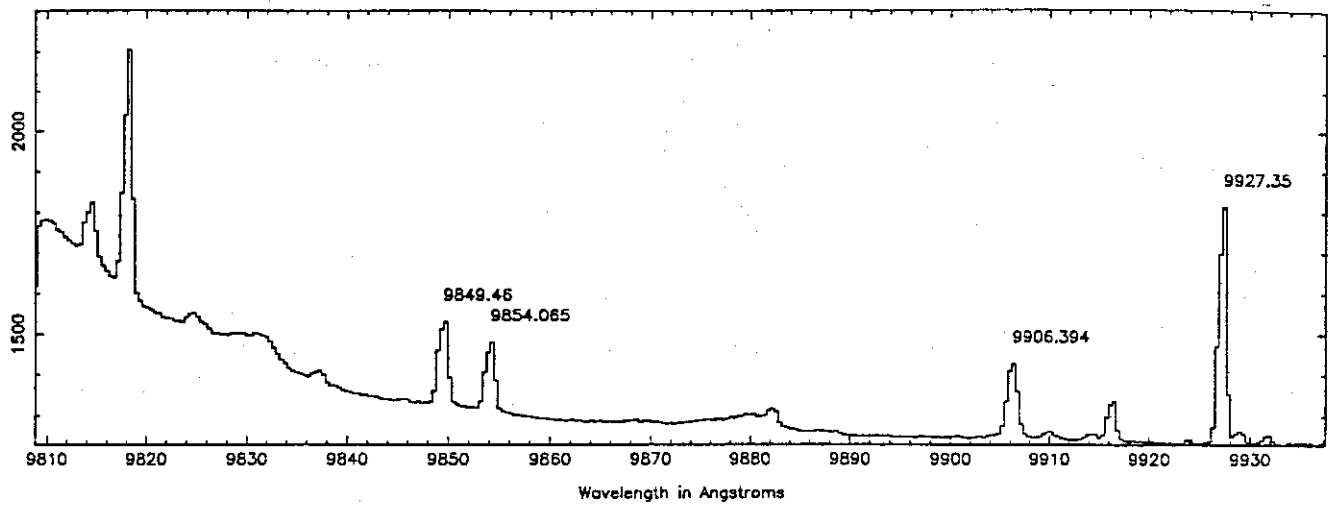
Cu–Ar (1200)

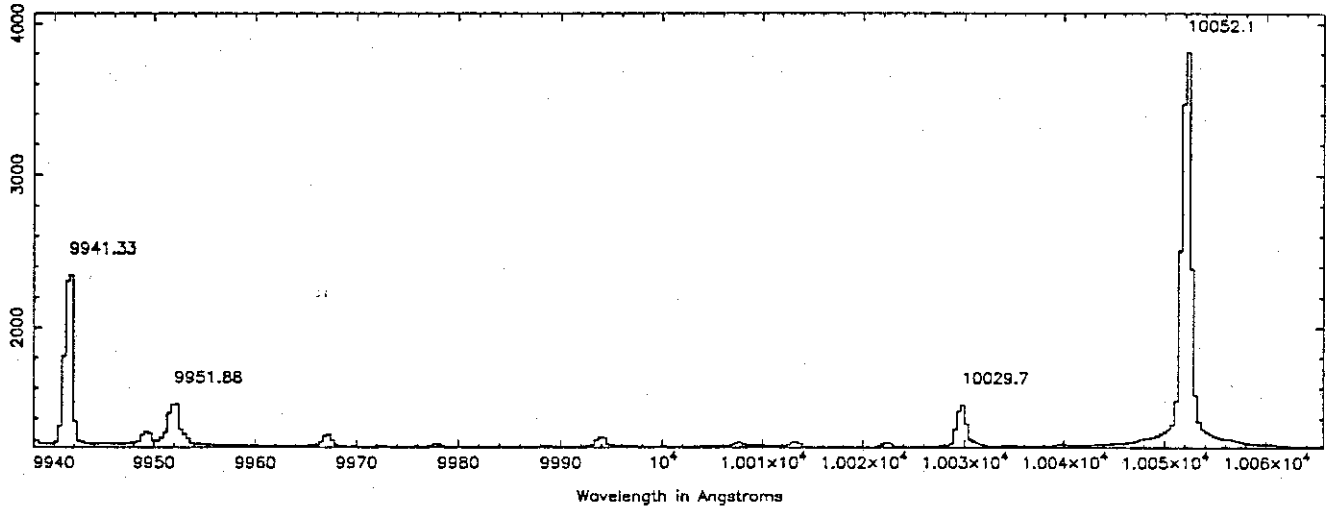

9459.09
9478.39
9535.64
1200
1150
9410
9420
9430
9440
9450
9460
9470
9480
9490
9500
9510
9520
9530
Wavelength in Angstroms

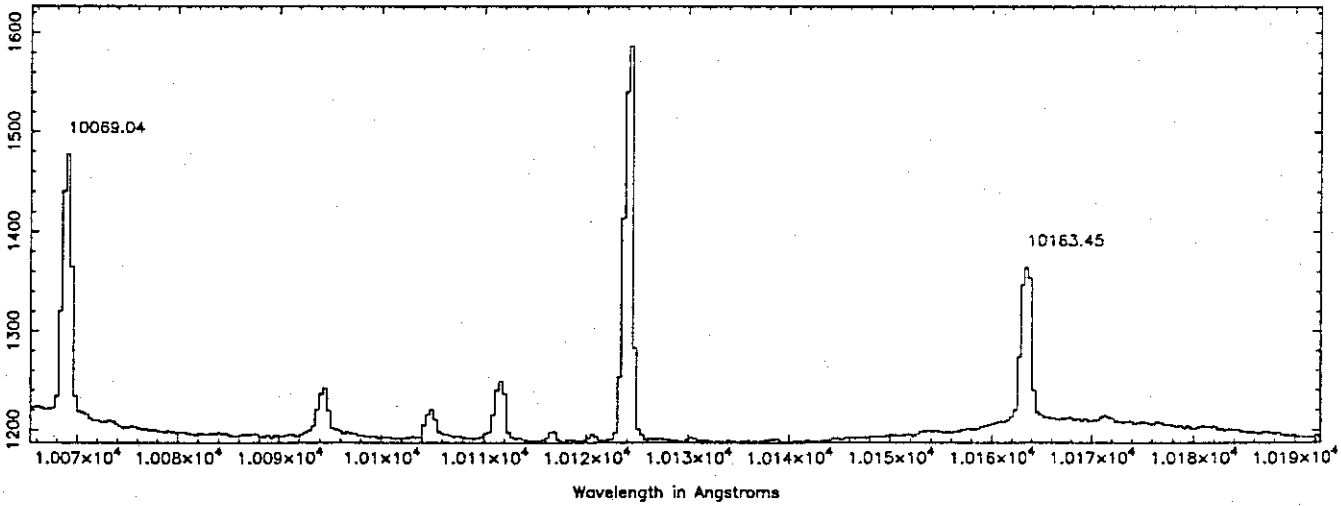

9657.784
4x10⁴
3x10⁴
2x10⁴
10⁴
9540
9550
9560
9570
9580
9590
9600
9610
9620
9630
9640
9650
9660
Wavelength in Angstroms


9784.501
6000
4000
2000
9670
9680
9690
9700
9710
9720
9730
9740
9750
9760
9770
9780
9790
Wavelength in Angstroms

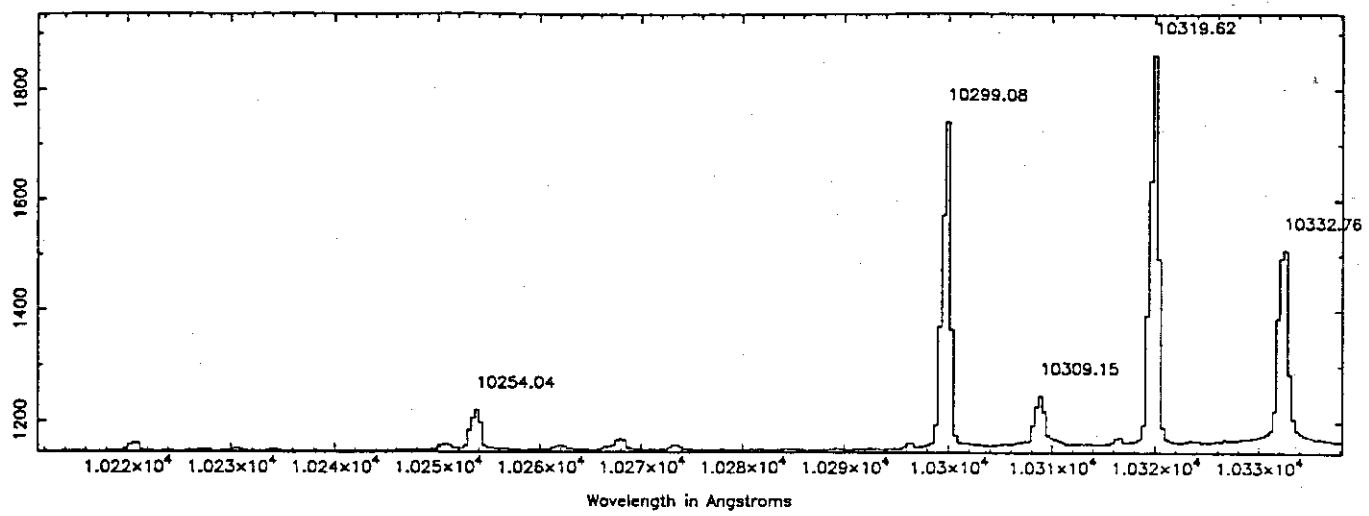
Cu–Ar (1200)

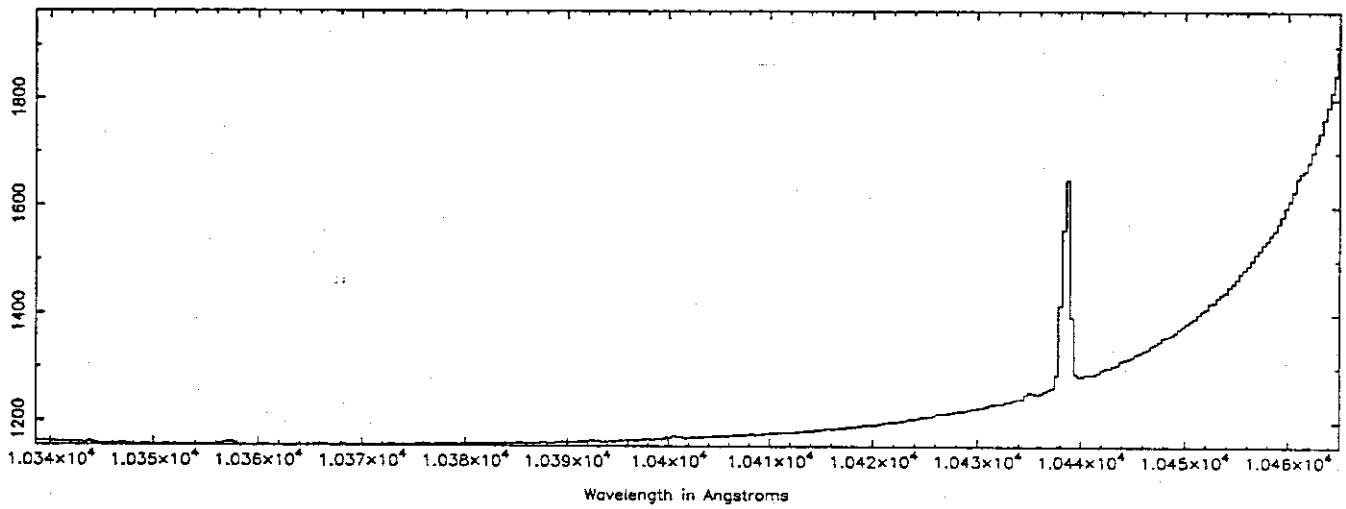

9927.35
9849.46
9854.065
9906.394
Wavelength in Angstroms

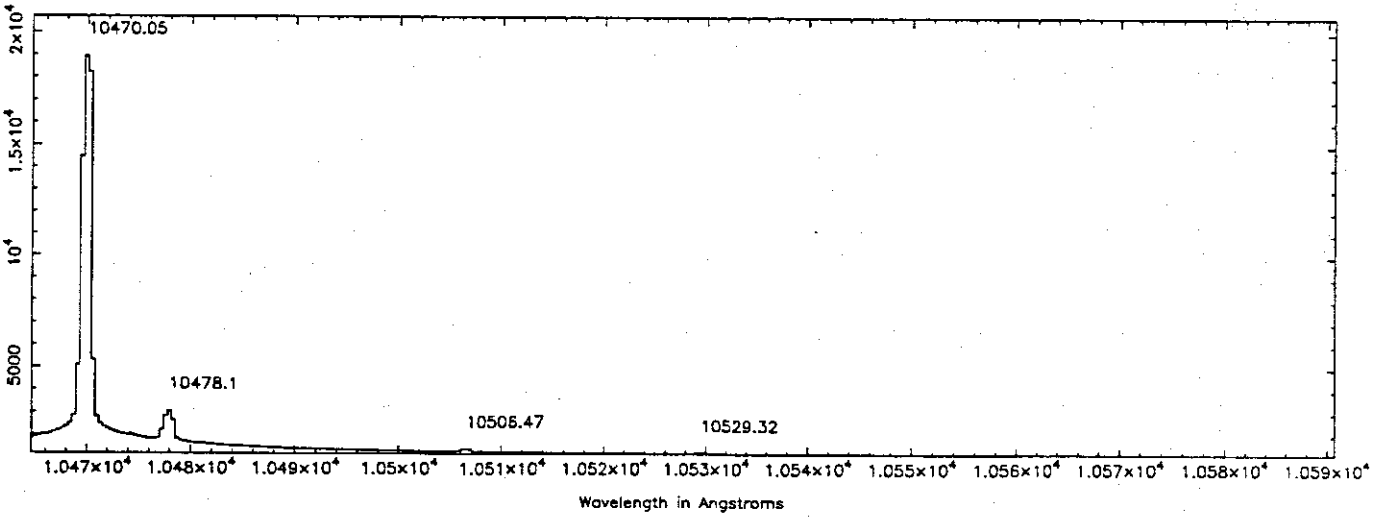

10052.1
9941.33
9951.88
10029.7
Wavelength in Angstroms


10069.04
10163.45
Wavelength in Angstroms

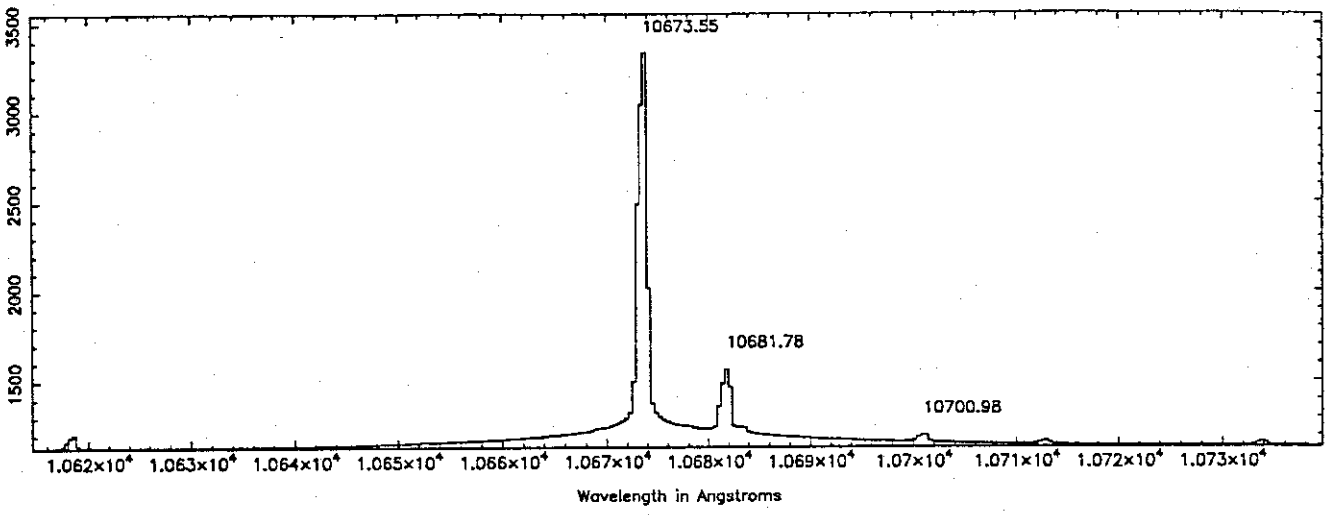
Cu–Ar (1200)

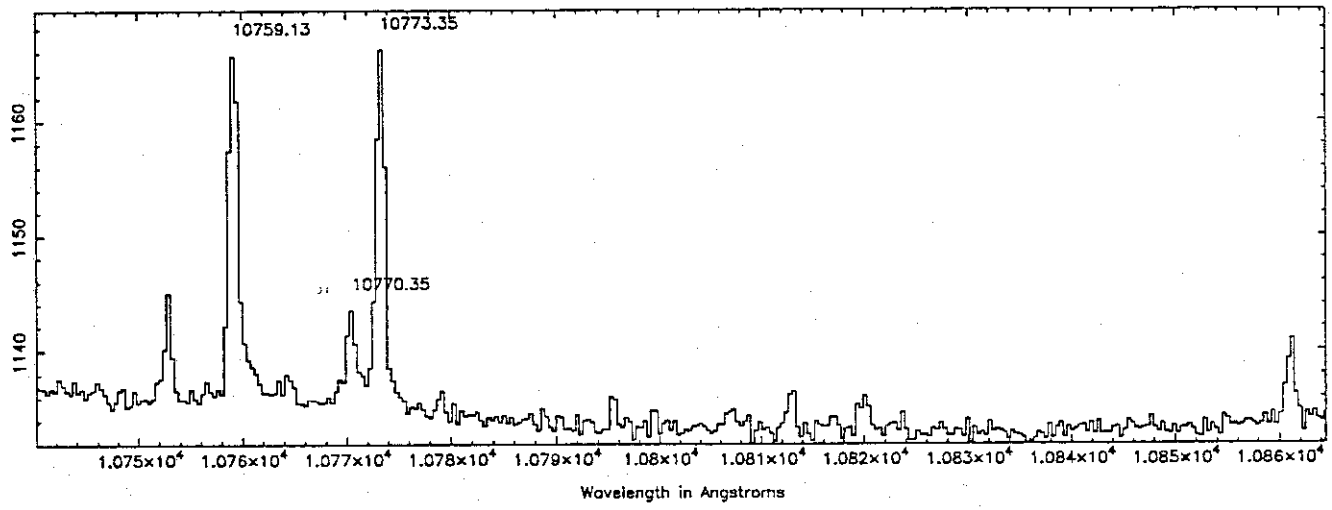

10319.62
10299.08
10332.76
10309.15
10254.04
1800
1600
1400
1200
1.022×10⁴ 1.023×10⁴ 1.024×10⁴ 1.025×10⁴ 1.026×10⁴ 1.027×10⁴ 1.028×10⁴ 1.029×10⁴ 1.03×10⁴ 1.031×10⁴ 1.032×10⁴ 1.033×10⁴
Wavelength in Angstroms

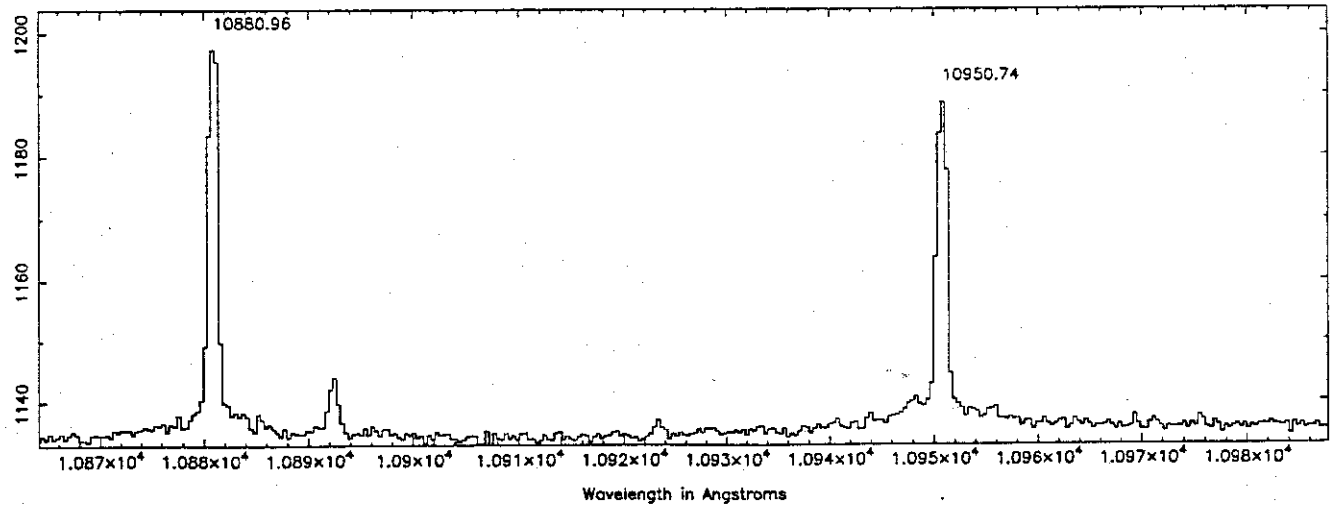

1800
1600
1400
1200
1.034×10⁴ 1.035×10⁴ 1.036×10⁴ 1.037×10⁴ 1.038×10⁴ 1.039×10⁴ 1.04×10⁴ 1.041×10⁴ 1.042×10⁴ 1.043×10⁴ 1.044×10⁴ 1.045×10⁴ 1.046×10⁴
Wavelength in Angstroms


10470.05
10478.1
10508.47
10529.32
2×10⁴
1.5×10⁴
10⁴
5000
1.047×10⁴ 1.048×10⁴ 1.049×10⁴ 1.05×10⁴ 1.051×10⁴ 1.052×10⁴ 1.053×10⁴ 1.054×10⁴ 1.055×10⁴ 1.056×10⁴ 1.057×10⁴ 1.058×10⁴ 1.059×10⁴
Wavelength in Angstroms

Cu–Ar (1200)


10673.55
10681.78
10700.98
3500
3000
2500
2000
1500
1.062×10⁴ 1.063×10⁴ 1.064×10⁴ 1.065×10⁴ 1.066×10⁴ 1.067×10⁴ 1.068×10⁴ 1.069×10⁴ 1.07×10⁴ 1.071×10⁴ 1.072×10⁴ 1.073×10⁴
Wavelength in Angstroms


10759.13
10773.35
10770.35
1160
1150
1140
1.075×10⁴ 1.076×10⁴ 1.077×10⁴ 1.078×10⁴ 1.079×10⁴ 1.08×10⁴ 1.081×10⁴ 1.082×10⁴ 1.083×10⁴ 1.084×10⁴ 1.085×10⁴ 1.086×10⁴
Wavelength in Angstroms

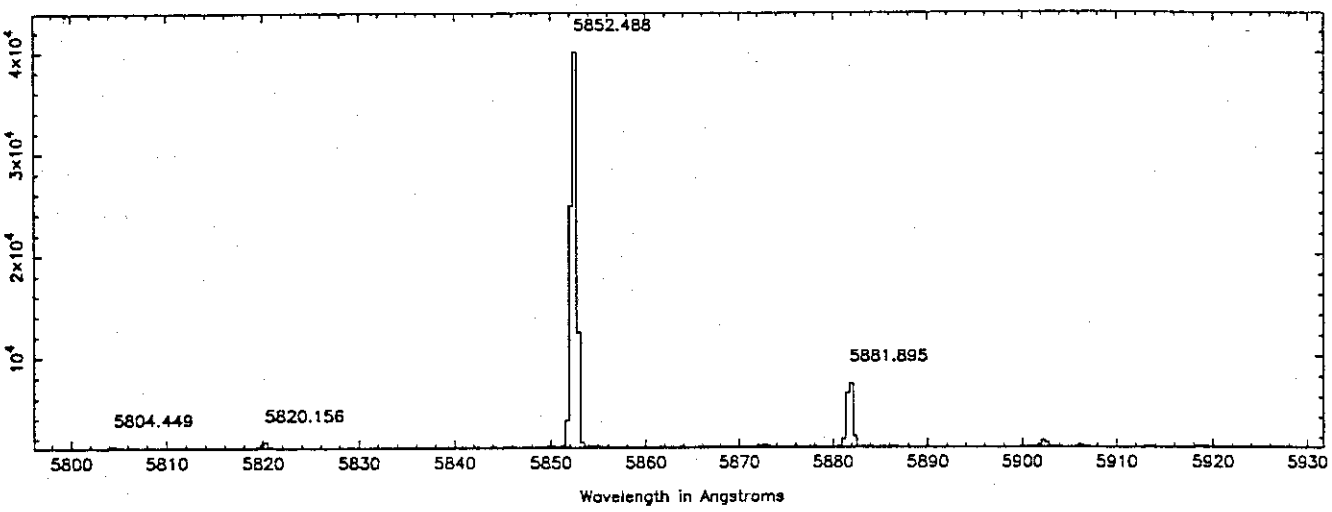

10880.96
10950.74
1200
1180
1160
1140
1.087×10⁴ 1.088×10⁴ 1.089×10⁴ 1.09×10⁴ 1.091×10⁴ 1.092×10⁴ 1.093×10⁴ 1.094×10⁴ 1.095×10⁴ 1.096×10⁴ 1.097×10⁴ 1.098×10⁴
Wavelength in Angstroms

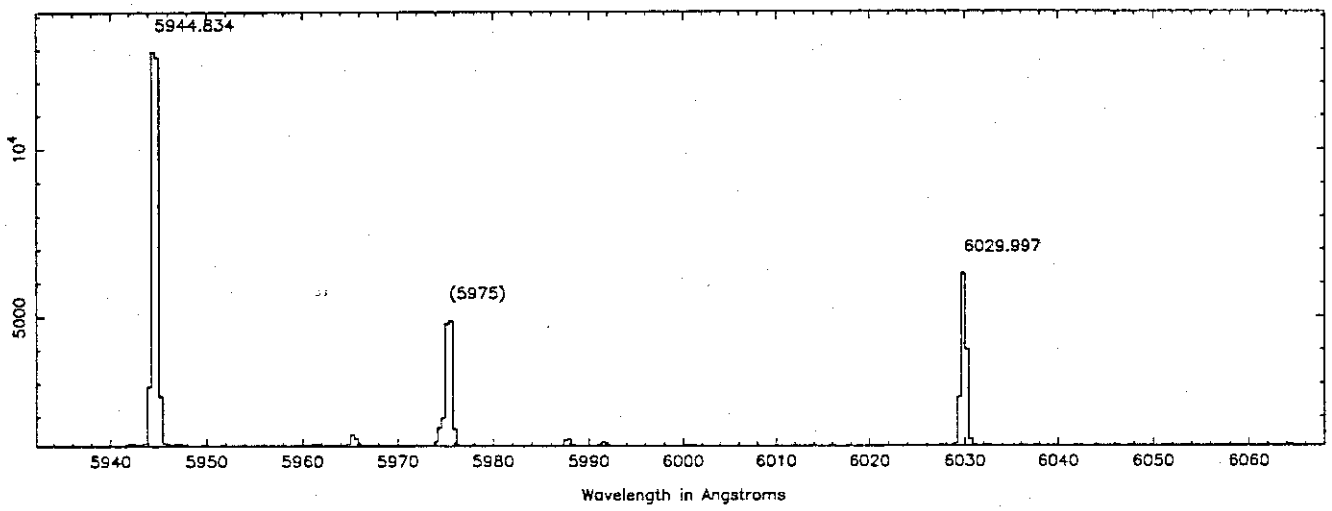
Copper Neon lines: 1200 line grating

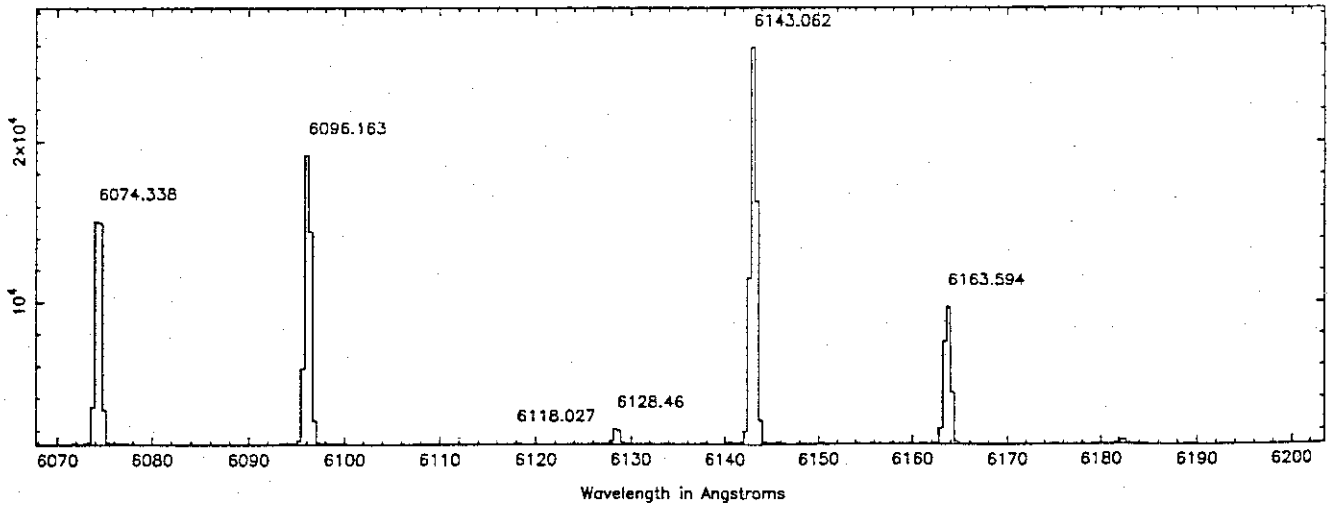
5820.156	Ne I	500	8082.458	Ne I	200	9534.167	Ne I	500
5852.488	Ne I	2000	8092.634	Cu I	2000	9547.40	Ne I	300
5881.895	Ne I	1000	8118.549	Ne I	100	9577.01	Ne II	120 *
5944.834	Ne I	500	8128.908	Ne I	60	9665.424	Ne I	1000
5974.627	Ne I	500	8136.406	Ne I	300	9837.47	Ne I	20
5975.534	Ne I	600	8248.681	Ne I	30	9900.58	Ne I	40
6029.997	Ne I	1000	8259.379	Ne I	150	9902.31	Ne I	30
6074.338	Ne I	1000	8266.079	Ne I	200	9915.13	Ne I	20
6096.163	Ne I	300	8267.117	Ne I	80	9918.52	Ne I	4
6118.027	Ne I	15	8300.325	Ne I	600	9936.83	Ne I	10
6128.460	Ne I	100	8301.54	Ne I	150	9938.35	Ne I	15
6142.508	Ne I	100	8365.746	Ne I	150	9947.94	Ne I	15
6143.062	Ne I	1000	8376.41	Ne I	200	9963.55	Ne I	6
6163.594	Ne I	1000	8377.606	Ne I	800	10005.54	Ne I	20
6217.281	Ne I	1000	8417.161	Ne I	100	10007.31	Ne I	30
6266.495	Ne I	1000	8418.426	Ne I	400	10008.55	Ne I	4
6293.745	Ne I	100	8463.357	Ne I	150	10210.73	Ne I	2
6304.789	Ne I	100	8495.359	Ne I	500	10295.40	Ne I	80
6313.692	Ne I	150	8544.695	Ne I	60	10562.43	Ne I	200
6328.165	Ne I	300	8571.353	Ne I	100	10620.63	Ne I	40
6334.428	Ne I	1000	8582.91	Ne I	60	10760.34	Ne I	1
6382.991	Ne I	1000	8591.258	Ne I	400	10764.09	Ne I	12
6401.076	Ne I	100	8634.647	Ne I	600	10766.15	Ne I	10
6402.246	Ne I	2000	8635.31	Ne I	50	10798.12	Ne I	150
6421.711	Ne I	100	8647.040	Ne I	300	10844.54	Ne I	200
6444.712	Ne I	150	8654.384	Ne I	1500			
6506.528	Ne I	100	8655.521	Ne I	400			
6532.882	Ne I	100	8679.490	Ne I	500			
6598.953	Ne I	1000	8681.922	Ne I	500			
6640.012	Ne I	10	8704.113	Ne I	200			
6640.80	Ne I	5	8771.659	Ne I	400			
6652.092	Ne I	150	8780.622	Ne I	1200			
6678.276	Ne I	500	8783.754	Ne I	1000			
6717.043	Ne I	70	8830.908	Ne I	50			
6738.058	Ne I	70	8853.867	Ne I	700			
6759.586	Ne I	15	8865.306	Ne I	100			
6929.467	Ne I	1000	8865.756	Ne I	500			
7024.050	Ne I	500	8919.499	Ne I	300			
7032.413	Ne I	1000	8988.58	Ne I	200			
7051.294	Ne I	70	9079.46	Ne II	100 *			
7059.108	Ne I	200	9148.68	Ne I	600			
7112.2	Ne I	10	9201.76	Ne I	600			
7173.938	Ne I	1000	9220.05	Ne I	400			
7245.167	Ne I	1000	9221.59	Ne I	200			
7304.82	Ne I	30	9221.88	Ne I	150			
7438.898	Ne I	300	9226.67	Ne I	200			
7472.438	Ne I	50	9275.53	Ne I	100			
7488.871	Ne I	500	9287.56	Ne II	200 *			
7535.774	Ne I	300	9300.85	Ne I	600			
7544.044	Ne I	100	9313.98	Ne I	300			
7724.628	Ne I	10	9326.52	Ne I	600			
7833.06	Ne I	7	9373.28	Ne I	200			
7839.055	Ne I	30	9425.38	Ne I	500			
7936.995	Ne I	70	9459.21	Ne I	300			
7943.181	Ne I	200	9486.680	Ne I	500			

* Wavelength and strength from Line Spectra of the Elements

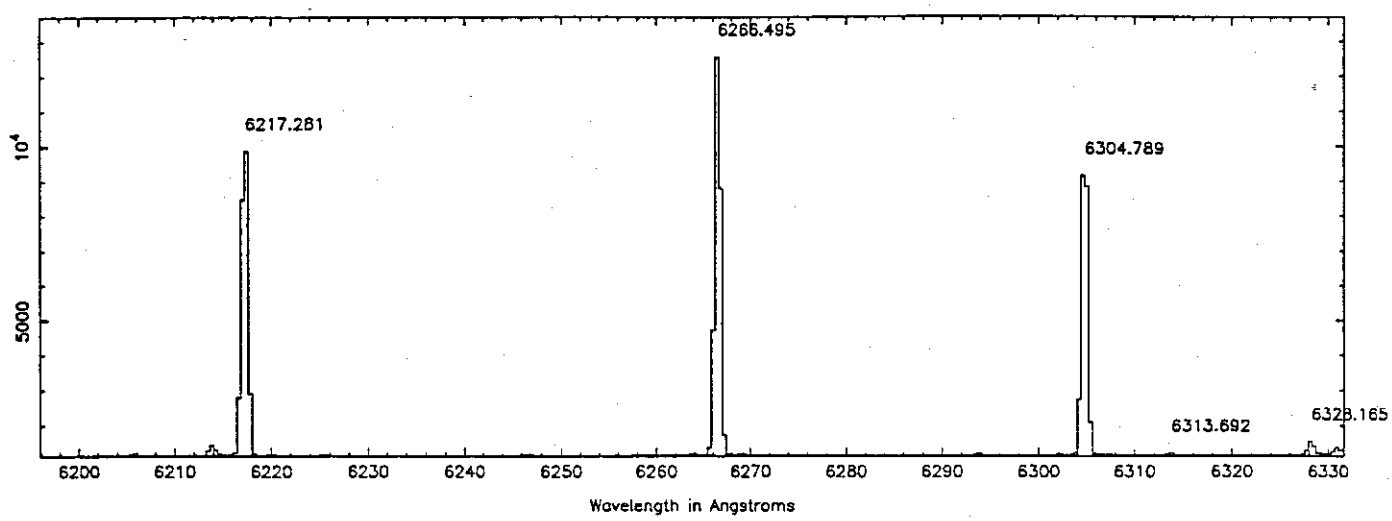
Cu–Ne (1200)

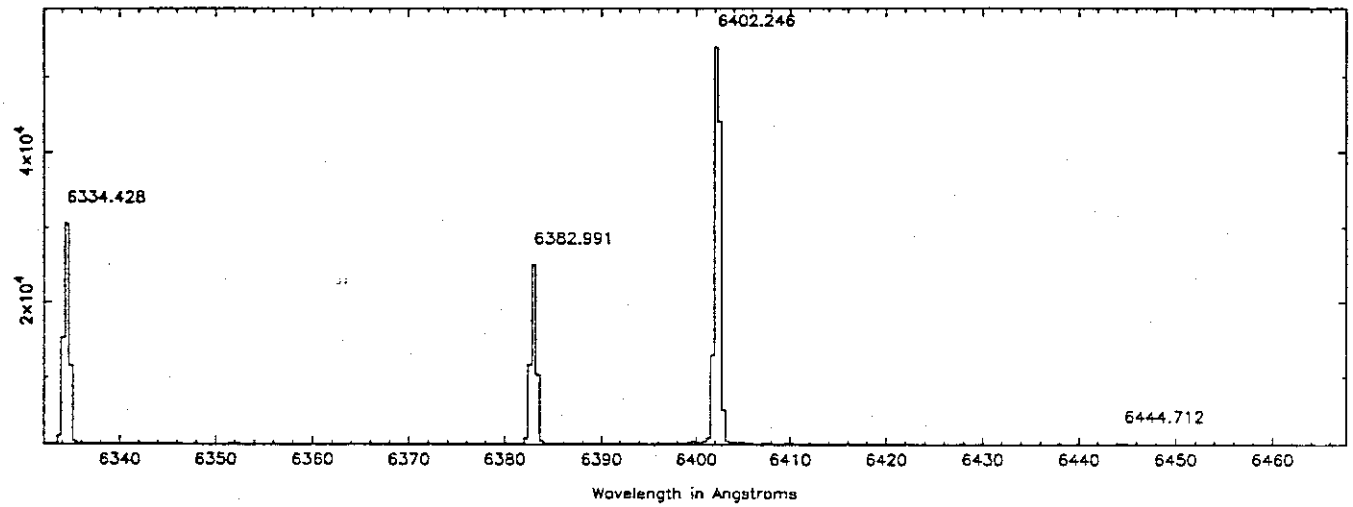

5852.488
5881.895
5804.449
5820.156
Wavelength in Angstroms

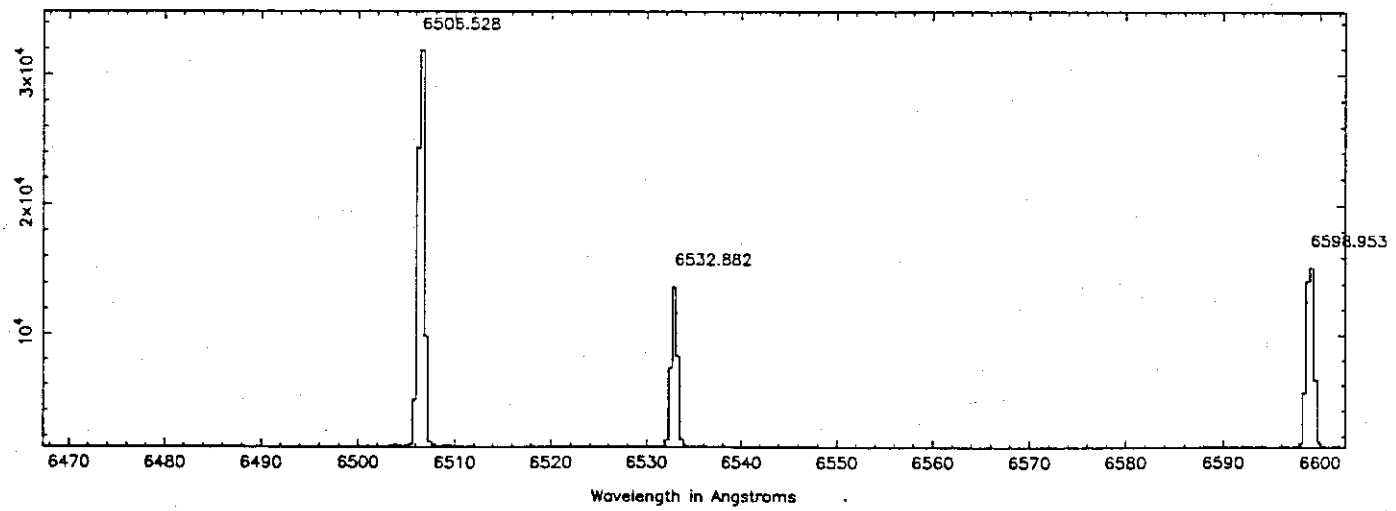

5944.834
6029.997
(5975)
Wavelength in Angstroms


6143.062
6096.163
6074.338
6163.594
6118.027
6128.46
Wavelength in Angstroms

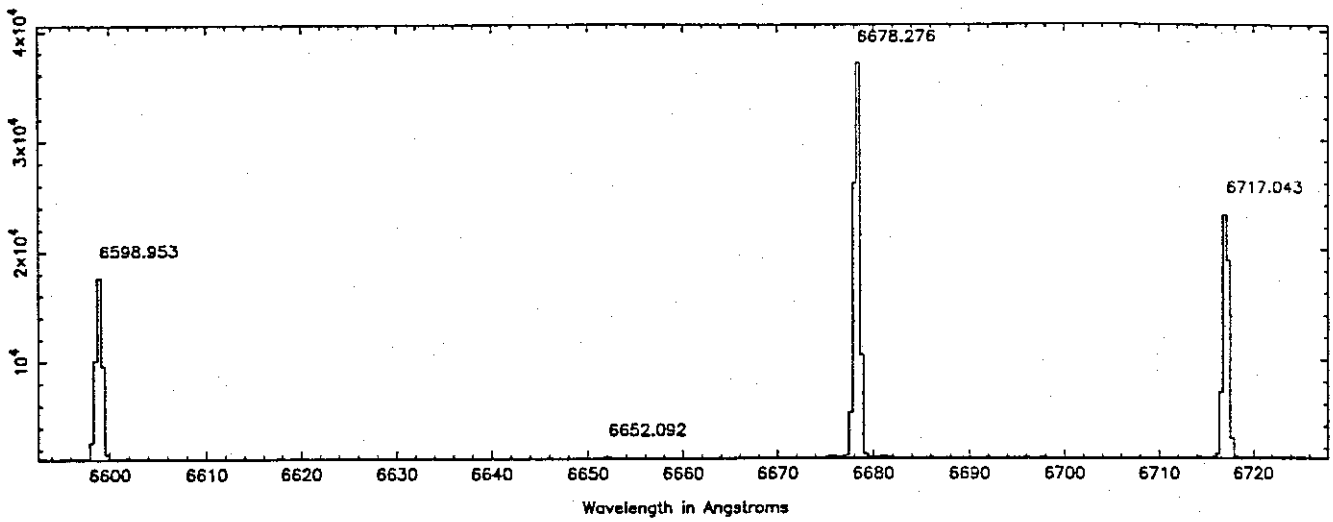
Cu–Ne (1200)

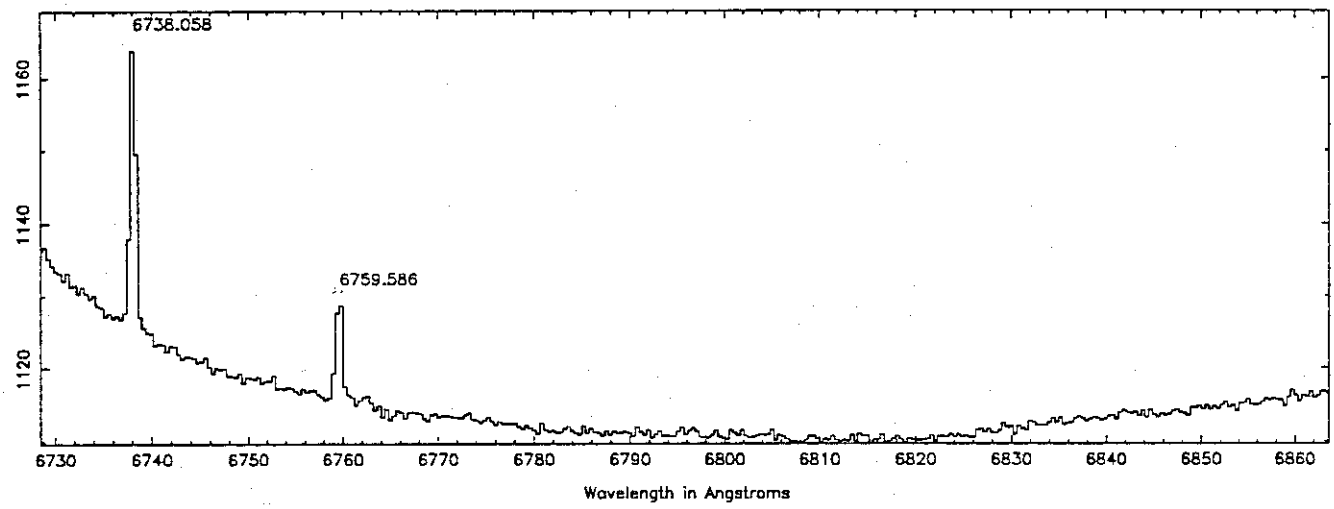

6266.495
6217.281
6304.789
6313.692
6328.165
10⁴
5000
6200 6210 6220 6230 6240 6250 6260 6270 6280 6290 6300 6310 6320 6330
Wavelength in Angstroms

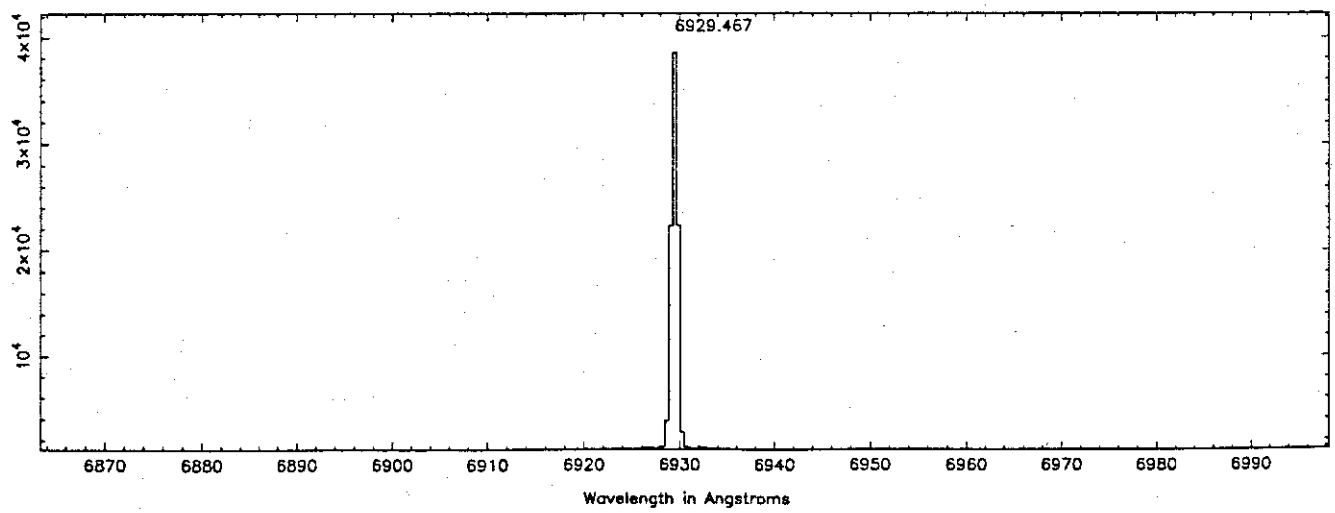

6402.246
6334.428
6382.991
6444.712
4×10⁴
2×10⁴
6340 6350 6360 6370 6380 6390 6400 6410 6420 6430 6440 6450 6460
Wavelength in Angstroms


6505.528
6532.882
6598.953
3×10⁴
2×10⁴
10⁴
6470 6480 6490 6500 6510 6520 6530 6540 6550 6560 6570 6580 6590 6600
Wavelength in Angstroms

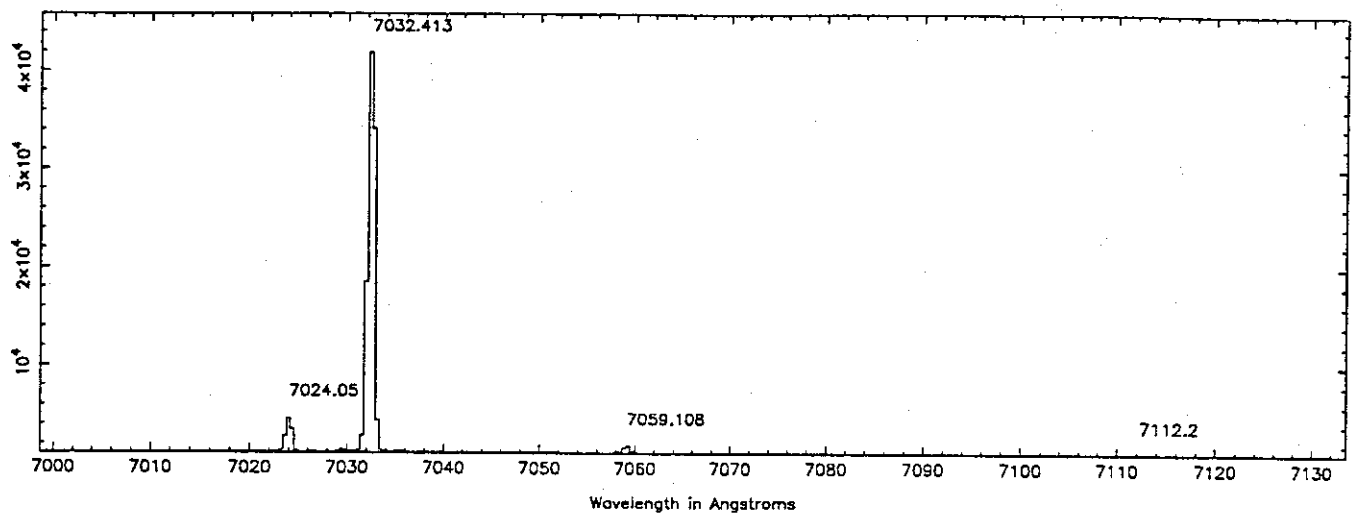
Cu–Ne (1200)

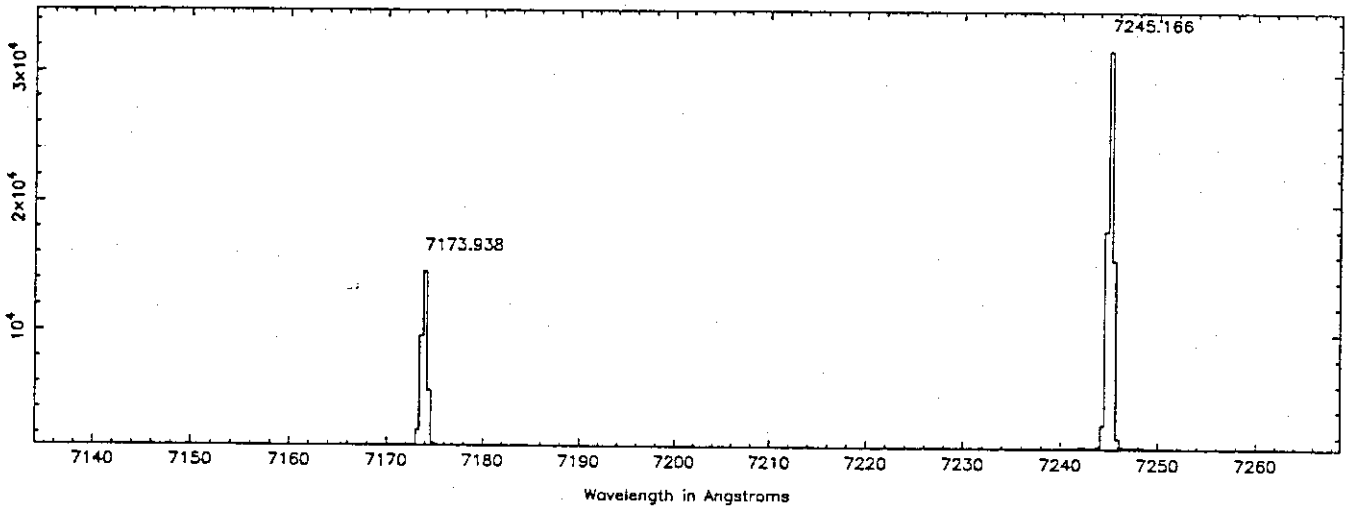

6678.276
6717.043
6598.953
6652.092
Wavelength in Angstroms

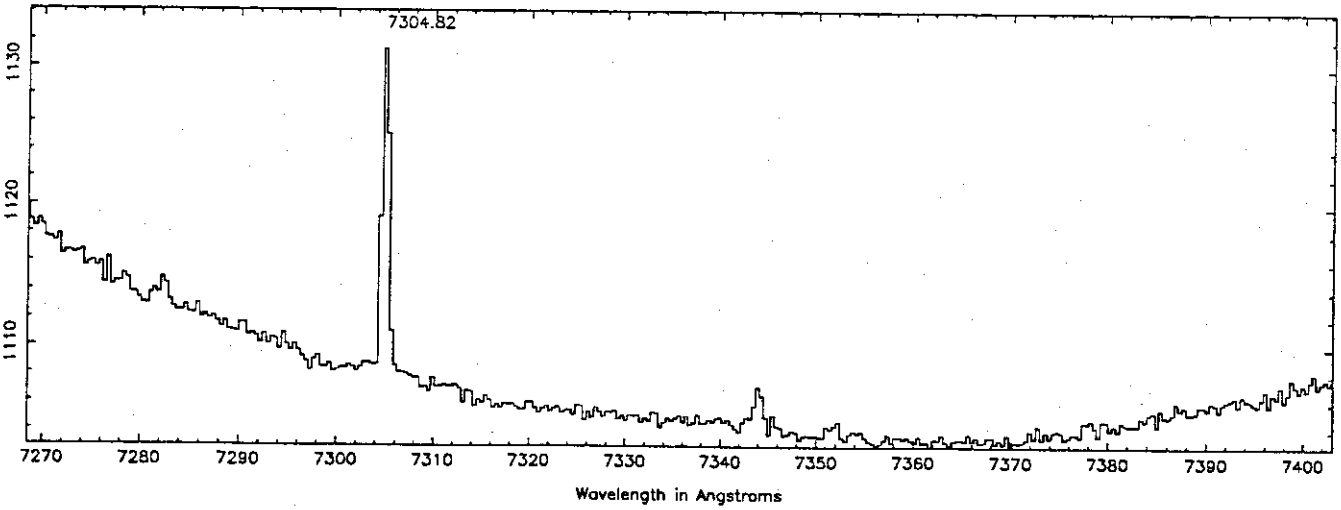

6738.058
6759.586
Wavelength in Angstroms


6929.467
Wavelength in Angstroms

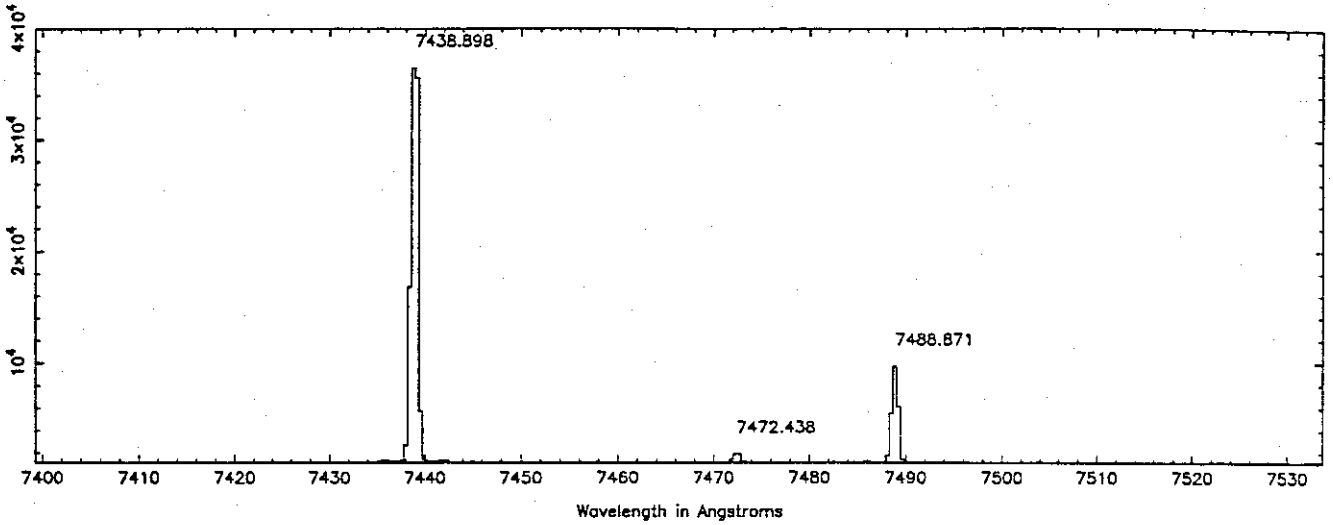
Cu–Ne (1200)

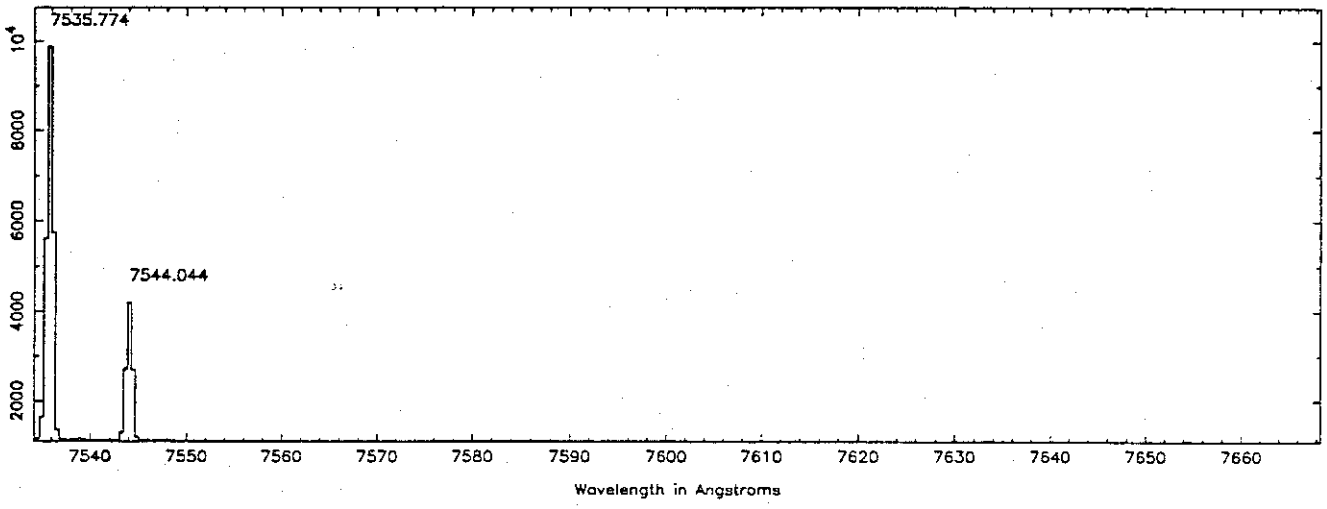

7032.413
7024.05
7059.108
7112.2
Wavelength in Angstroms

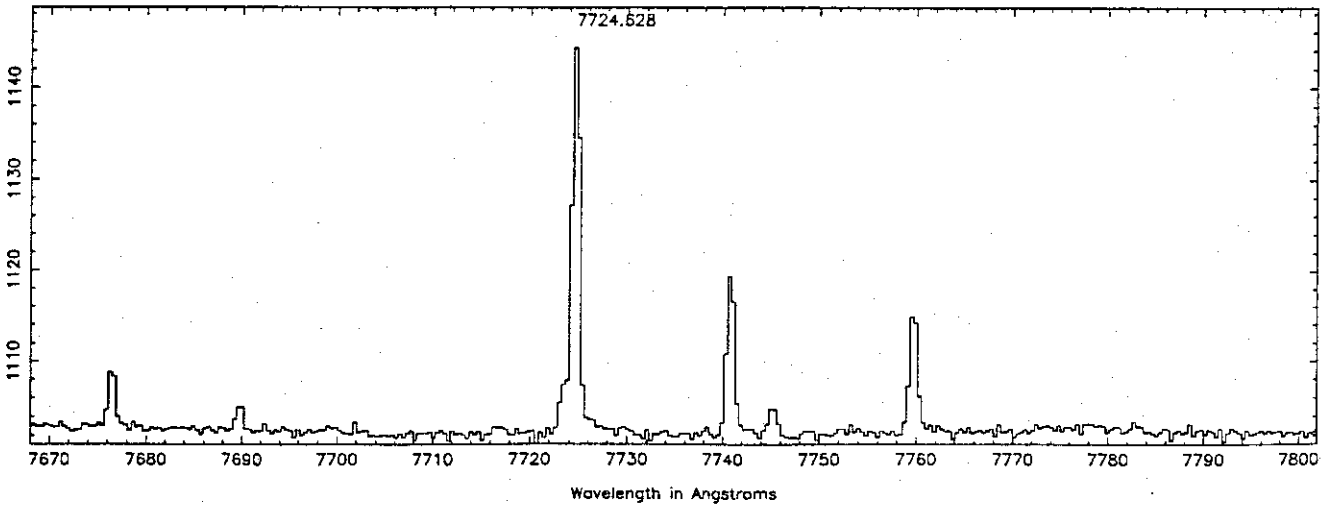

7245.166
7173.938
Wavelength in Angstroms


7304.82
Wavelength in Angstroms

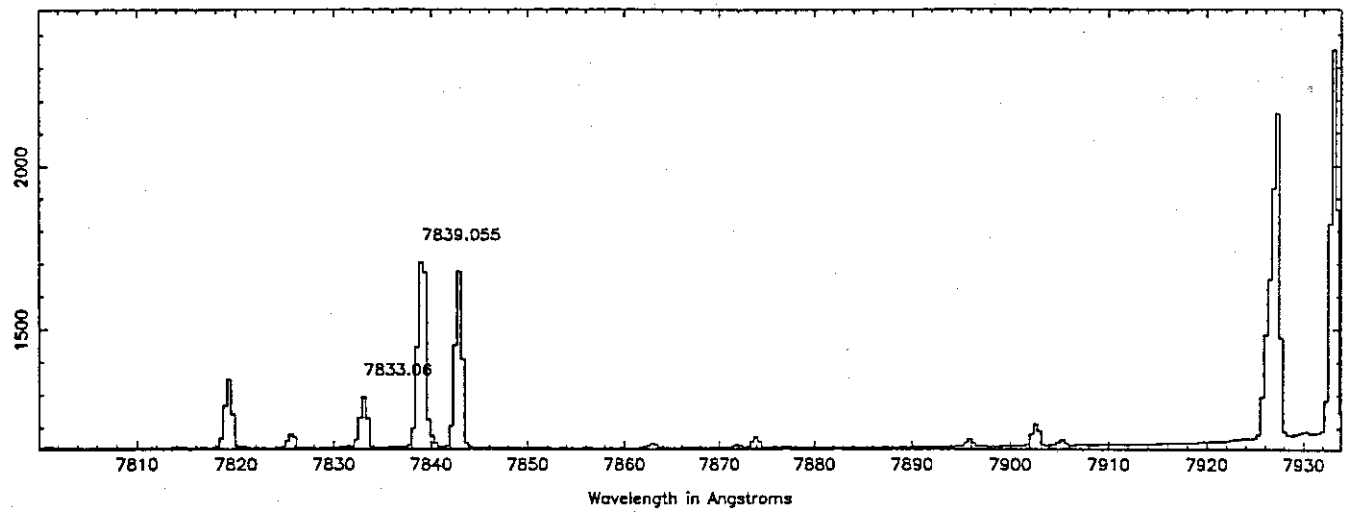
Cu–Ne (1200)

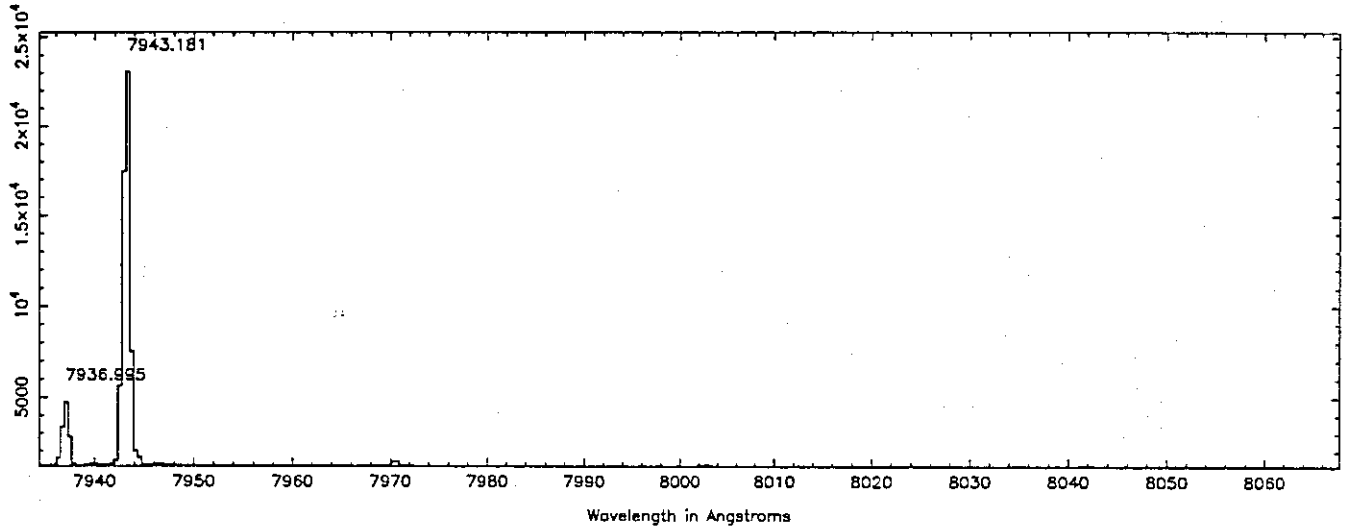

7438.898
7488.871
7472.438
Wavelength in Angstroms

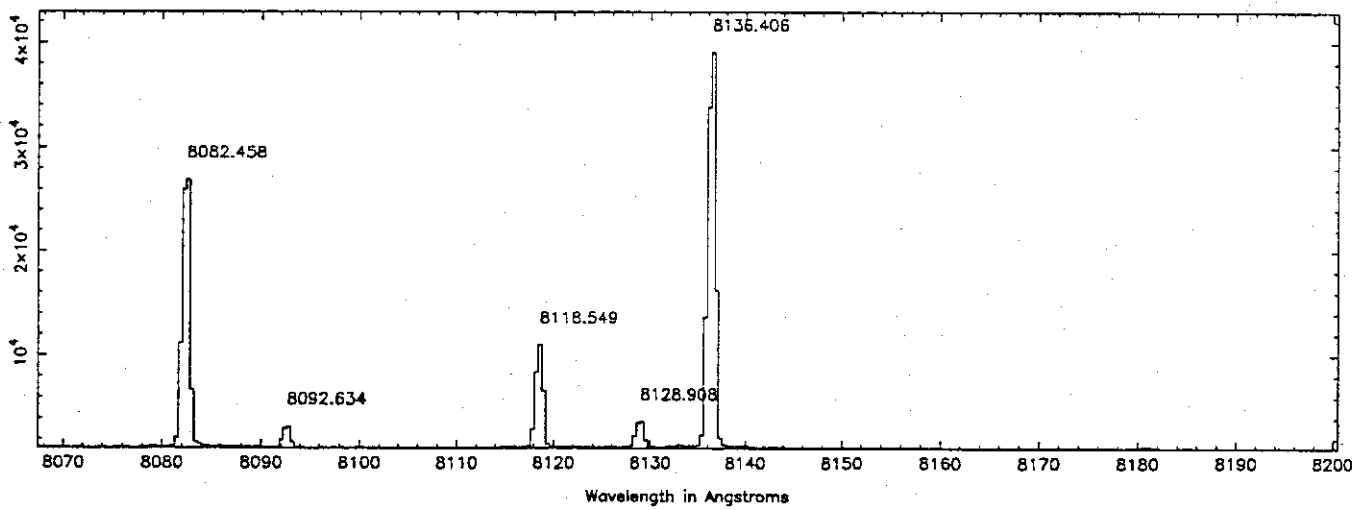

7535.774
7544.044
Wavelength in Angstroms


7724.528
Wavelength in Angstroms

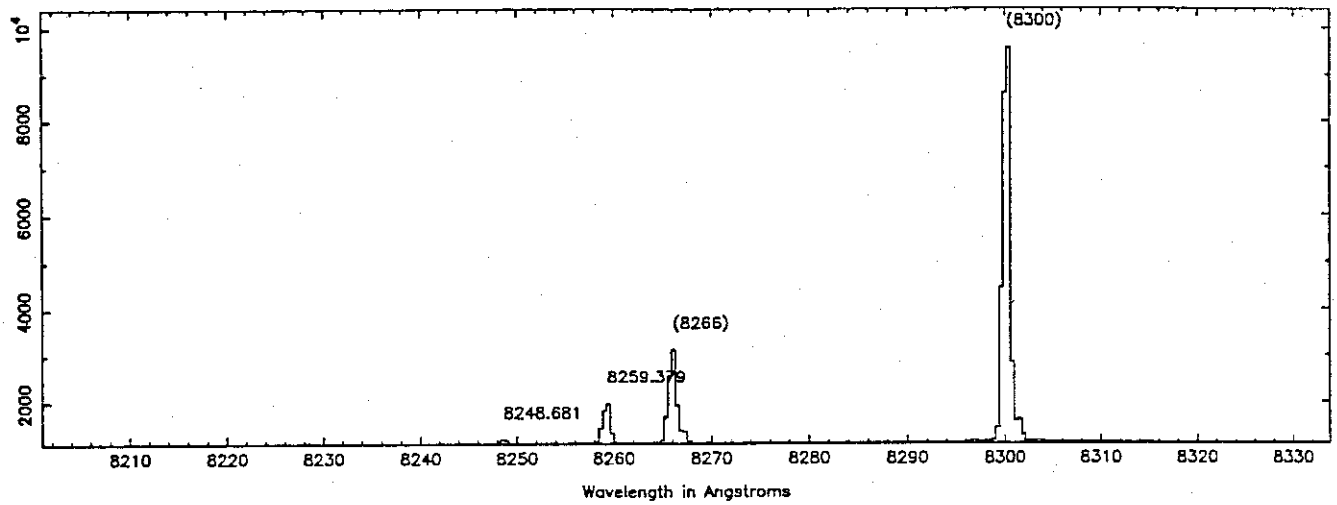
Cu–Ne (1200)

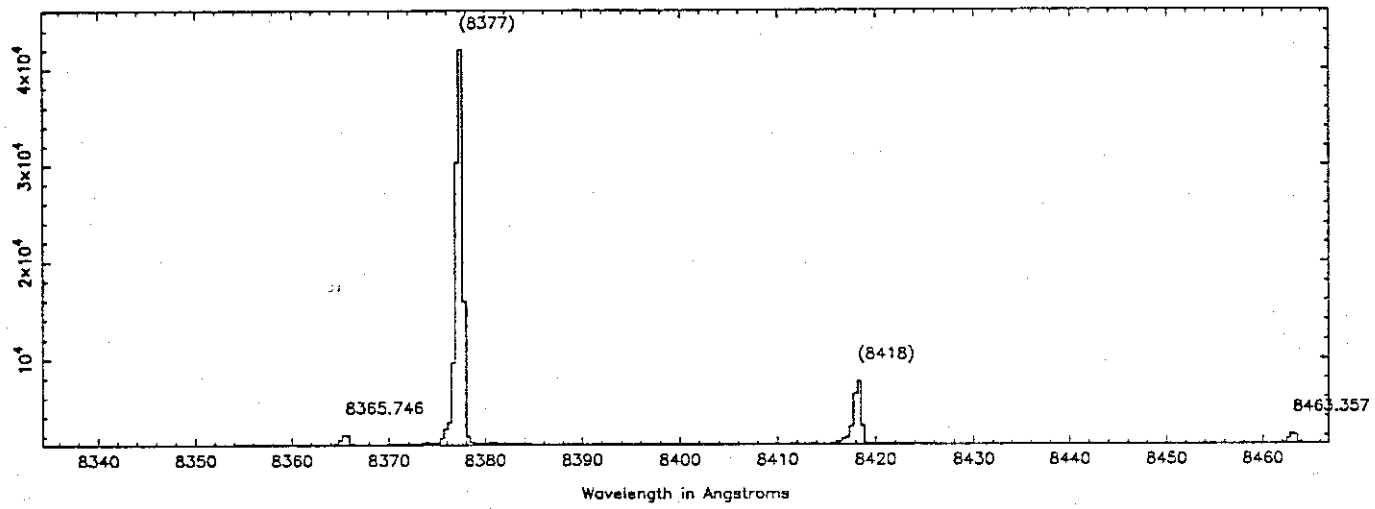

7839.055
7833.06
2000
1500
7810
7820
7830
7840
7850
7860
7870
7880
7890
7900
7910
7920
7930
Wavelength in Angstroms

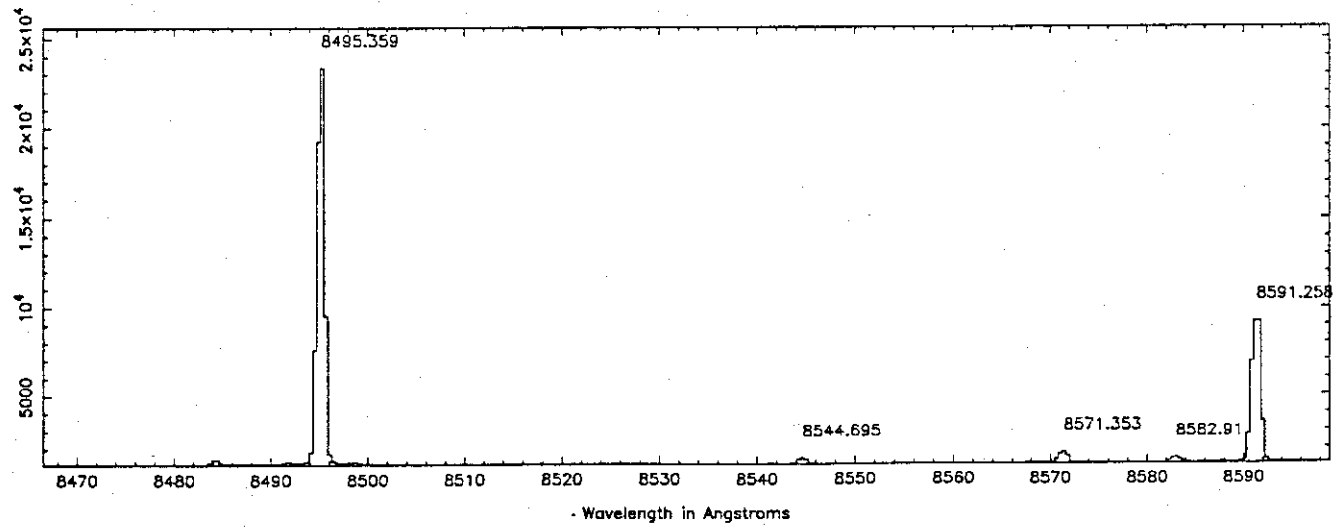

7943.181
7936.995
2.5x10⁴
2x10⁴
1.5x10⁴
10⁴
5000
7940
7950
7960
7970
7980
7990
8000
8010
8020
8030
8040
8050
8060
Wavelength in Angstroms


8136.406
8082.458
8118.549
8092.634
8128.908
4x10⁴
3x10⁴
2x10⁴
10⁴
8070
8080
8090
8100
8110
8120
8130
8140
8150
8160
8170
8180
8190
8200
Wavelength in Angstroms

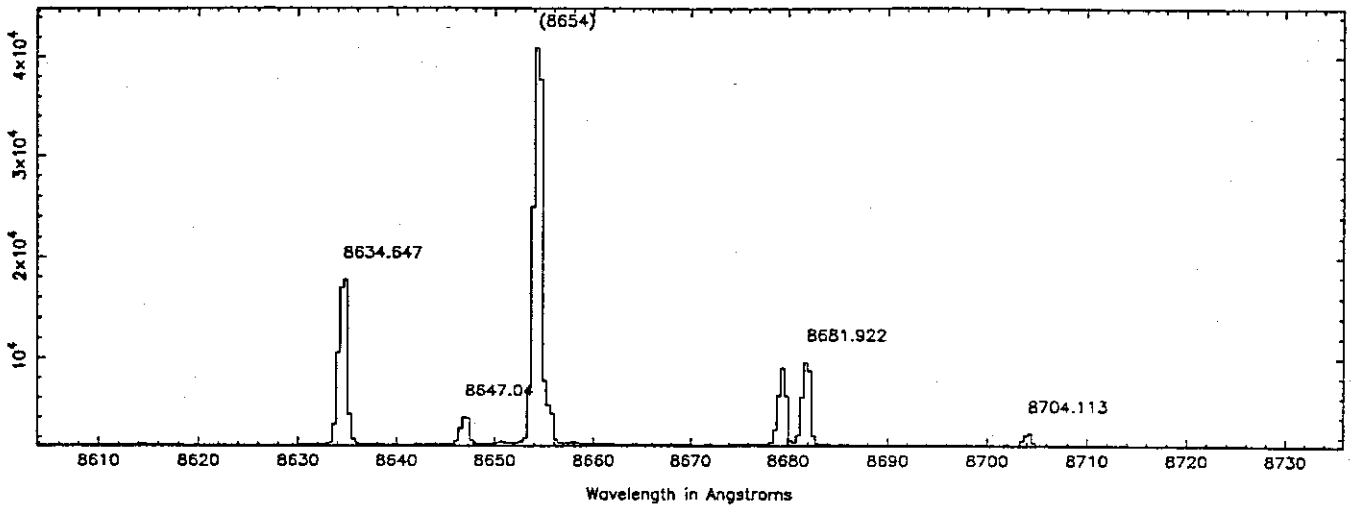
Cu–Ne (1200)

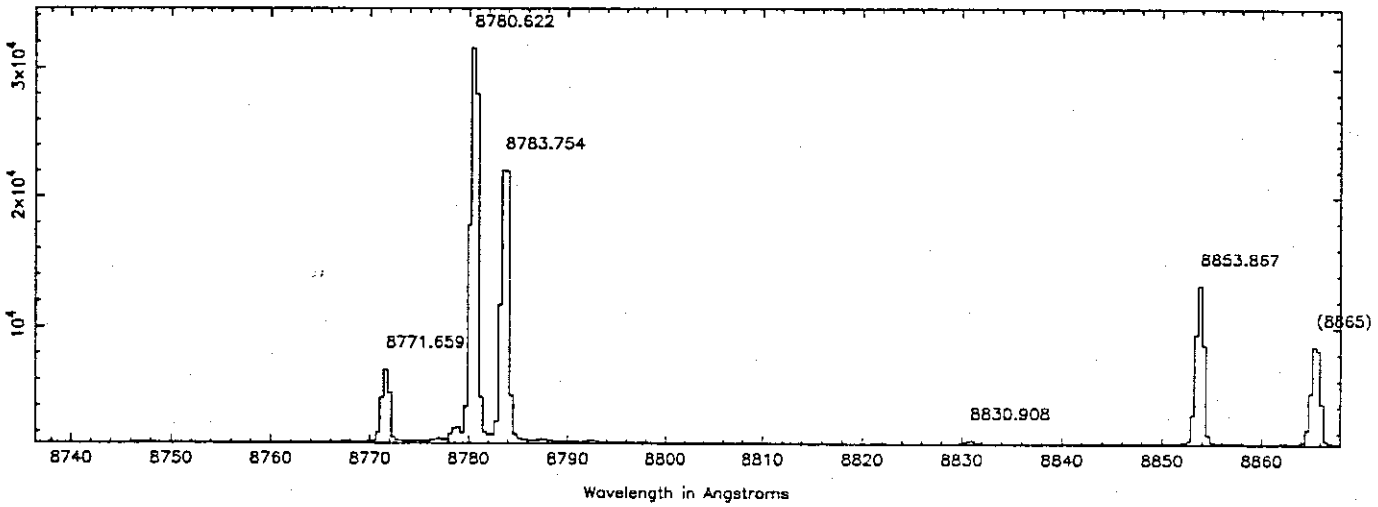

(8300)
(8266)
8259.379
8248.681
Wavelength in Angstroms

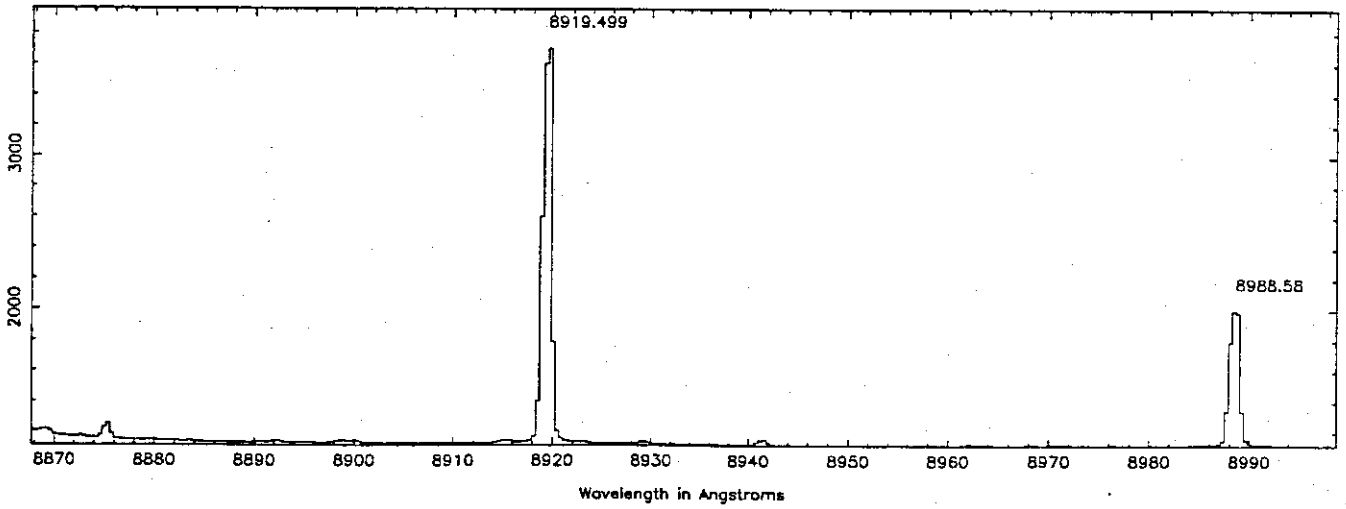

(8377)
(8418)
8365.746
8463.357
Wavelength in Angstroms


8495.359
8591.258
8544.695
8571.353
8582.91
Wavelength in Angstroms

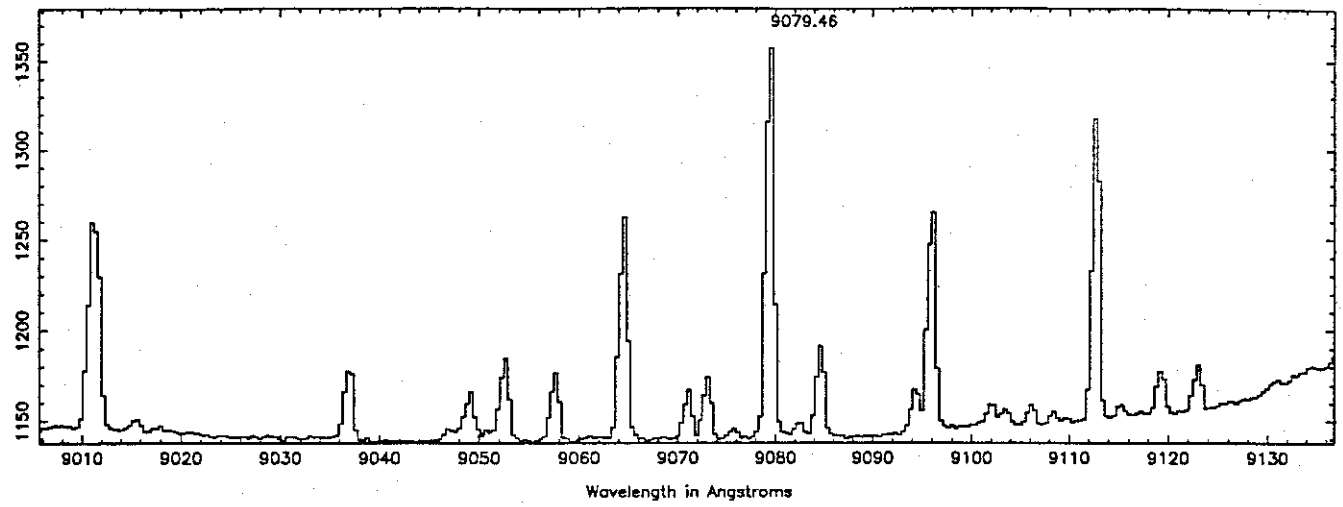
Cu–Ne (1200)

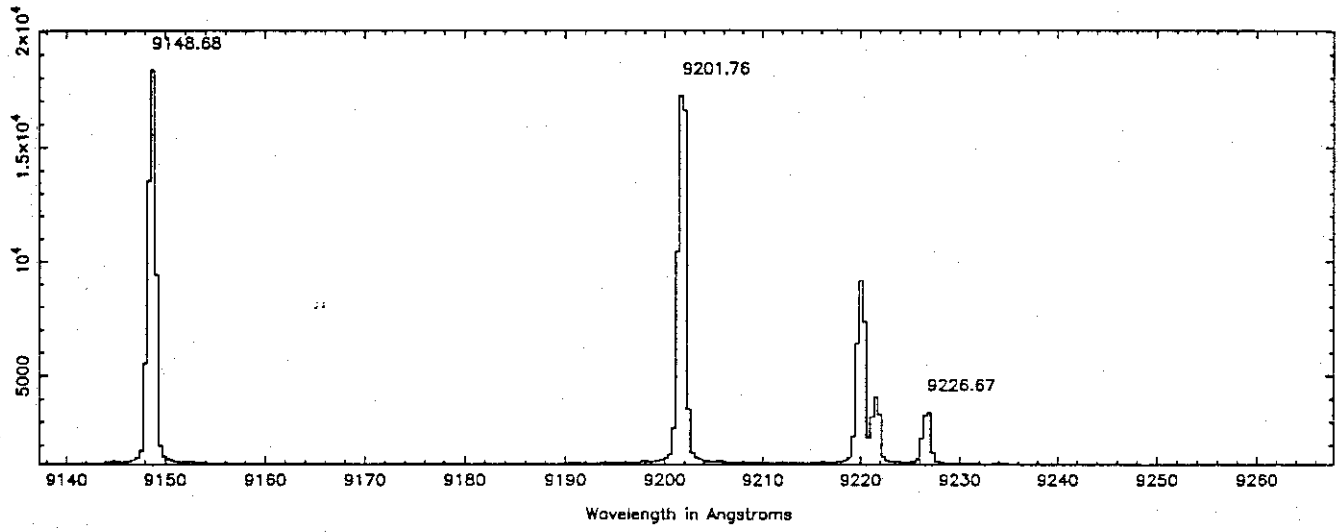

(8654)
8634.647
8647.04
8681.922
8704.113
Wavelength in Angstroms

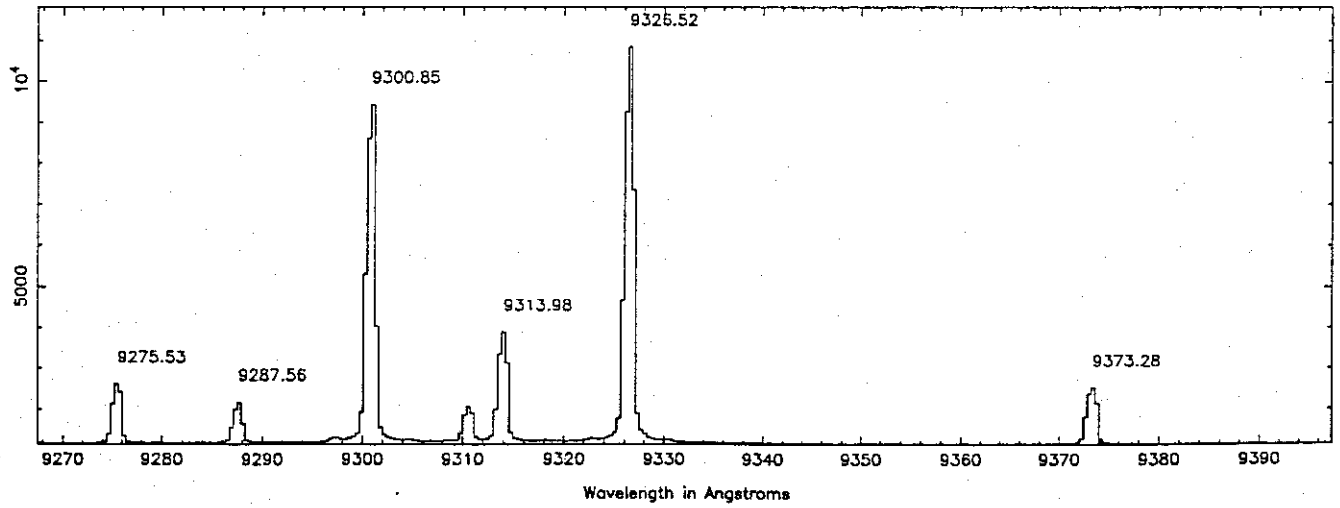

8780.622
8783.754
8771.659
8853.867
(8865)
8830.908
Wavelength in Angstroms


8919.499
8988.58
Wavelength in Angstroms

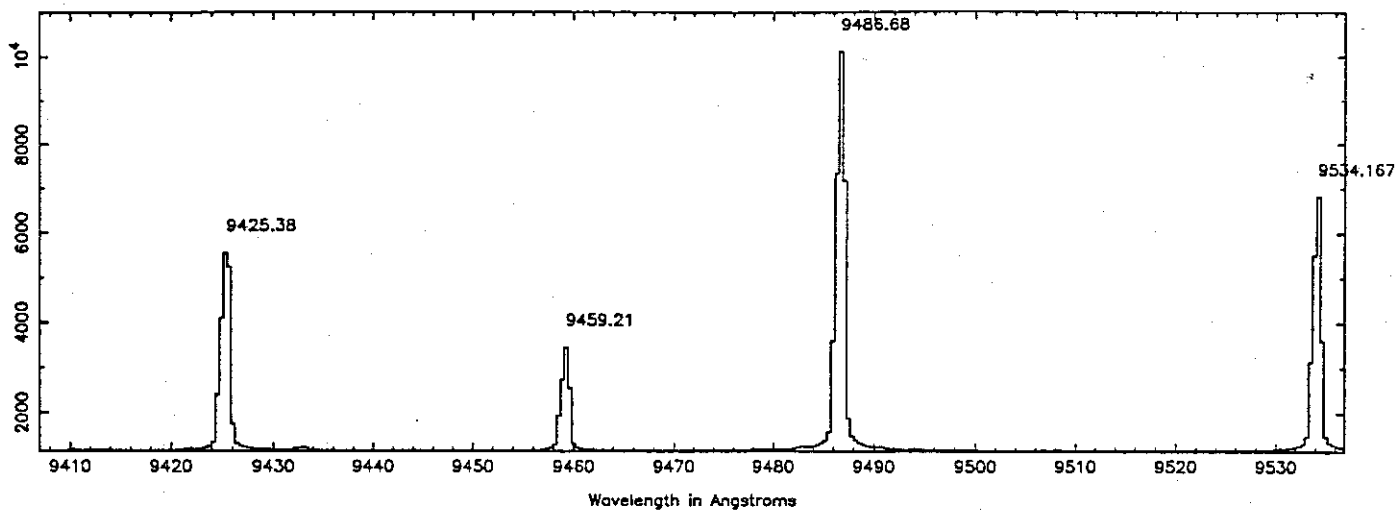
Cu–Ne (1200)

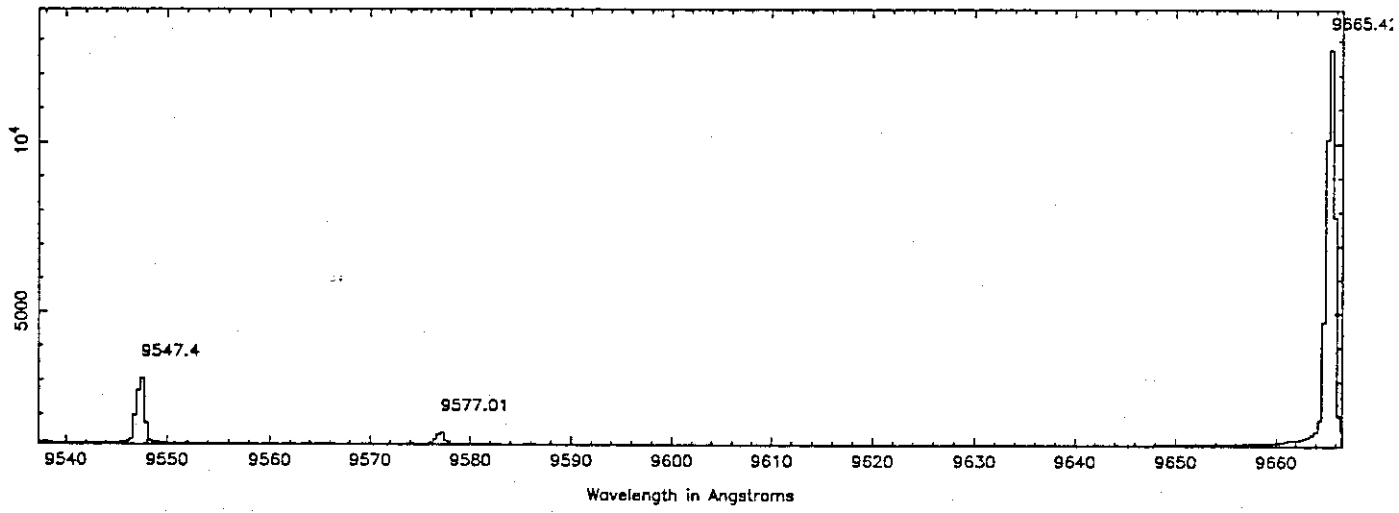

9079.46
1350
1300
1250
1200
1150
9010
9020
9030
9040
9050
9060
9070
9080
9090
9100
9110
9120
9130
Wavelength in Angstroms

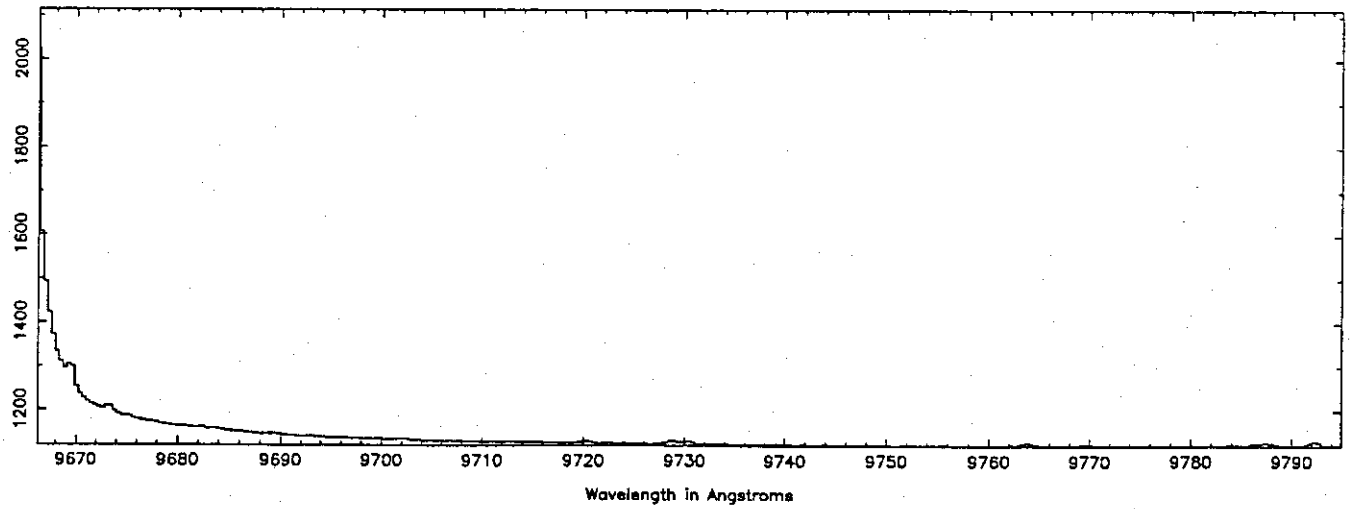

9148.68
9201.76
9226.67
2×10⁴
1.5×10⁴
10⁴
5000
9140
9150
9160
9170
9180
9190
9200
9210
9220
9230
9240
9250
9260
Wavelength in Angstroms


9325.52
9300.85
9313.98
9275.53
9287.56
9373.28
10⁴
5000
9270
9280
9290
9300
9310
9320
9330
9340
9350
9360
9370
9380
9390
Wavelength in Angstroms

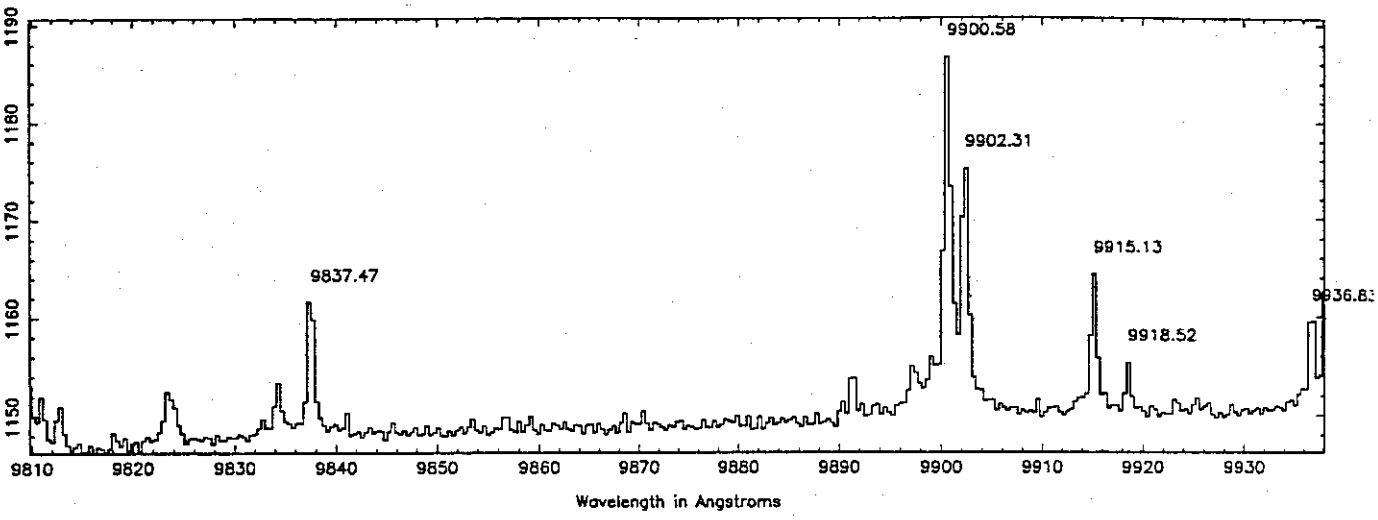
Cu–Ne (1200)

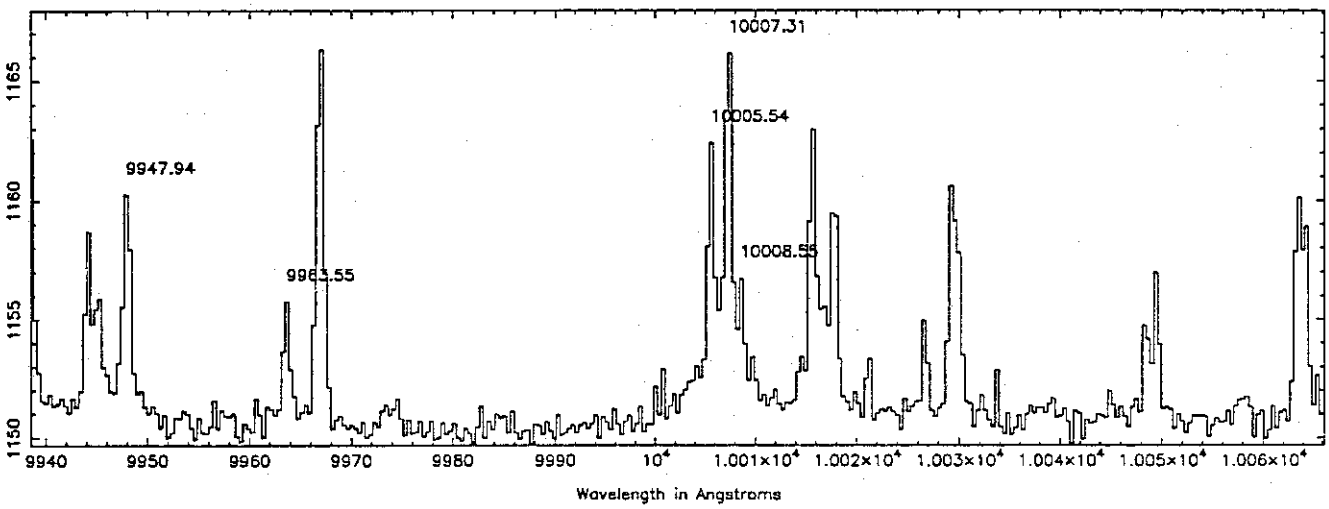

9486.68
9425.38
9459.21
9534.167
Wavelength in Angstroms

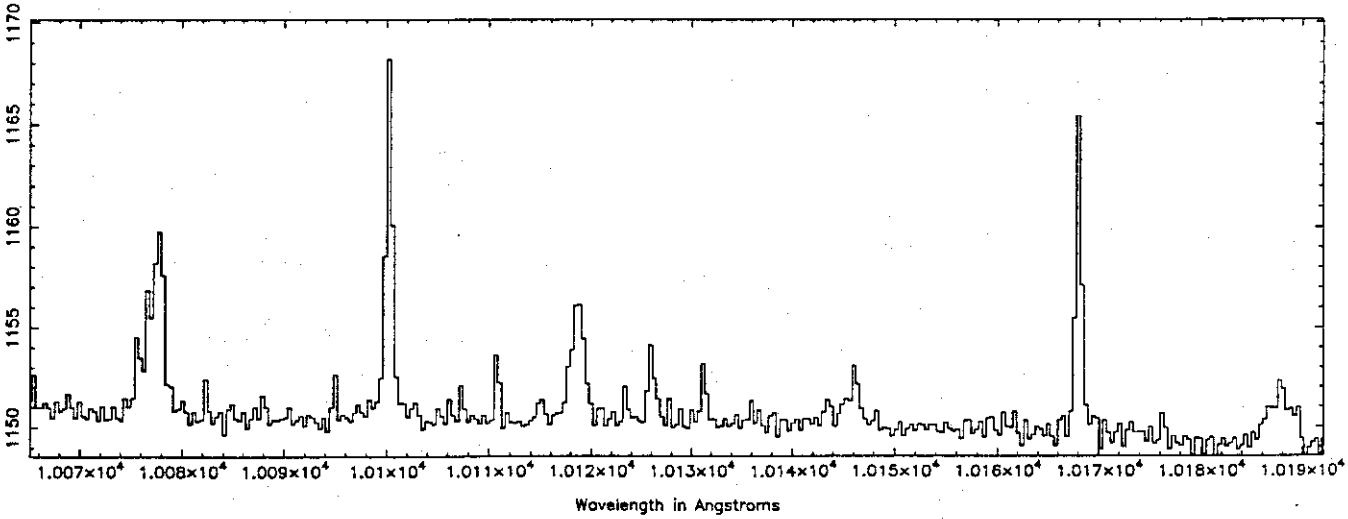

9547.4
9577.01
Wavelength in Angstroms


Wavelength in Angstroms

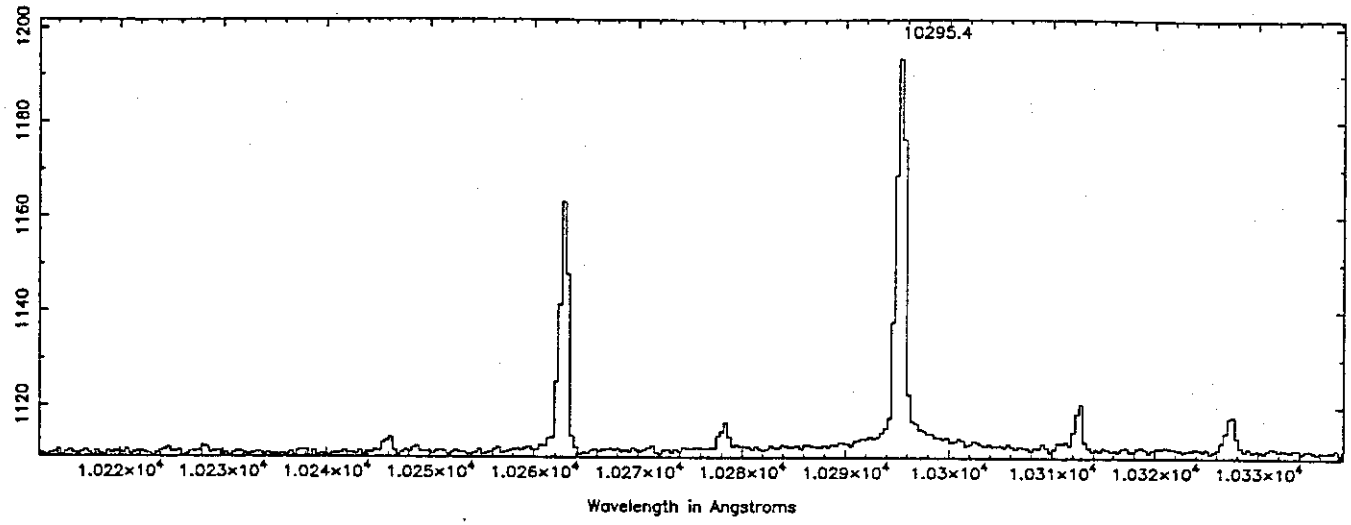
Cu–Ne (1200)

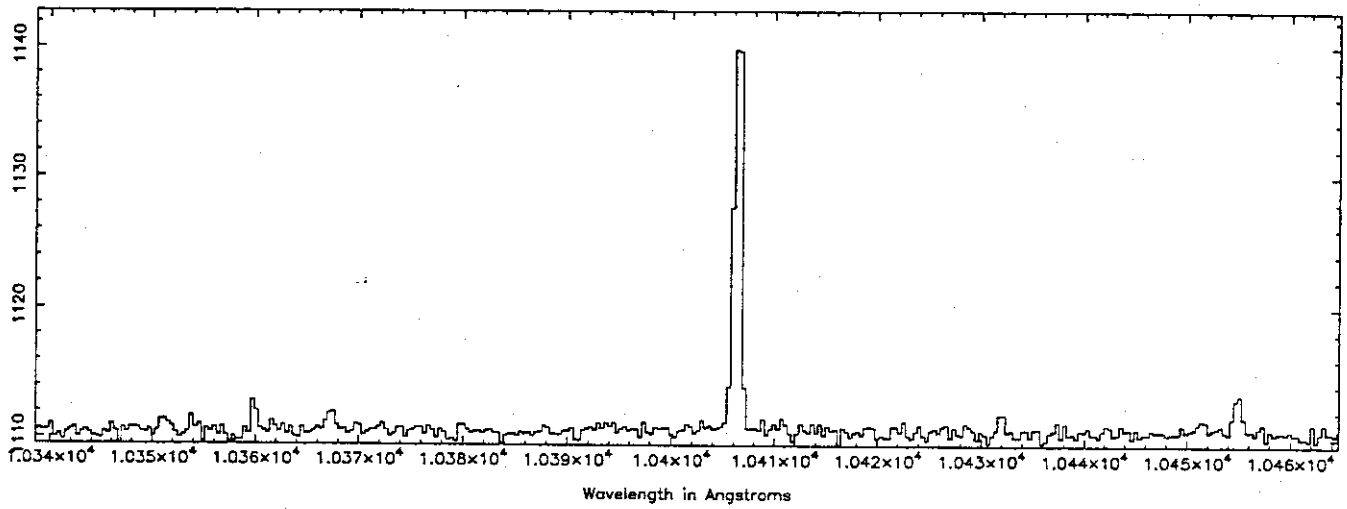

9900.58
9902.31
9915.13
9837.47
9918.52
9936.83
Wavelength in Angstroms

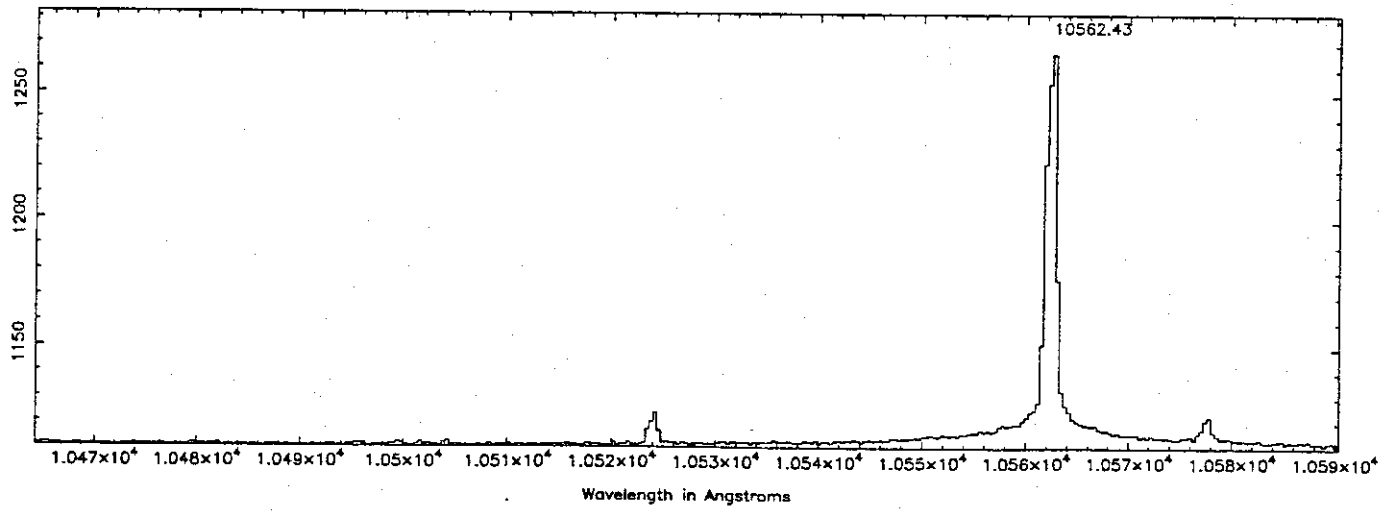

10007.31
10005.54
9947.94
10008.55
9963.55
Wavelength in Angstroms


Wavelength in Angstroms

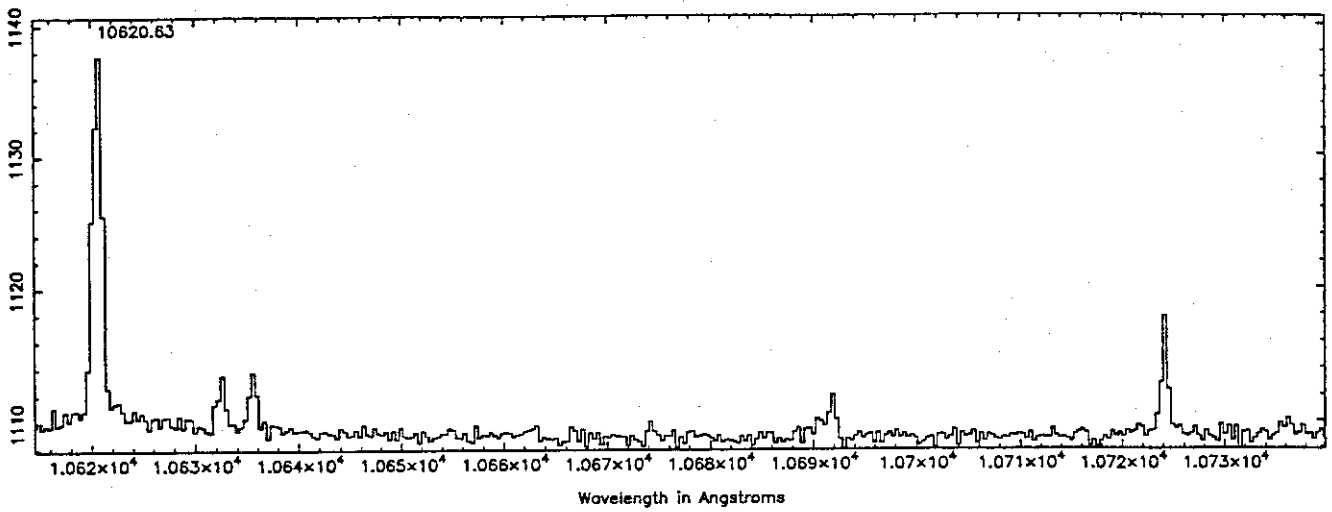
Cu–Ne (1200)

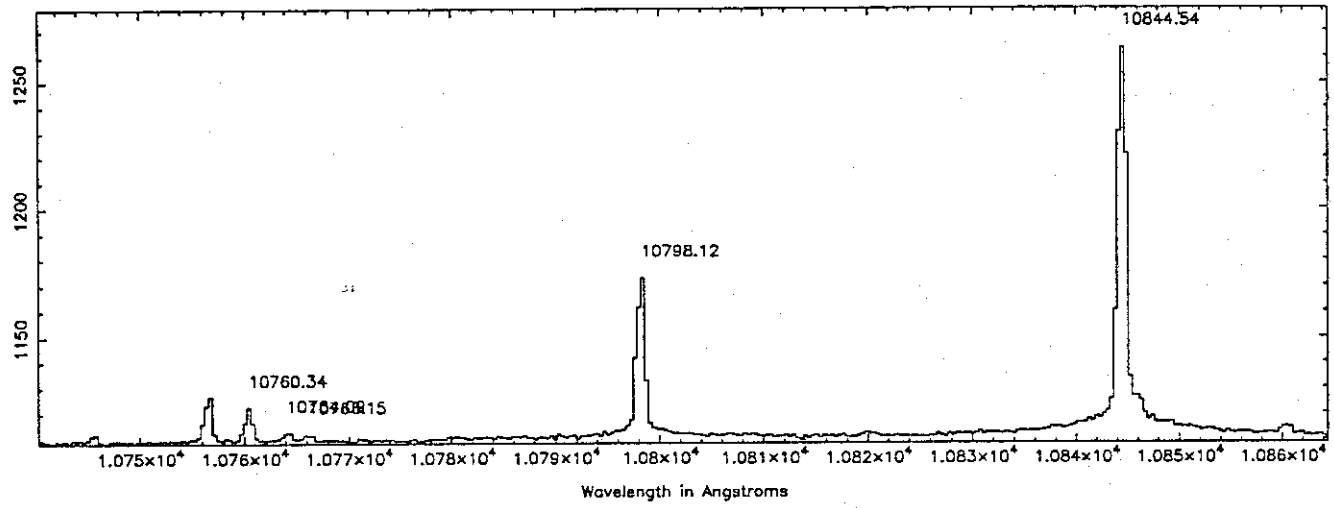

10295.4
1200
1180
1160
1140
1120
1.022×10⁴ 1.023×10⁴ 1.024×10⁴ 1.025×10⁴ 1.026×10⁴ 1.027×10⁴ 1.028×10⁴ 1.029×10⁴ 1.03×10⁴ 1.031×10⁴ 1.032×10⁴ 1.033×10⁴
Wavelength in Angstroms

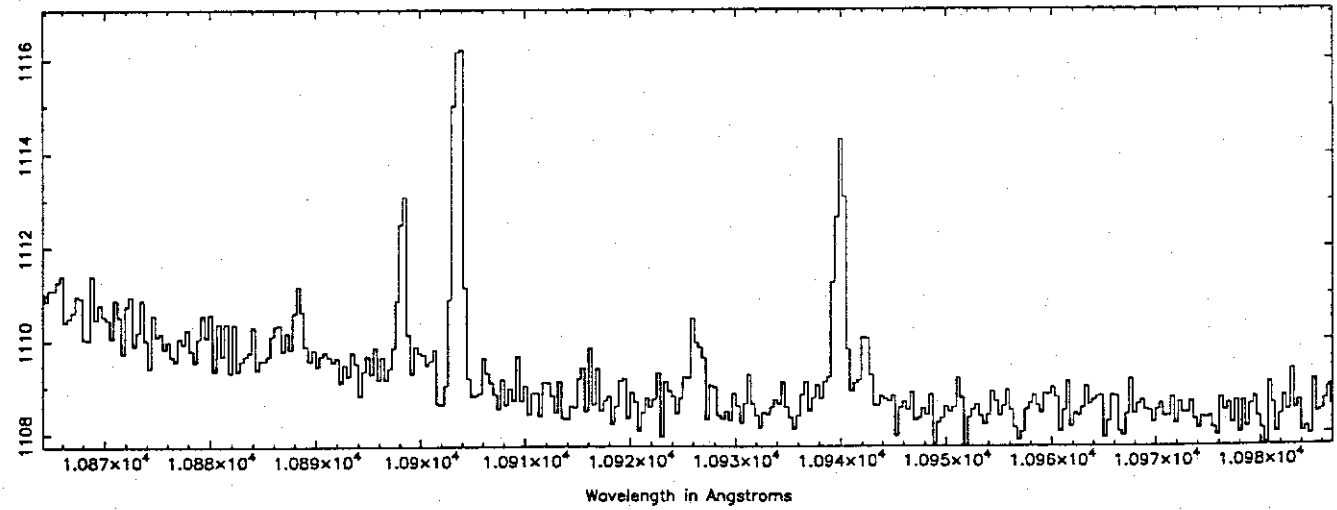

1140
1130
1120
110
1.034×10⁴ 1.035×10⁴ 1.036×10⁴ 1.037×10⁴ 1.038×10⁴ 1.039×10⁴ 1.04×10⁴ 1.041×10⁴ 1.042×10⁴ 1.043×10⁴ 1.044×10⁴ 1.045×10⁴ 1.046×10⁴
Wavelength in Angstroms


10562.43
1250
1200
1150
1.047×10⁴ 1.048×10⁴ 1.049×10⁴ 1.05×10⁴ 1.051×10⁴ 1.052×10⁴ 1.053×10⁴ 1.054×10⁴ 1.055×10⁴ 1.056×10⁴ 1.057×10⁴ 1.058×10⁴ 1.059×10⁴
Wavelength in Angstroms

Cu–Ne (1200)


10620.63
1140
1130
1120
1110
1.062×10⁴ 1.063×10⁴ 1.064×10⁴ 1.065×10⁴ 1.066×10⁴ 1.067×10⁴ 1.068×10⁴ 1.069×10⁴ 1.07×10⁴ 1.071×10⁴ 1.072×10⁴ 1.073×10⁴
Wavelength in Angstroms

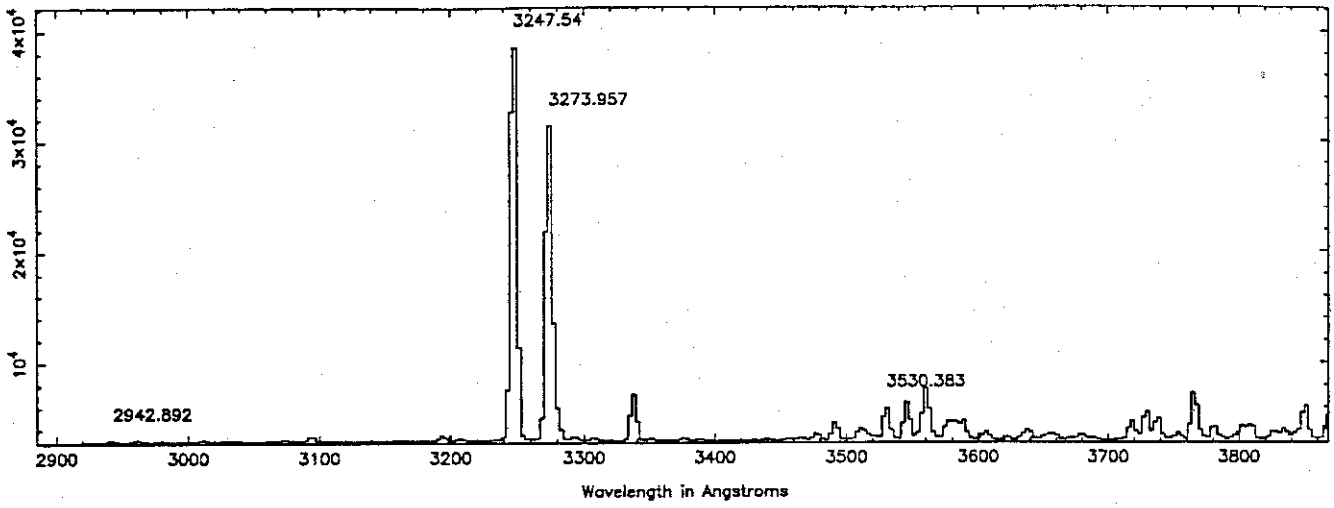

10844.54
10798.12
10760.34
1250
1200
1150
1.075×10⁴ 1.076×10⁴ 1.077×10⁴ 1.078×10⁴ 1.079×10⁴ 1.08×10⁴ 1.081×10⁴ 1.082×10⁴ 1.083×10⁴ 1.084×10⁴ 1.085×10⁴ 1.086×10⁴
Wavelength in Angstroms

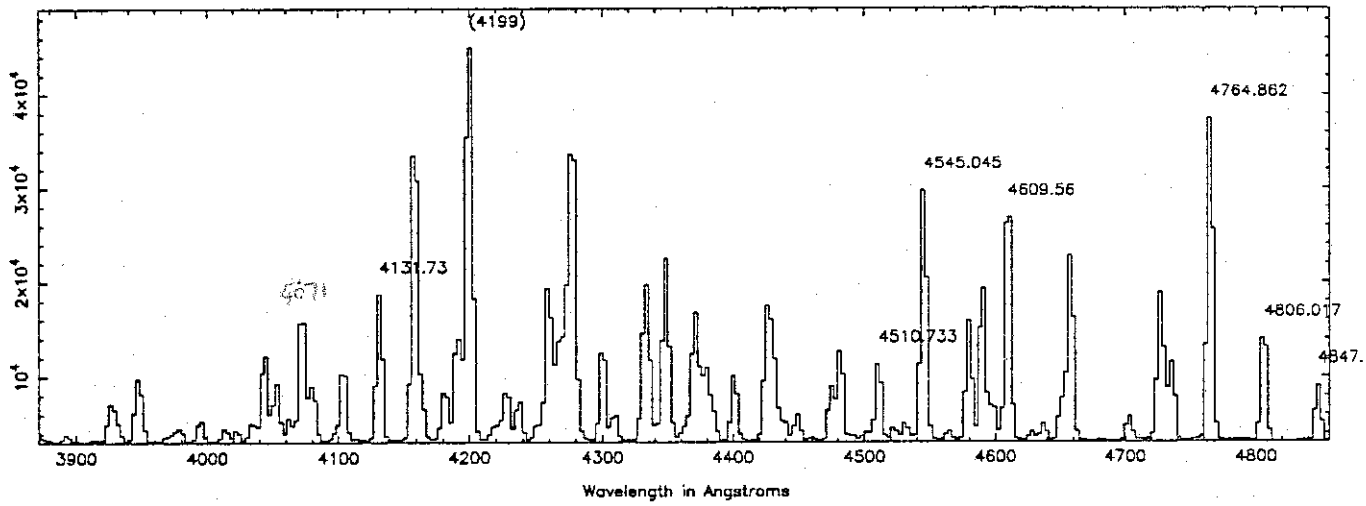

1116
1114
1112
1110
1108
1.087×10⁴ 1.088×10⁴ 1.089×10⁴ 1.09×10⁴ 1.091×10⁴ 1.092×10⁴ 1.093×10⁴ 1.094×10⁴ 1.095×10⁴ 1.096×10⁴ 1.097×10⁴ 1.098×10⁴
Wavelength in Angstroms

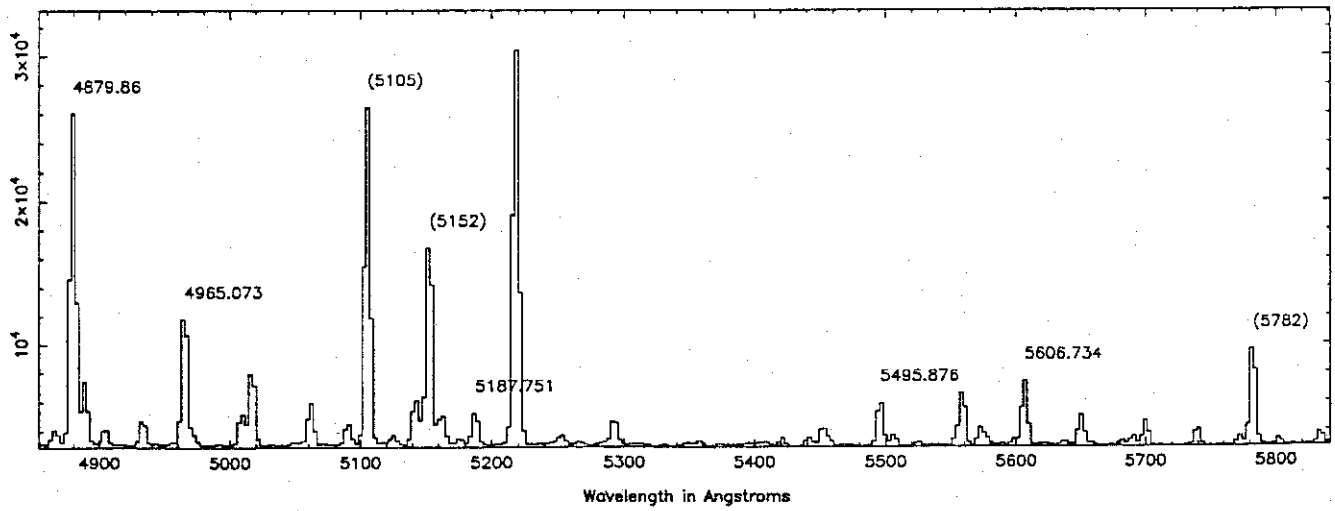
Copper Argon lines: 158 line Grating

2942.892	Ar II	20	8006.157	Ar I	600
2979.051	Ar II	15	8014.785	Ar I	800
3093.403	Ar II	10	8103.692	Ar I	2000
3093.989	Cu I	1500	8115.311	Ar I	5000
3194.229	Ar II	9	8264.522	Ar I	1500
3247.540	Cu I	10000	8408.209	Ar I	3000
3273.957	Cu I	10000	8424.647	Ar I	2500
3530.383	Cu I	2000	8521.443	Ar I	2000
3718.208	Ar II	12	8605.779	Ar I	150
3729.310	Ar II	30	8667.944	Ar I	400
4131.730	Ar II	15	8761.691	Ar I	200
4158.590	Ar I	1200	8849.97	Ar I	150
4198.318	Ar I	1200	9122.966	Ar I	500
4200.675	Ar I	1200	9224.495	Ar I	1000
4510.733	Ar I	1000	9354.218	Ar I	200
4545.045	Ar II	25	9459.09	Ar I	100
4579.346	Ar II	25	9657.784	Ar I	1500
4589.896	Ar II	25	9784.501	Ar I	1000
4609.560	Ar II	25	10052.10	Ar I	150
4657.893	Ar II	25	10470.051	Ar I	500
4764.862	Ar II	25	10673.55	Ar I	500
4806.017	Ar II	35	10681.78	Ar I	200
4847.815	Ar II	25			
4879.860	Ar II	30			
4965.073	Ar II	25			
5104.74	Ar I	20			
5105.541	Cu I	1500			
5151.394	Ar I	200			
5153.235	Cu I	2000			
5187.751	Ar I	800			
5495.876	Ar I	1000			
5558.703	Ar I	500			
5559.62	Ar I	200			
5606.734	Ar I	500			
5782.132	Cu I	1500			
5783.541	Ar I	40			
5888.585	Ar I	300			
5912.086	Ar I	500			
6032.129	Ar I	60			
6043.225	Ar I	100			
6114.929	Ar II	50			
6172.290	Ar II	40			
6173.098	Ar I	100			
6384.719	Ar I	100			
6416.307	Ar I	100			
6677.281	Ar I	30			
6752.835	Ar I	100			
6871.290	Ar I	150			
6965.430	Ar I	400			
7030.252	Ar I	100			
7067.217	Ar I	400			
7147.041	Ar I	30			
7272.935	Ar I	100			
7383.980	Ar I	400			
7503.868	Ar I	700			
7514.651	Ar I	200			
7635.106	Ar I	500			
7723.760	Ar I	200			
7724.206	Ar I	200			
7948.175	Ar I	400			

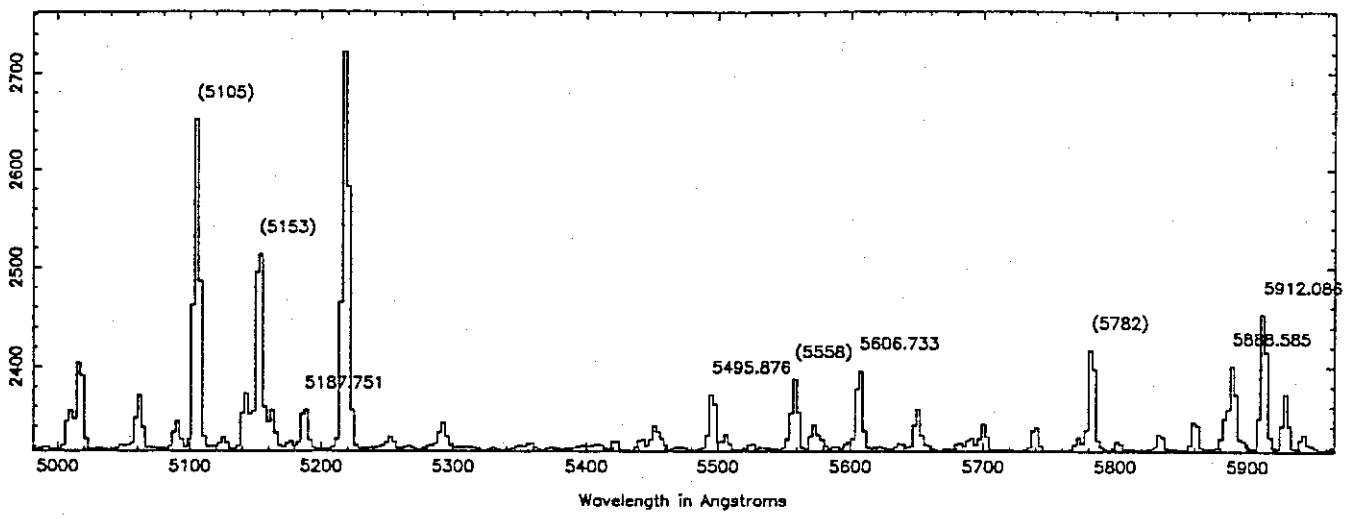
Cu–Ar (158)

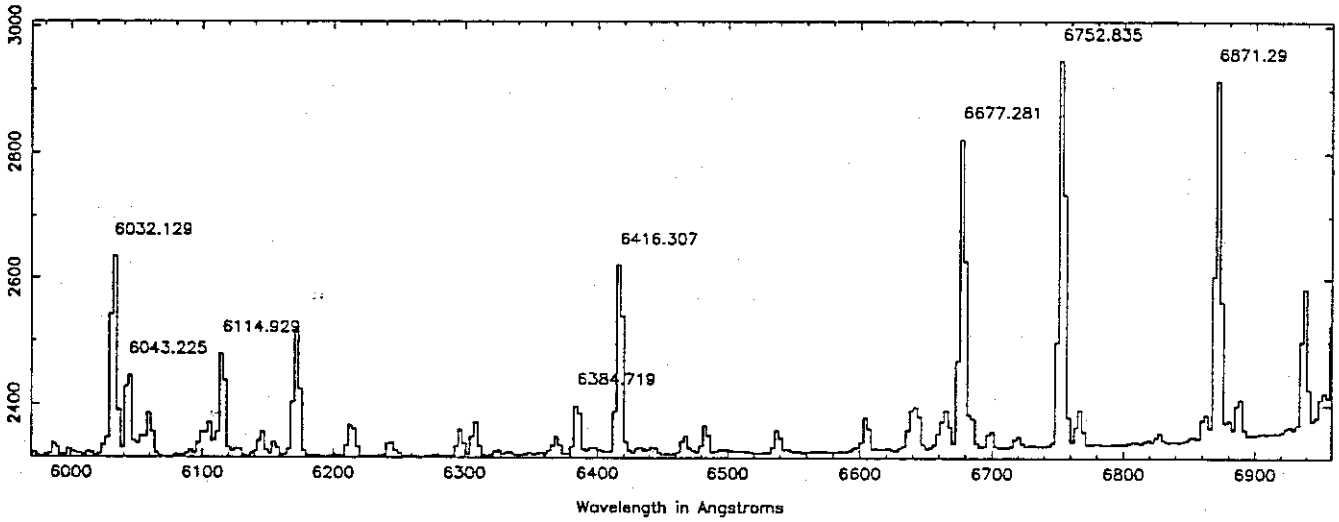

3247.54
3273.957
3530.383
2942.892
Wavelength in Angstroms

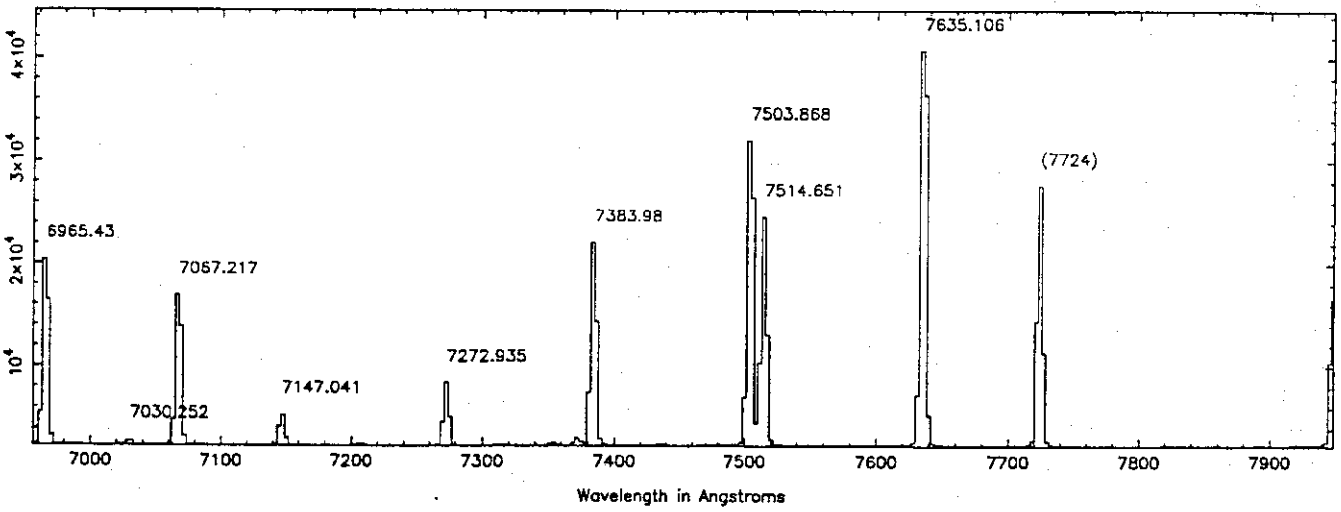

(4199)
4764.862
4545.045
4609.56
4131.73
4510.733
4806.017
Wavelength in Angstroms


4879.86
(5105)
(5152)
4965.073
5187.751
5495.876
5606.734
(5782)
Wavelength in Angstroms

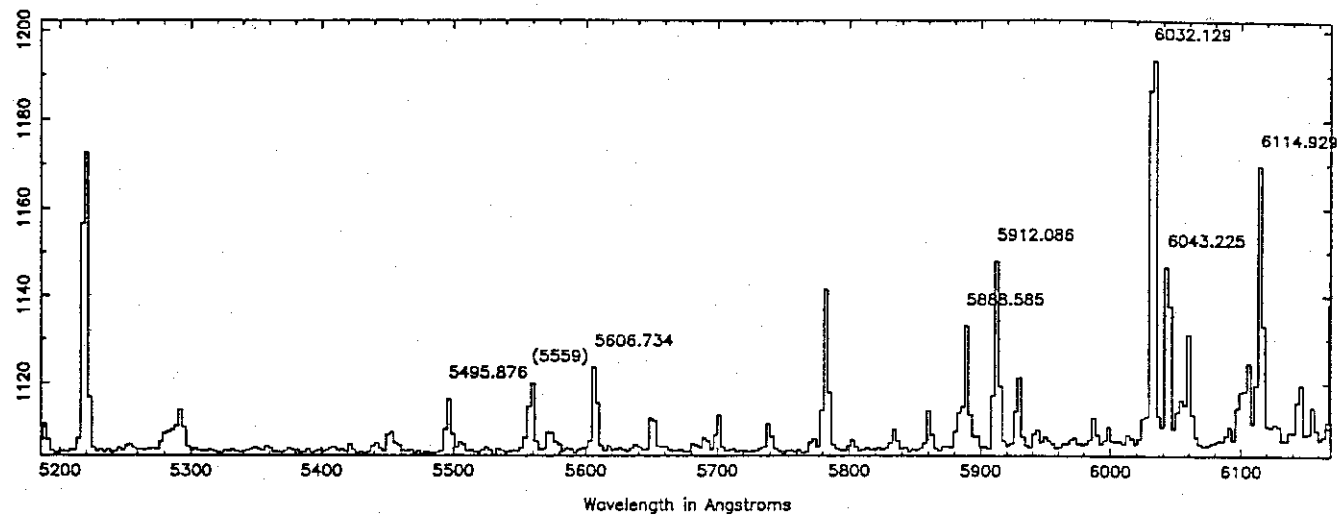
Cu–Ar (158)

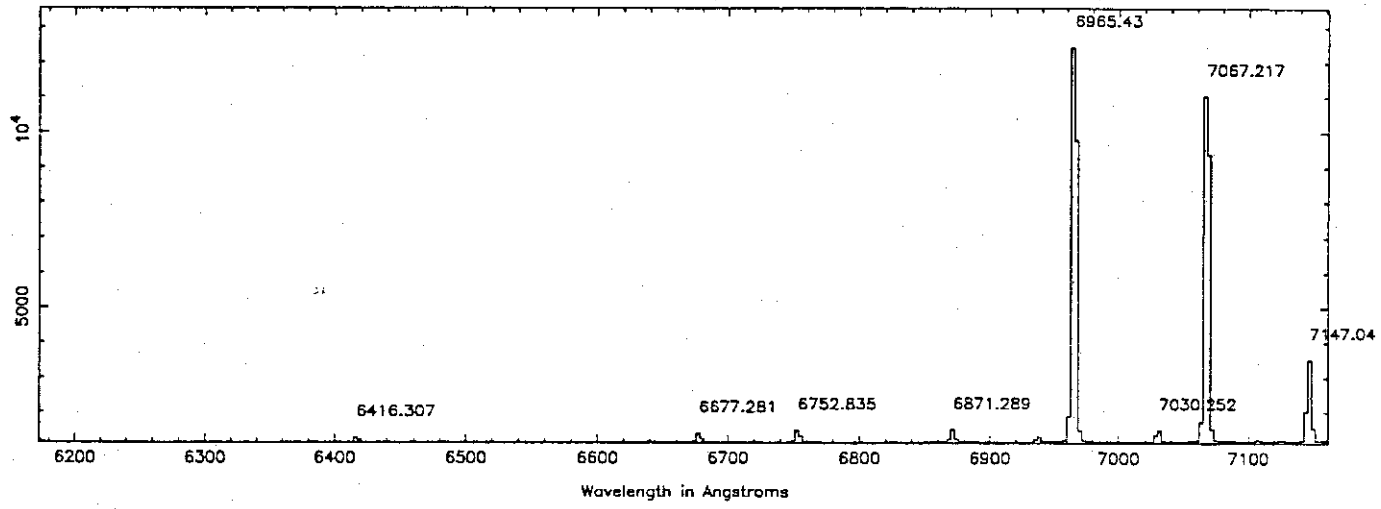

(5105)
(5153)
5187.751
5495.876
(5558)
5606.733
(5782)
5912.086
5888.585
Wavelength in Angstroms

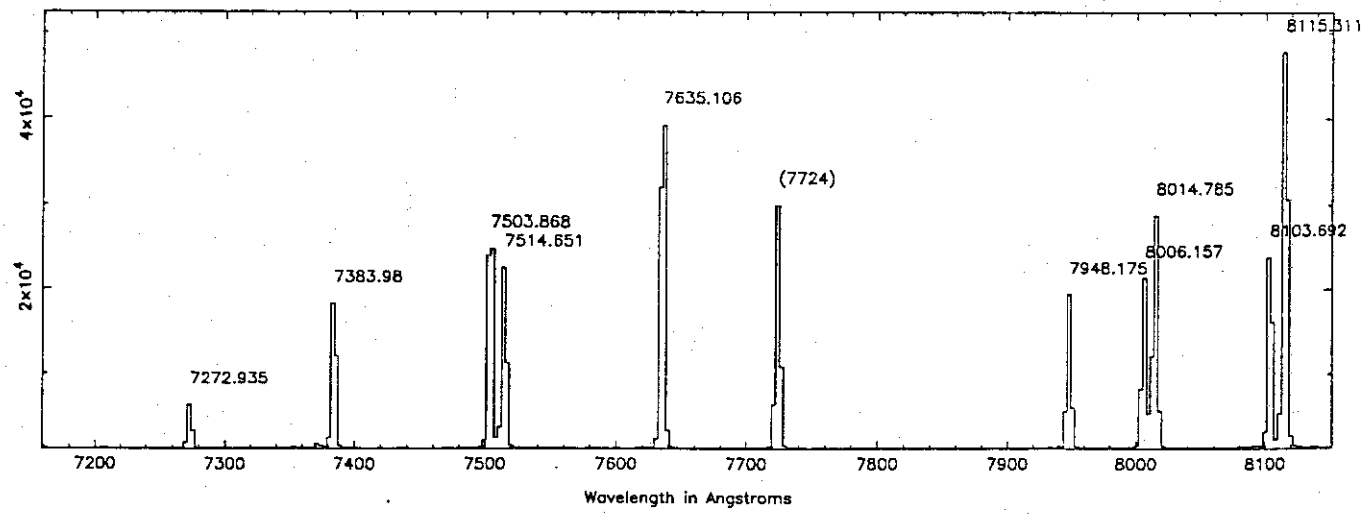

6032.129
6043.225
6114.929
6384.719
6416.307
6677.281
6752.835
6871.29
Wavelength in Angstroms


6965.43
7067.217
7030.252
7147.041
7272.935
7383.98
7503.868
7514.651
7635.106
(7724)
Wavelength in Angstroms

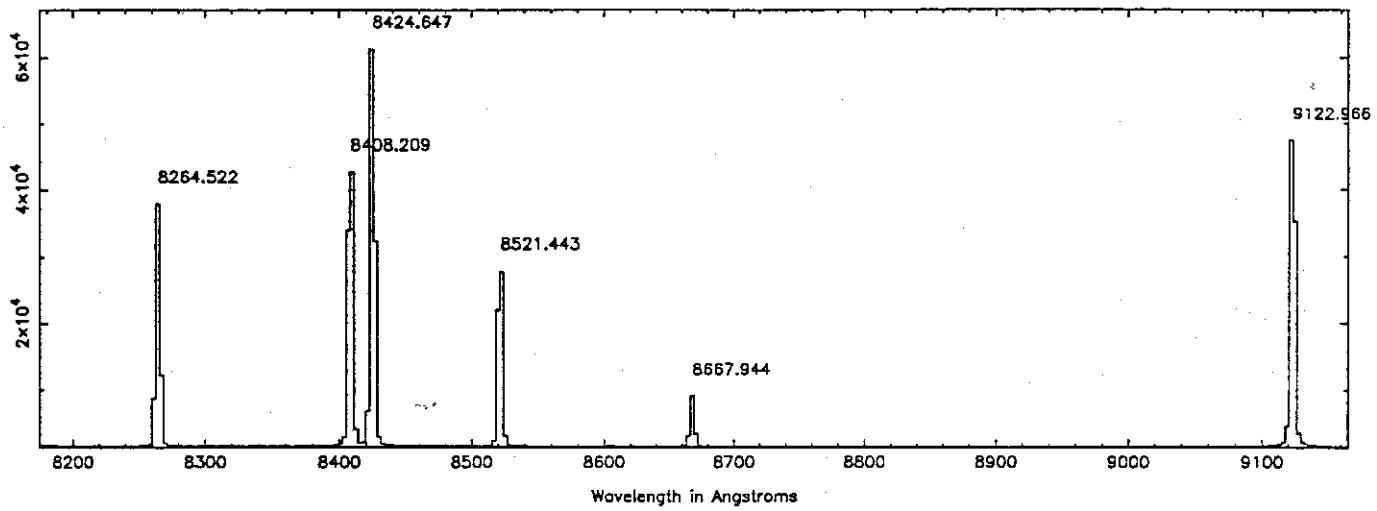
Cu–Ar (158)

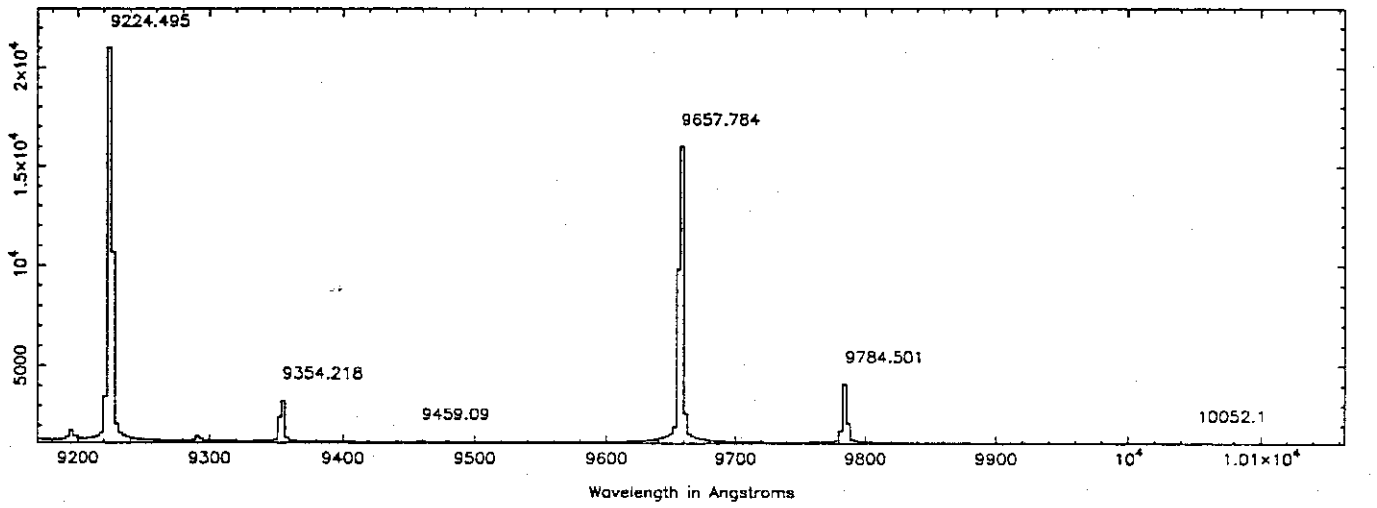

6032.129
6114.929
5912.086
6043.225
5888.585
5606.734
(5559)
5495.876
1200
1180
1160
1140
1120
5200
5300
5400
5500
5600
5700
5800
5900
6000
6100
Wavelength in Angstroms

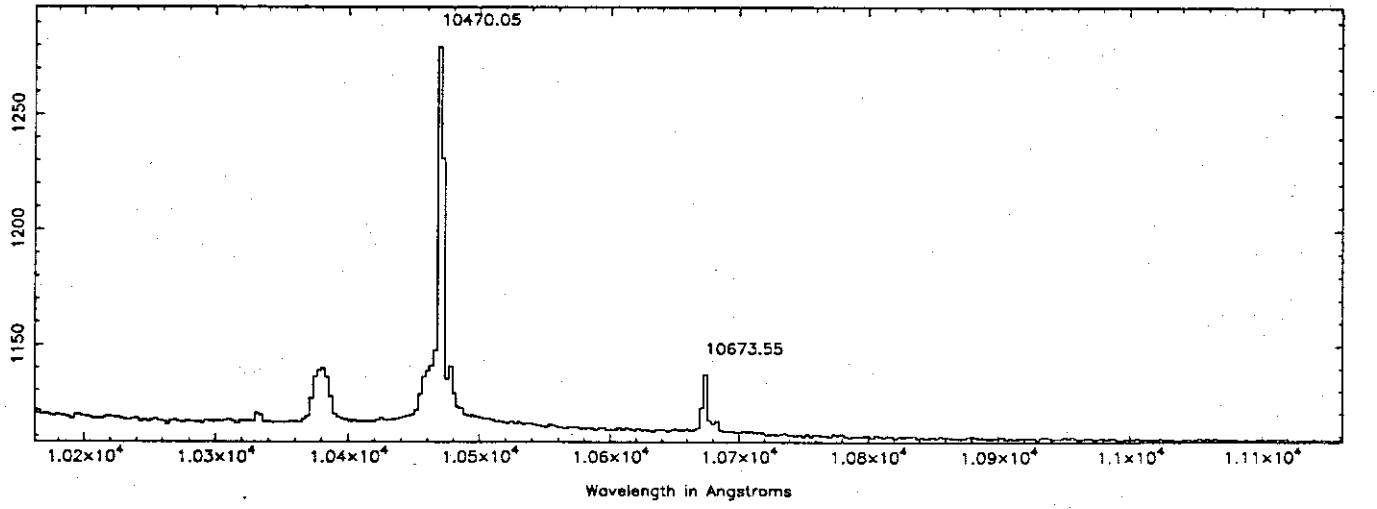

6965.43
7067.217
7147.04
6416.307
6677.281
6752.835
6871.289
7030.252
10⁴
5000
6200
6300
6400
6500
6600
6700
6800
6900
7000
7100
Wavelength in Angstroms


8115.311
7635.106
(7724)
8014.785
8103.692
8006.157
7948.175
7503.868
7514.651
7383.98
7272.935
4x10⁴
2x10⁴
7200
7300
7400
7500
7600
7700
7800
7900
8000
8100
Wavelength in Angstroms

Cu–Ar (158)


8424.647
8408.209
8264.522
8521.443
8667.944
9122.966
6×10⁴
4×10⁴
2×10⁴
8200
8300
8400
8500
8600
8700
8800
8900
9000
9100
Wavelength in Angstroms


9224.495
9657.784
9354.218
9459.09
9784.501
10052.1
2×10⁴
1.5×10⁴
10⁴
5000
9200
9300
9400
9500
9600
9700
9800
9900
10⁴
1.01×10⁴
Wavelength in Angstroms

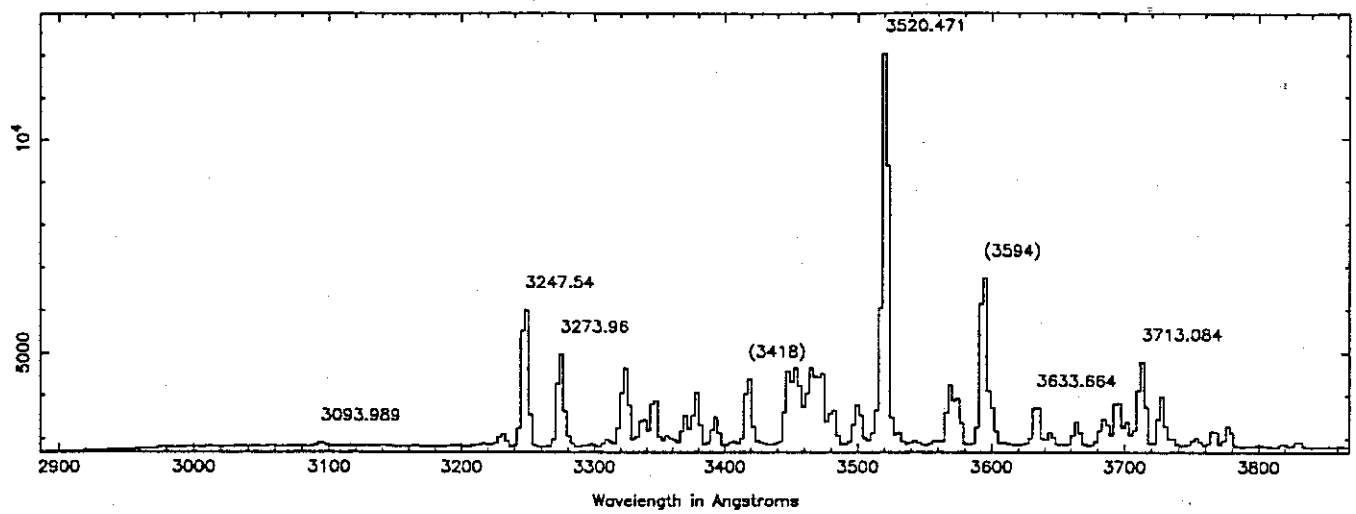

10470.05
10673.55
1250
1200
1150
1.02×10⁴
1.03×10⁴
1.04×10⁴
1.05×10⁴
1.06×10⁴
1.07×10⁴
1.08×10⁴
1.09×10⁴
1.1×10⁴
1.11×10⁴
Wavelength in Angstroms

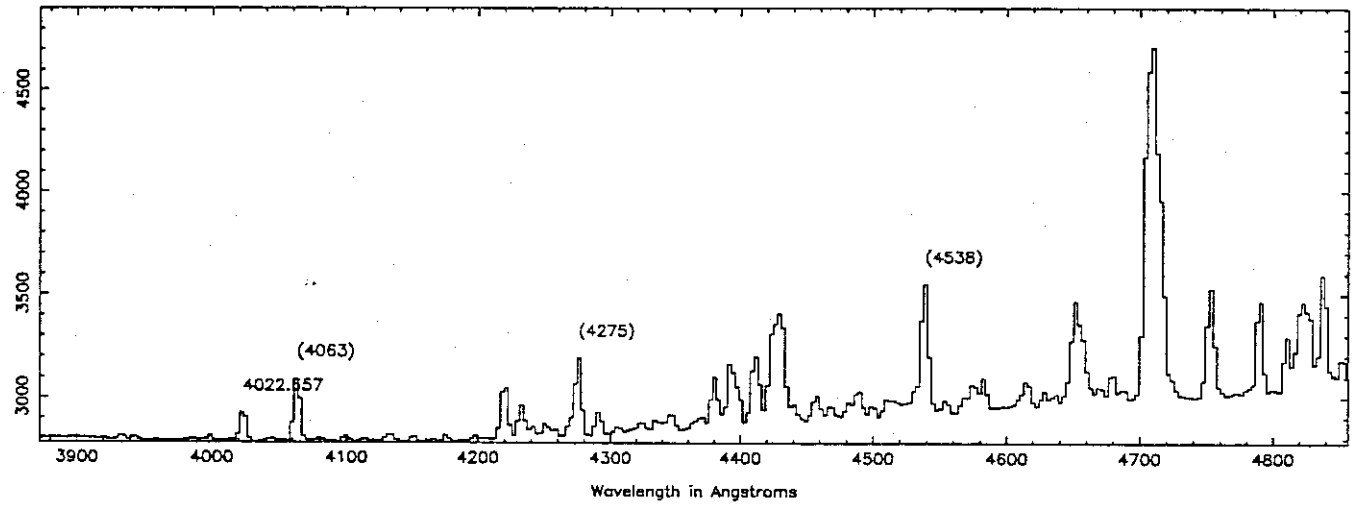
Copper Neon lines: 158 line Grating

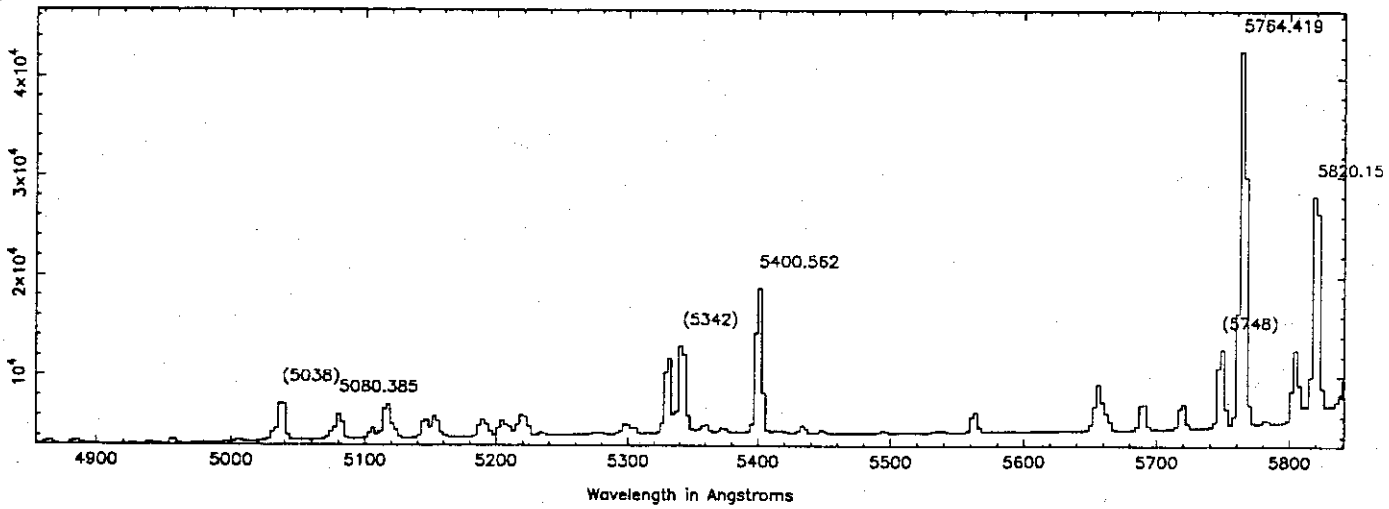
3093.989	Cu	I	1500	5748.650	Ne	I	70	9220.05	Ne	I	400
3247.540	Cu	I	10000	5764.419	Ne	I	700	9221.59	Ne	I	200
3273.957	Cu	I	10000	5820.156	Ne	I	500	9221.88	Ne	I	150
3417.71	Ne	II	5	5852.488	Ne	I	2000	9275.53	Ne	I	100
3417.903	Ne	I	500	5881.895	Ne	I	1000	9287.56	Ne	II	200 *
3418.007	Ne	I	50	5944.834	Ne	I	500	9300.85	Ne	I	600
3520.471	Ne	I	1000	5975.534	Ne	I	600	9313.98	Ne	I	300
3593.526	Ne	I	500	6029.997	Ne	I	1000	9326.52	Ne	I	600
3593.640	Ne	I	300	6074.338	Ne	I	1000	9373.28	Ne	I	200
3594.18	Ne	II	4	6096.163	Ne	I	300	9425.38	Ne	I	500
3633.664	Ne	I	100	6143.062	Ne	I	1000	9459.21	Ne	I	300
3713.084	Ne	II	10	6163.594	Ne	I	1000	9486.68	Ne	I	500
4022.629	Cu	I	1250	6217.281	Ne	I	1000	9534.167	Ne	I	500
4062.641	Cu	I	2000	6266.495	Ne	I	1000	9547.40	Ne	I	300
4062.90	Ne	II	3	6304.789	Ne	I	100	9577.01	Ne	II	120 *
4274.656	Ne	I	50	6334.428	Ne	I	1000	9665.424	Ne	I	1000
4275.560	Ne	I	70	6382.991	Ne	I	1000	9808.86	Ne	II	100 *
4421.38	Ne	II	3	6402.246	Ne	I	2000	10295.40	Ne	I	80
4421.559	Ne	I	50	6506.528	Ne	I	100	10562.43	Ne	I	200
4422.520	Ne	I	300	6532.882	Ne	I	100	10798.12	Ne	I	150
4424.810	Ne	I	300	6598.953	Ne	I	1000	10844.54	Ne	I	200
4425.400	Ne	I	150	6678.276	Ne	I	500	11143.09	Ne	I	300
4428.54	Ne	II	6	6717.043	Ne	I	70				
4429.60	Ne	II	2	6929.467	Ne	I	1000				
4430.90	Ne	II	4	7032.413	Ne	I	1000				
4536.312	Ne	I	150	7173.938	Ne	I	1000				
4537.683	Ne	I	300	7245.167	Ne	I	1000				
4537.754	Ne	I	1000	7438.898	Ne	I	300				
4538.293	Ne	I	300	7488.871	Ne	I	500				
4708.862	Ne	I	1200	7535.774	Ne	I	300				
4712.067	Ne	I	1000	7544.044	Ne	I	100				
4712.135	Ne	I	15	7724.628	Ne	I	10				
4714.336	Ne	I	70	7839.055	Ne	I	30				
4715.132	Ne	I	30	7943.181	Ne	I	200				
4715.246	Ne	I	30	8082.458	Ne	I	200				
4715.347	Ne	I	1500	8118.549	Ne	I	100				
4717.608	Ne	I	70	8136.406	Ne	I	300				
4749.575	Ne	I	300	8300.325	Ne	I	600				
4750.686	Ne	I	30	8376.41	Ne	I	200				
4751.802	Ne	I	30	8377.606	Ne	I	800				
4752.732	Ne	I	500	8418.426	Ne	I	400				
4788.927	Ne	I	1000	8495.359	Ne	I	500				
4790.218	Ne	I	500	8591.258	Ne	I	400				
4790.728	Ne	I	30	8634.647	Ne	I	600				
5037.751	Ne	I	500	8654.384	Ne	I	1500				
5116.503	Ne	I	150	8655.521	Ne	I	400				
5117.011	Ne	I	35	8679.490	Ne	I	500				
5330.777	Ne	I	600	8780.622	Ne	I	1200				
5333.323	Ne	I	50	8853.867	Ne	I	700				
5341.094	Ne	I	1000	8865.306	Ne	I	100				
5343.283	Ne	I	600	8865.756	Ne	I	500				
5400.562	Ne	I	2000	8919.499	Ne	I	300				
5562.441	Ne	I	150	8988.58	Ne	I	200				
5562.766	Ne	I	500	9148.68	Ne	I	600				
5563.047	Ne	I	75	9201.76	Ne	I	600				

* Wavelength and strength from Line Spectra of the Elements

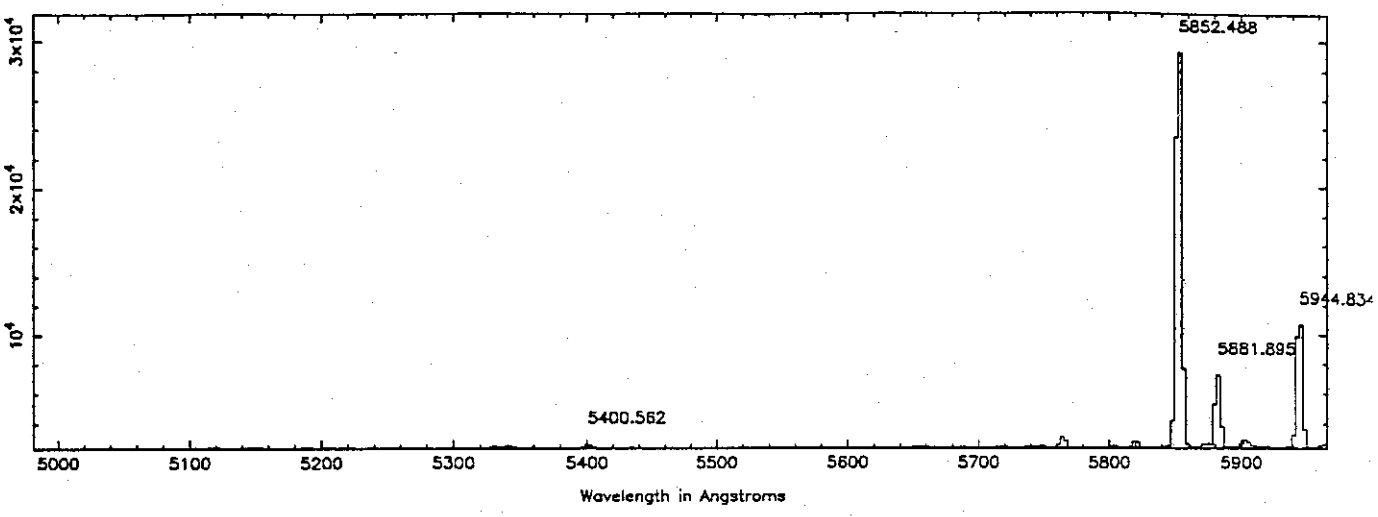
Cu–Ne (158)

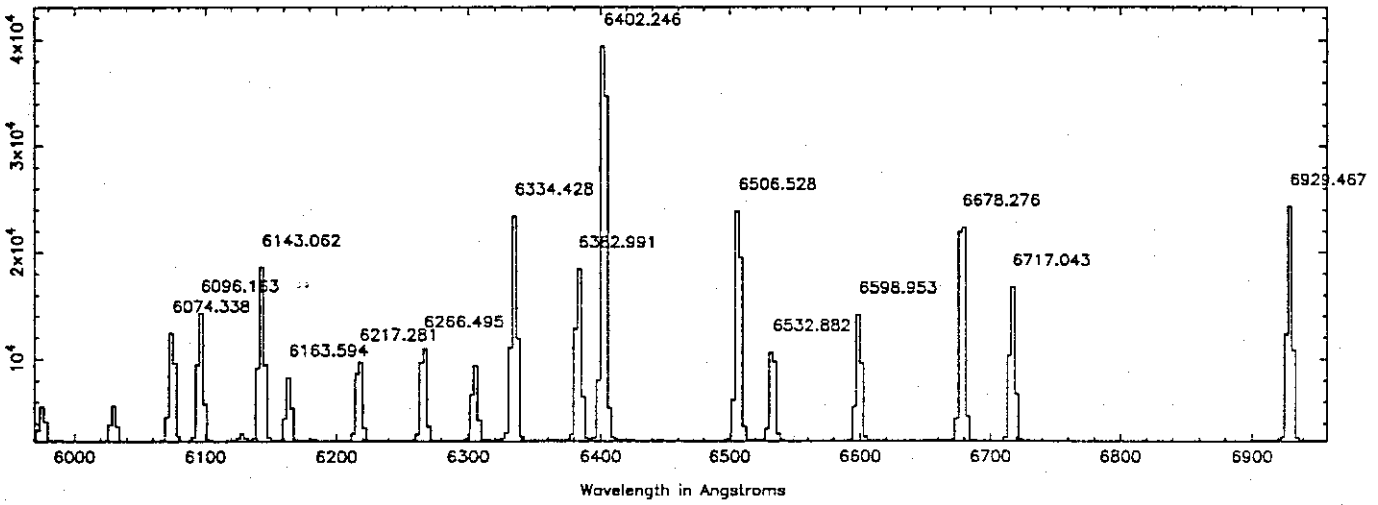

3520.471
(3594)
3247.54
3273.96
(3418)
3713.084
3633.664
3093.989
Wavelength in Angstroms

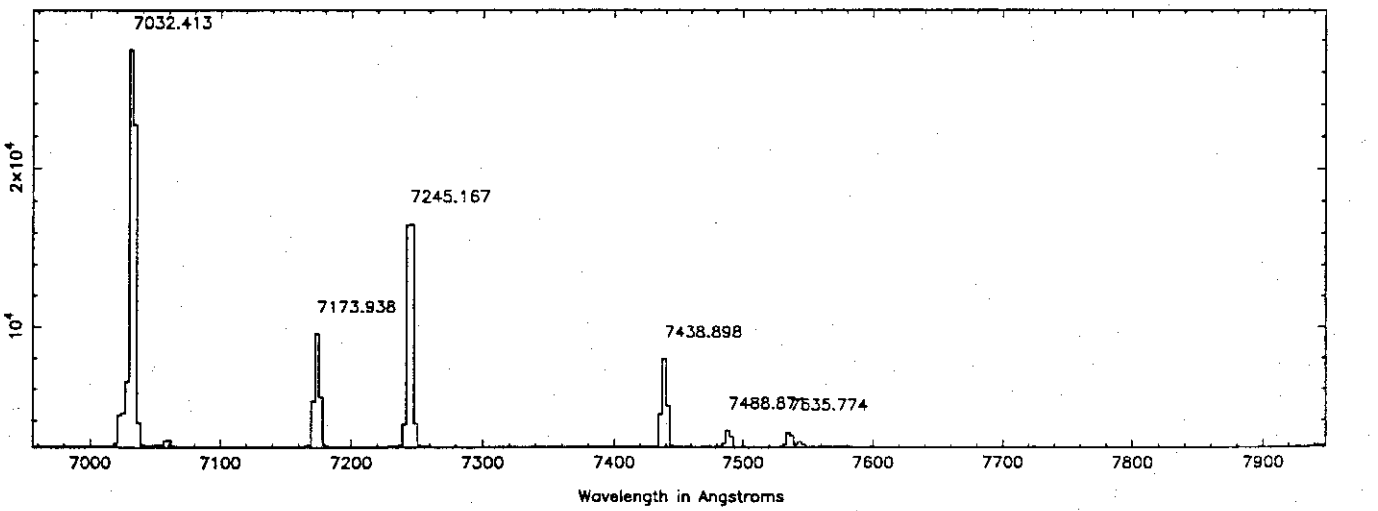

(4538)
(4275)
(4063)
4022.857
Wavelength in Angstroms

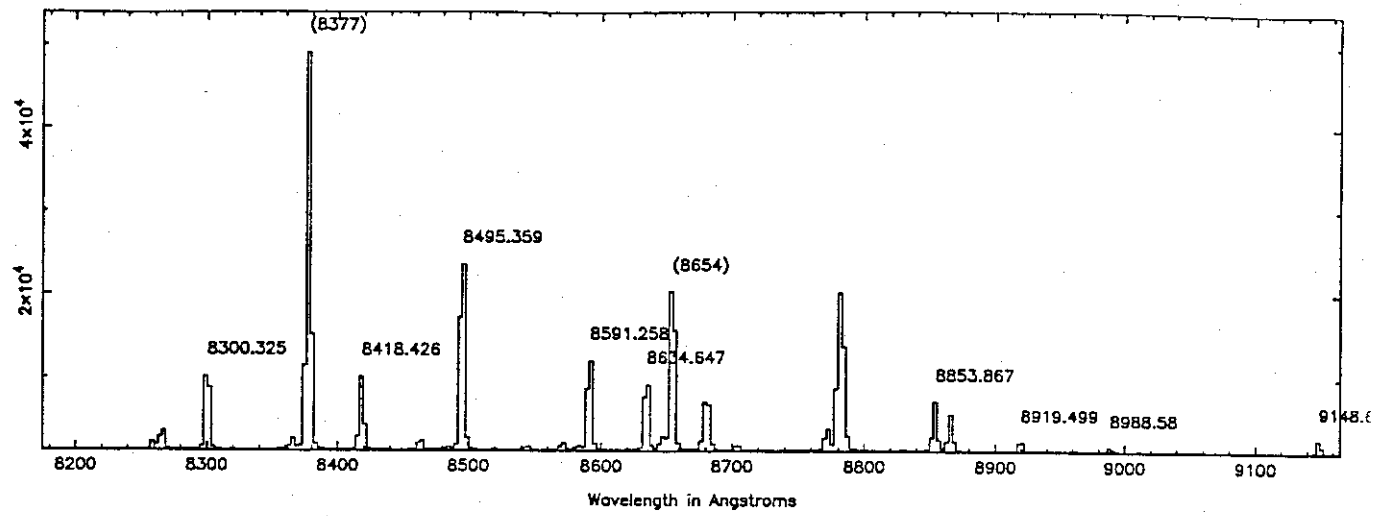

5764.419
5820.15
5400.552
(5342)
(5038)
5080.385
Wavelength in Angstroms

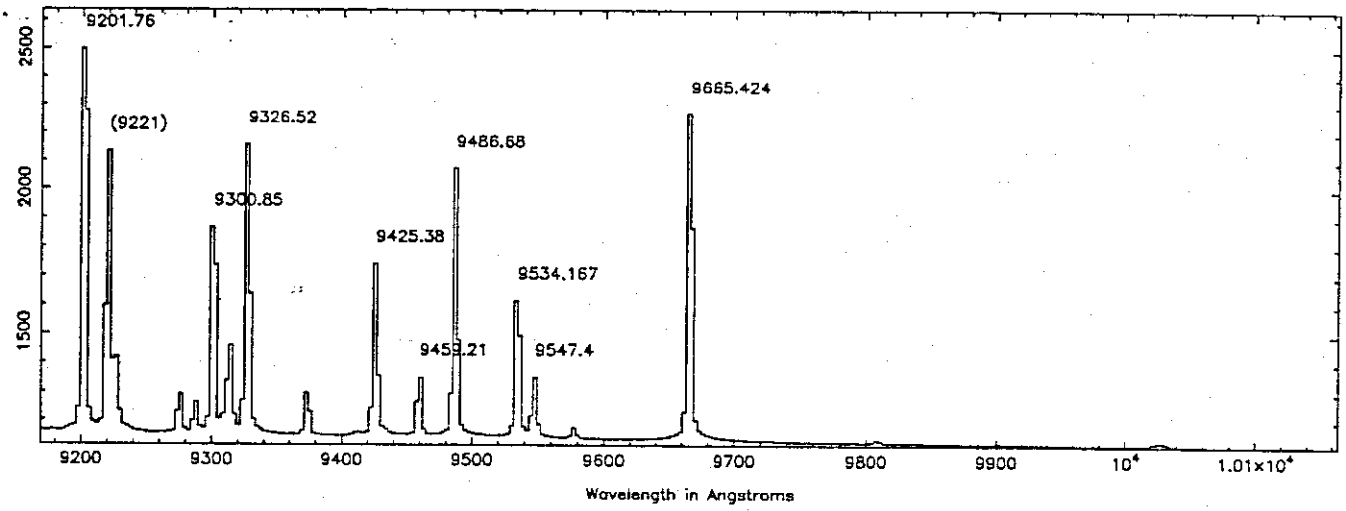
Cu–Ne (158)

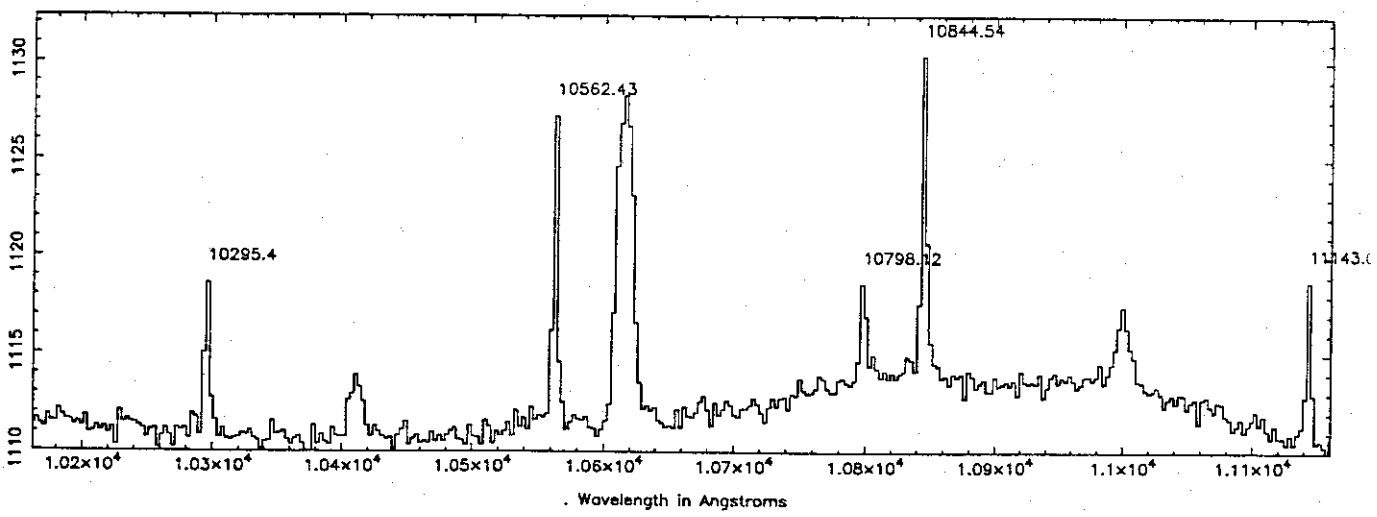

5852.488
5944.834
5881.895
5400.562
Wavelength in Angstroms


6402.246
6334.428
6506.528
6678.276
6929.467
6143.062
6362.991
6717.043
6096.153
6074.338
6598.953
6266.495
6217.281
6532.882
6163.594
Wavelength in Angstroms

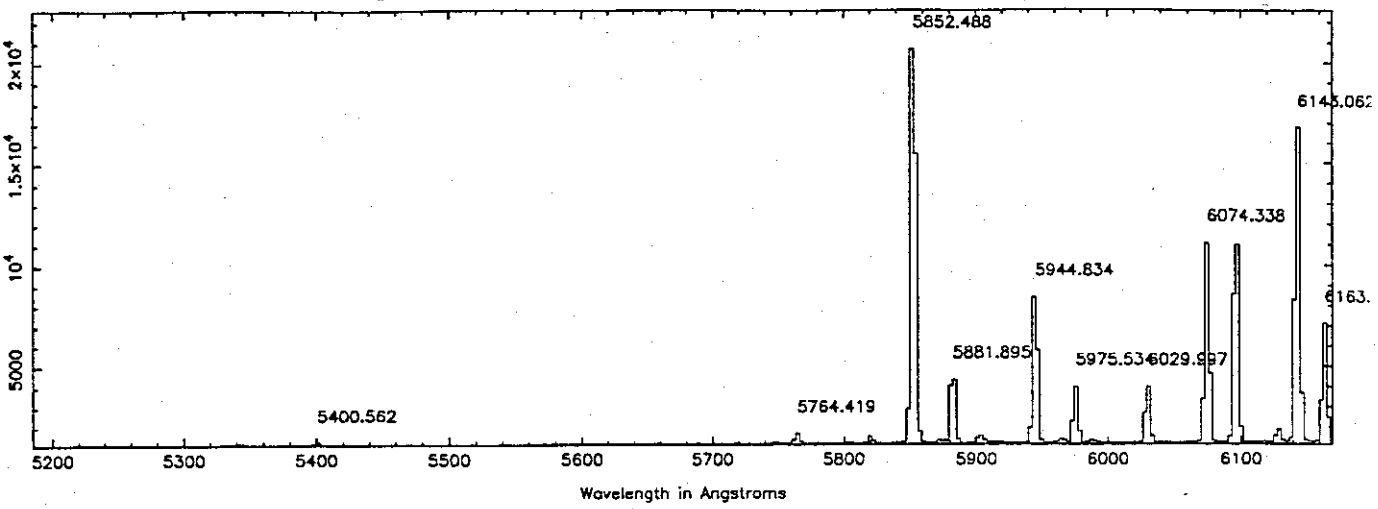

7032.413
7245.167
7173.938
7438.898
7488.87
7635.774
Wavelength in Angstroms

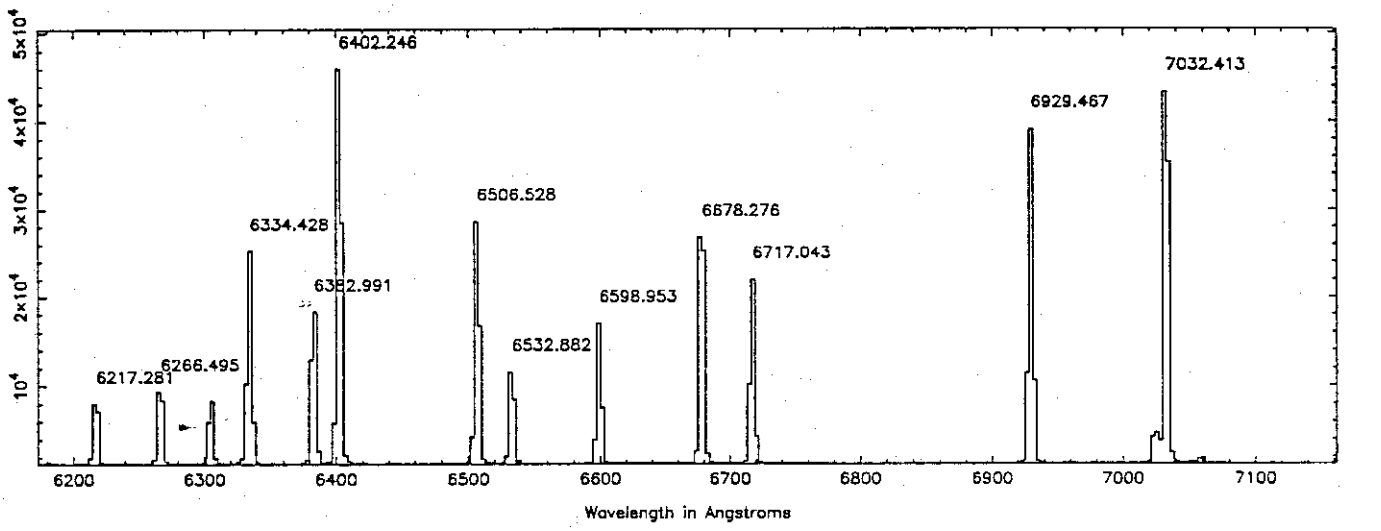

(8377)
8495.359
(8654)
8300.325
8418.426
8591.258
8634.647
8853.867
8919.499
8988.58
Wavelength in Angstroms

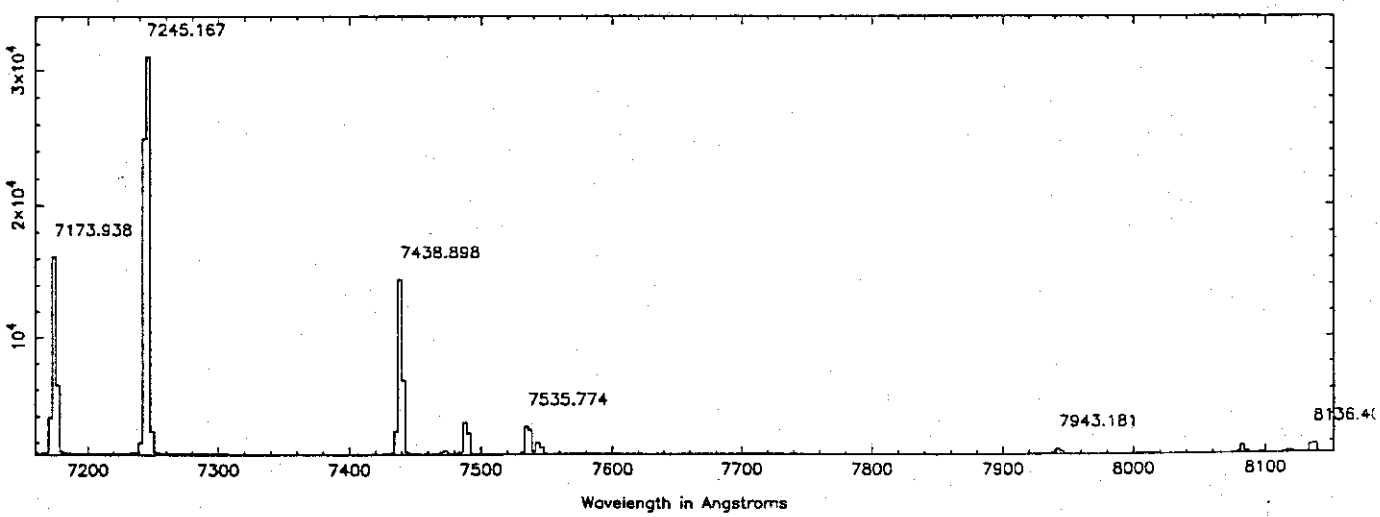

9201.76
(9221)
9326.52
9665.424
9486.68
9300.85
9425.38
9534.167
9459.21
9547.4
Wavelength in Angstroms


10844.54
10562.43
10295.4
10798.12
Wavelength in Angstroms

Cu–Ne (158)


5852.488
6143.062
6074.338
5944.834
6163.
5881.895
5975.534
6029.997
5764.419
5400.562
5000
10⁴
1.5×10⁴
2×10⁴
5200
5300
5400
5500
5600
5700
5800
5900
6000
6100
Wavelength in Angstroms


6402.246
7032.413
6929.467
6506.528
6678.276
6334.428
6717.043
6382.991
6598.953
6532.882
6266.495
6217.281
10⁴
2×10⁴
3×10⁴
4×10⁴
5×10⁴
6200
6300
6400
6500
6600
6700
6800
6900
7000
7100
Wavelength in Angstroms


7245.167
7173.938
7438.898
7535.774
7943.181
8136.4
10⁴
2×10⁴
3×10⁴
7200
7300
7400
7500
7600
7700
7800
7900
8000
8100
Wavelength in Angstroms