The Spectrum of the Th-Ar Hollow-Cathode Lamp Used with the *2dcoudé* Spectrograph

Carlos Allende Prieto

McDonald Observatory and Department of Astronomy
The University of Texas at Austin

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Part I

Description

Introduction

Thorium-Argon lamps are the most popular choice for wavelength calibration on high-resolution grating spectrographs. The wealth of emission lines, the lack of hyperfine splitting for the only isotope of thorium naturally occuring (^{232}Th), and its heavy weight, that results in a very small Doppler broadening, makes of this actinide a good choice. Thorium (Z=90) is responsible for most of the emission lines observed in the optical spectrum emitted by a hollow-cathode Th-Ar lamp. In this type of lamp, an electric discharge ionizes Ar atoms, which are accelerated into the cup-shaped thorium cathode. The Ar II ions sputter Th atoms that get excited by collisions and then radiatively decay to lower levels.

Using a state-of-the-art CCD, a short exposure can register with high quality the spectrum of a commercial hollow-cathode lamp, even at very high dispersion. The appearance of the spectrum changes depending on the characteristics of the lamp (e.g. the vendor), the spectral resolution, the electric current applied, and also as a result of aging. For this reason, atlases of the spectrum of the calibration sources are commonly prepared for specific combinations of lamps/spectrographs. In fact, almost all recently developed spectrographs are provided with maps of the spectra of their wavelength-calibration sources. Often, these maps are accessible through the World Wide Web (WWW), taking advantage of the added flexibility compared to printed copies (e.g. UVES on the Very Large Telescope, FEROS on the ESO 1.52m, UCLES on the Anglo-Australian Telescope, MUSICOS on the Isaac Newton Telescope, the Coudé spectrograph on the KPNO 2.1m, or UES on the William Herschel Telescope).

To produce one such atlas for the *2dcoudé* (Tull, MacQueen, Sneden & Lambert 1995) at a resolving power $R \sim 60{,}000$ is an easy task, as the cross-dispersion allows for a large spectral coverage – the complete optical range can be acquired in just two exposures. As part of a survey of nearby stars, we recently observed a number of standard stars that are likely of wide interest for other observers. With little more effort the Th-Ar exposures obtained for the survey were combined to produce an atlas.

The Th-Ar linelist commonly used for calibration in IRAF, (Willmarth 1992) provides standard (15° C, 760 torr) dry air wavelengths for 3056 features[1]. The line list seems to be a combination of the identifications of Palmer and Engleman (1983) for Th and Norlén (1973) for Ar. About 90 % of the lines are attributed to neutral or ionized Th. Palmer and Engleman used the Fourier Transform Spectrometer (FTS) at Kitt Peak National Observatory. They quote an average accuracy for their wavenumbers of 0.002 cm^{-1}, which is equivalent to 0.0002 Å at 3000 Å and 0.001 Å at 7000 Å. It became apparent that the McDonald spectra would provide similar, and in some cases improved, precision. For this reason, and because errors in the FTS measurements have a different dependence with wavelength or line strength than they do in our grating spectrograph, the wavelengths labeling lines in this atlas are those determined in the McDonald spectra.

Some users may be happy with this printed version of the *2dcoudé* Th-Ar atlas. However, further advantages can be obtained from the digital version that is available through the WWW. With prior knowledge of the central wavelength or order, the presentation of the atlas can be changed interactively to match the actual spectral setup.

Acquisition and Reduction of Data

The Th-Ar hollow-cathode employed is a Westinghouse lamp, Type WL-23418, powered with a 14 mA current. This lamp has been used at McDonald since December 1992. The detector was TK3, a thin 2048×2048 Tektronix CCD with 24 μm pixels, which was installed at the $R \sim 60,000$ focus F3. We used grating E2, a 53.67 gr mm^{-1} R2 echelle from Milton Roy Co. We used slit #4, which has a central width of 511 μm (or approx. 1.2 arcsec on the sky). We refer the reader to Tull et al. (1995) for more details about the instrument.

The exposures used in this atlas were obtained in three different epochs (December 2000, May 2001, and September 2001), as part of a survey of nearby stars (Lambert, Allende Prieto & Cunha 2001). We scaled and combined 42 individual exposures obtained centering 5112 Å in order 67 in the middle of the CCD (*blue* setup), and 29 exposures obtained with 5178 Å (in the same order) at the center of TK3 (*red* setup). Figure 1 shows the area covered by the detector on the focal plane for each setup. Most of the exposures were 30s long, but some were up to a factor of three longer.

[1]A recent Th-Ar atlas produced by Willmarth et al. with the KPNO 2.1m coudé spectrograph is available online from `http://www.noao.edu/kpno/specatlas/`.

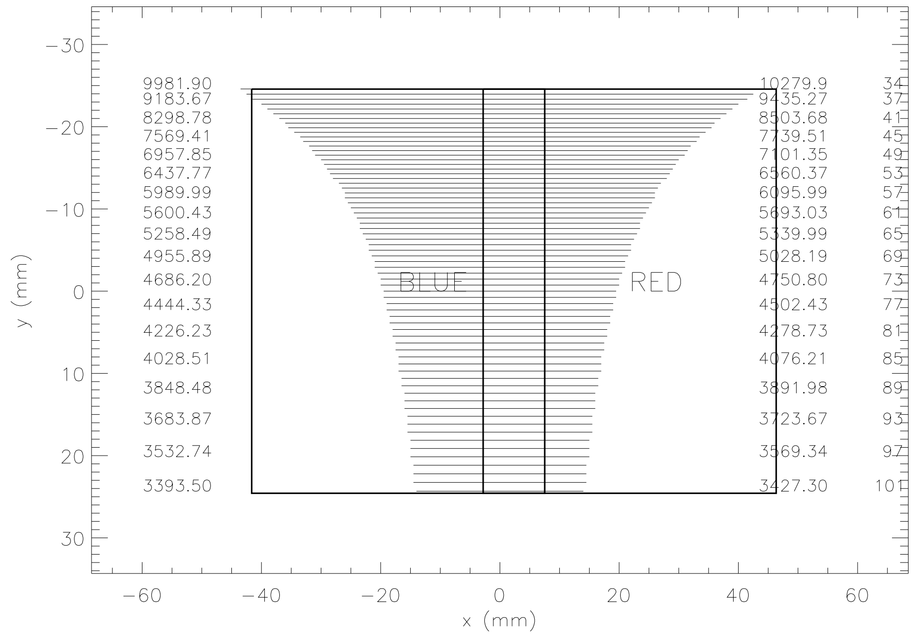

Figure 1: Spectral setups employed in the making of the atlas. The boxes labeled as RED and BLUE show the size of TK3 on the focal plane. The horizontal rules indicate the free spectral range for each order. Order numbers and the beginning and ending wavelengths for some orders (in Å) are printed.

Using IRAF tasks, we removed the bias, estimated from the overscan area, and we extracted the spectra. The apertures for extraction were defined with the help of a standard star (tracing of the orders) and the spectrum of a quartz lamp that is normally used for flatfield correction (width of the orders). Each of the individual spectra was calibrated in wavelength using the Th-Ar linelist available within IRAF (`thar.dat`), identifying about 1000 lines per setup, and fitting a $4^{\rm th}$ order polynomial in the dispersion direction, and a $5^{\rm th}$ order polynomial in the cross-dispersion direction. The rms scatter was always in the range $0.0016 - 0.0026$ Å. No attempt was made to correct the instrumental response or the pixel-to-pixel sensitivity variations. Mixing observations from three different observing periods, with multiple changes between the two setups in each run, smoothes out most systematic sensitivity variations between nearby pixels, as the positioning mechanism for the grating is imperfect.

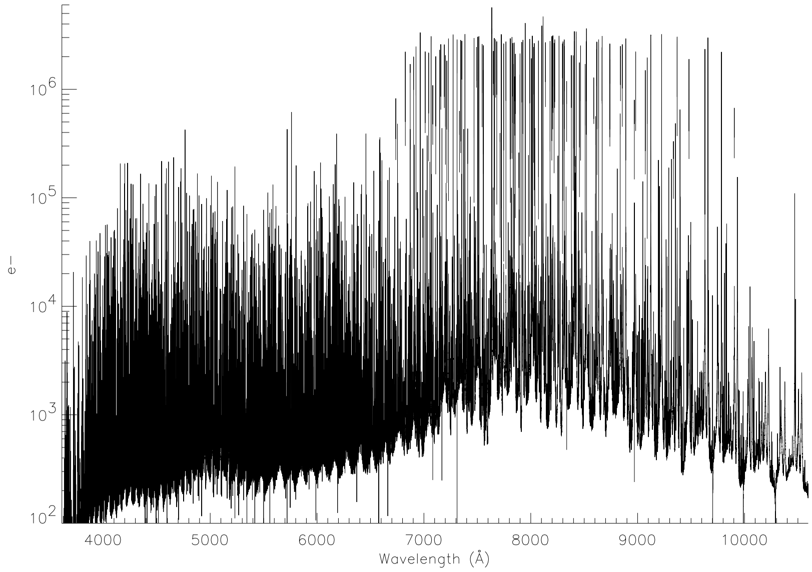

Figure 2: Full spectrum of the Th-Ar hollow-cathode used with the *2dcoudé* spectrograph.

It is indeed desirable to keep corrections to a minimum, as the main goal of this atlas is helping *2dcoudé* observers in the identification of the Th-Ar spectrum. As an example, there is a number of spurious features in the orders next to some very strong features in the red. These artifacts cannot be generally matched with wavelengths of thorium or argon features, and they tend to have a distinctive shape. Therefore, we could easily *clean* the spectra of these features, but in doing so we would be altering significantly the aspect of the lamp spectrum as extracted by an observer for calibration. Most observers do not removed scattered light from the Th-Ar calibration spectra. At a resolving power of 60,000 the stray light is significant only in the red (see Fig. 2), and it has little impact on the accuracy of the calibration. We have not removed it from our spectra. Finally, many strong lines present in the red part of the spectrum are saturated. Observers intentionally overexpose those features in order to bring out weaker lines in the blue and near infrared. Very short exposures and a filter can provide more reliable intensities and wavelengths for those lines, but would alter their aspect compared to typical observations. Thus, we have not taken any measure to correct this problem.

The center of the lines identified in the McDonald spectra were determined with the `center1d` algorithm in the IRAF task `ecidentify`. For each of the lines whose wavelength was measured at least in twice in one of the setups, the average and standard error of the mean were determined. Multiple measures of a line occur because of the availability of multiple exposures for each setup, the overlap between the two setups, and the wavelength overlap between adjacent orders. When average values were derived for a line measured in both the *blue* and *red* setups, which happened for half of the features, they were weighted with the inverse of the square of their standard errors, and averaged.

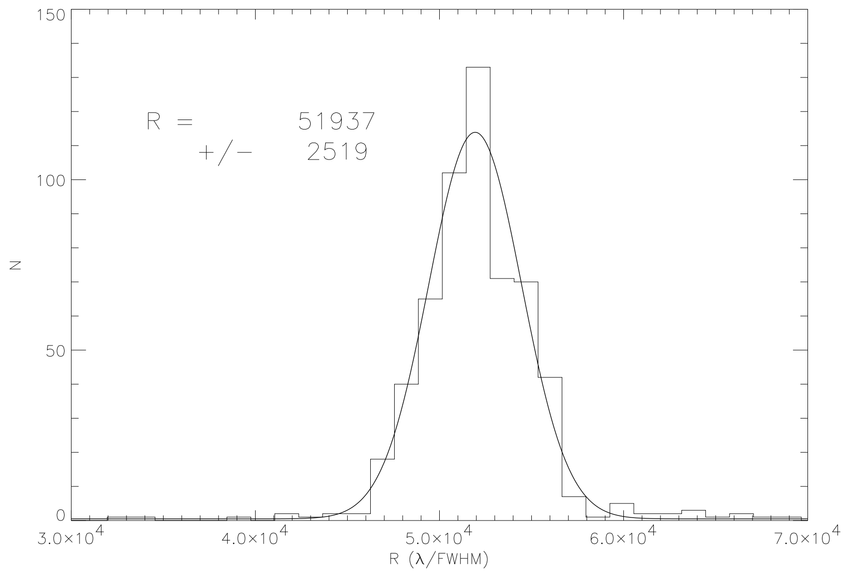

Figure 3: Number of emission lines measured in the Th-Ar hollow-cathode spectra as a function of the resolving power.

The final digital atlas available on the WWW[2] covers the region between 3611.9 and 10596.4 Å. However, as the line identification was based on Willmarth's list, the pictorial atlas and the list of wavelengths was restricted to the interval 3642.2 Å – 9664.7 Å. To produce the pictorial atlas, we scaled the individual exposures by their level of counts, averaging them out after rejecting deviant pixels. We plotted the resulting spectrum in segments of 30

[2] `http://hebe.as.utexas.edu/2dcoude/`

Å, and labeled the lines keeping only the relevant number of digits. Table 1 (Part III) lists the determined wavelengths and their uncertainty (standard error).

To determine the resolution of the Th-Ar atlas we selected 584 lines with a standard error in their wavelengths ≤ 0.0002 Å, and fitted a Gaussian profile with a constant background to the spectrum in an interval 0.4 λ(Å)/3700 around the line center. Figure 3 displays the histogram of the lines as a function of the resolving power R= λ/FWHM, which peaks at about 52,000. The intrinsic width of the lines only contributes about 10 % of the observed width.

Acknowledgements

Sincere thanks to Ed Barker, David Doss, David Lambert, Bob Tull, and Russel White for help and guidance with the *2dcoudé* and in the preparation of this atlas.

References

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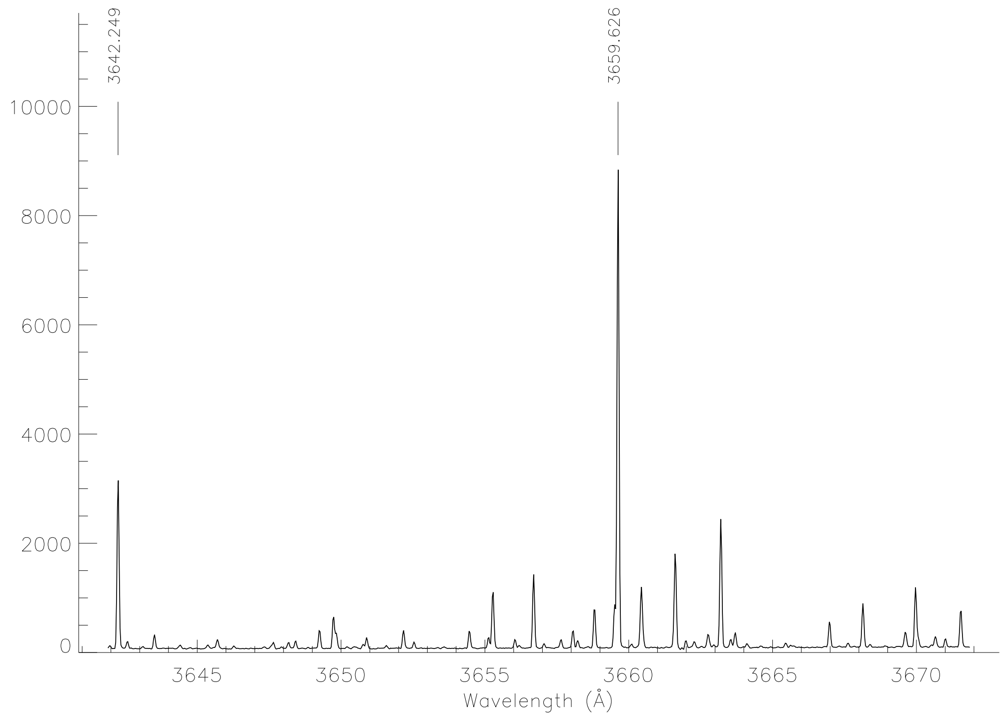
Part II

Pictorial Atlas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6000
4000
2000
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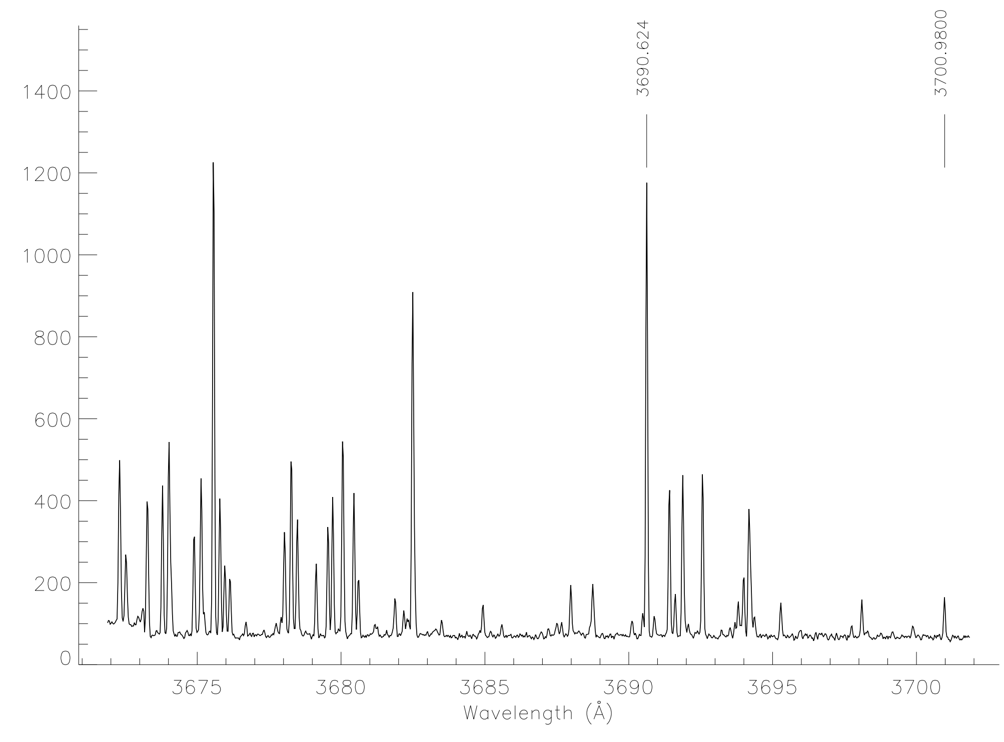
3645
3650
3655
3660
3665
3670
Wavelength (Å)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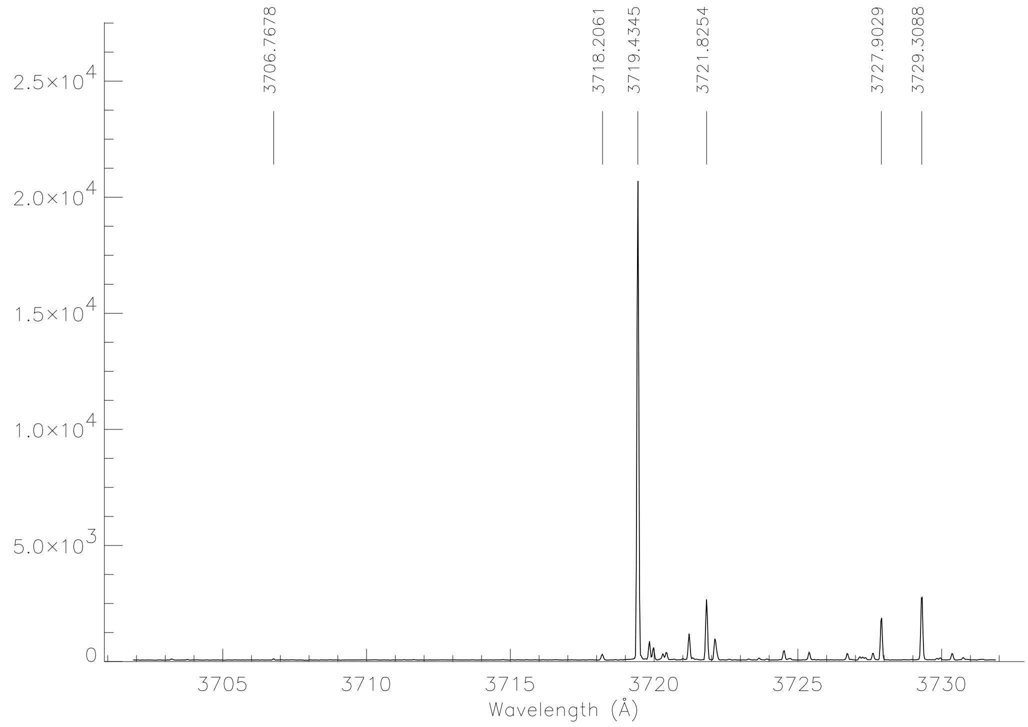
3685
3690
3695
3700
Wavelength (Å)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2.0×10^4
1.5×10^4
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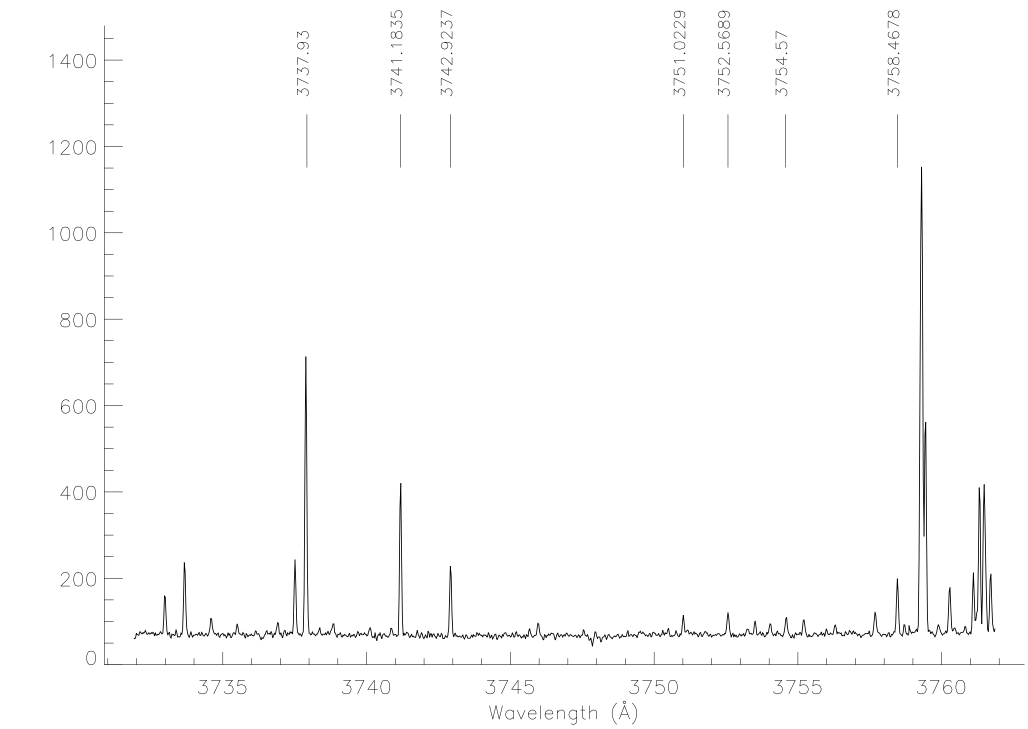
3710
3715
3720
3725
3730
Wavelength (Å)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3742.9237
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400
200
0
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3745
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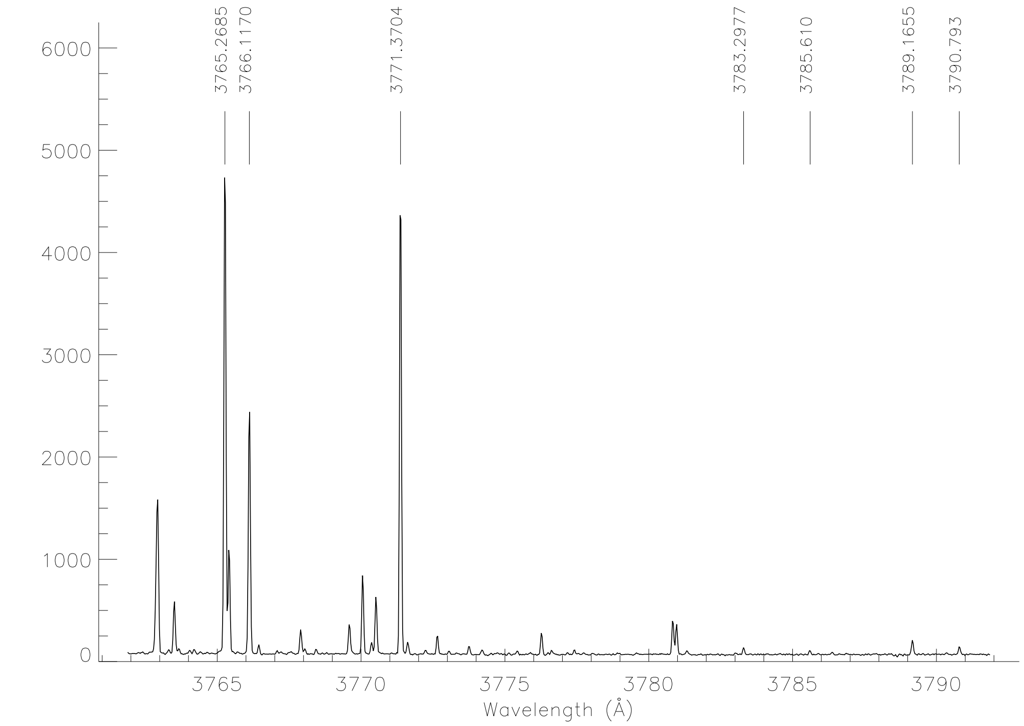
3755
3760
Wavelength (Å)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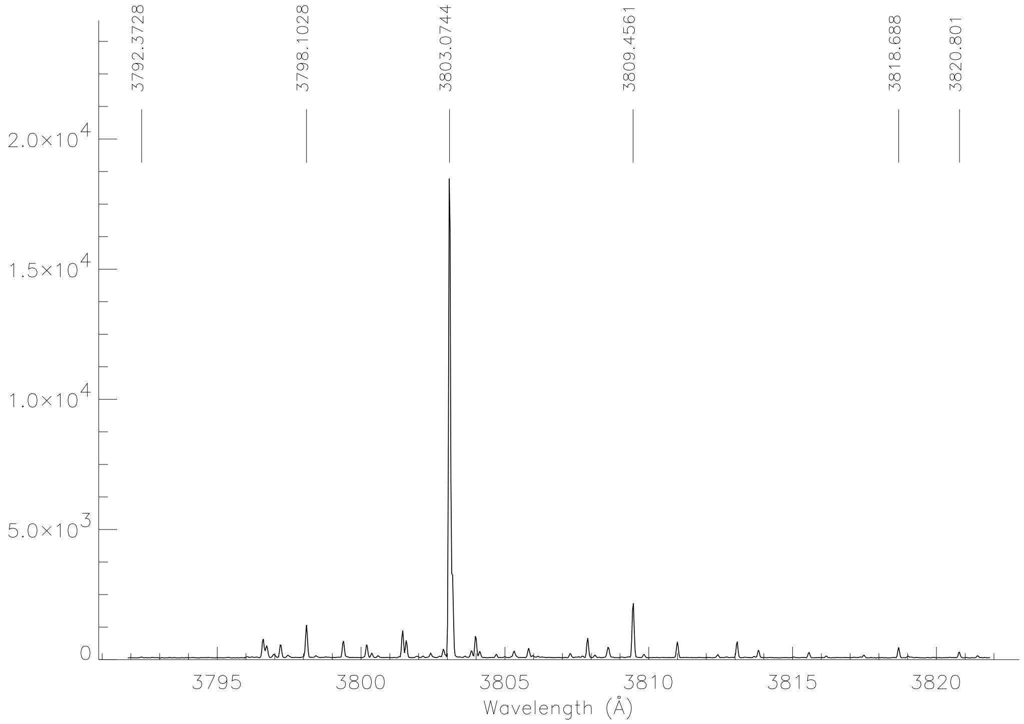
3785
3790
Wavelength (Å)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3805
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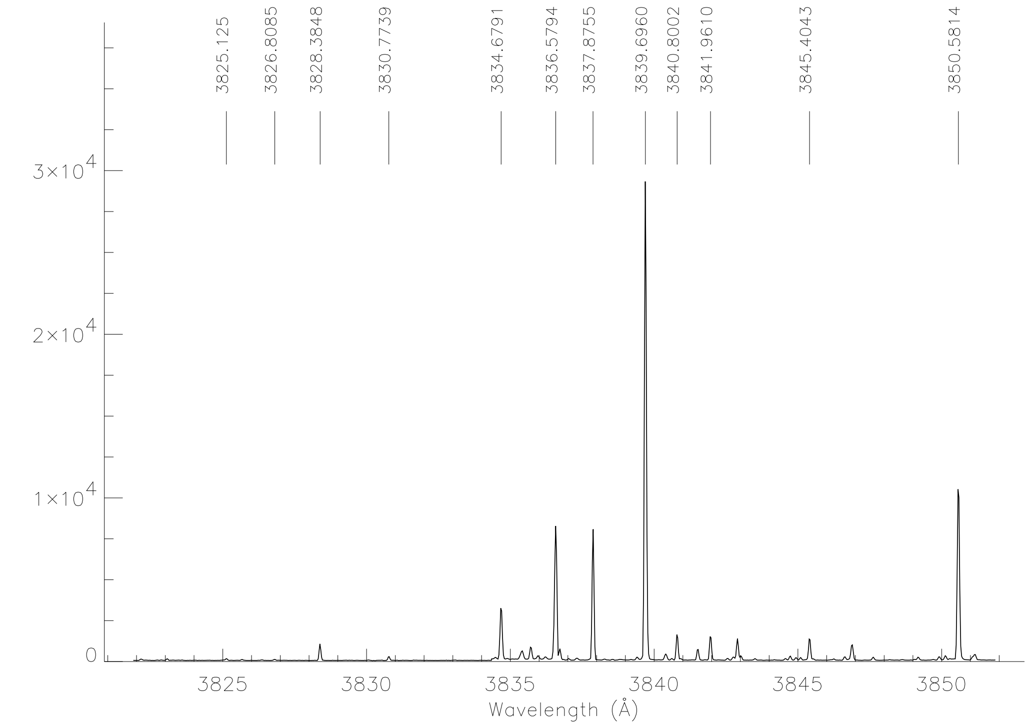
3815
3820
Wavelength (Å)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3845.4043
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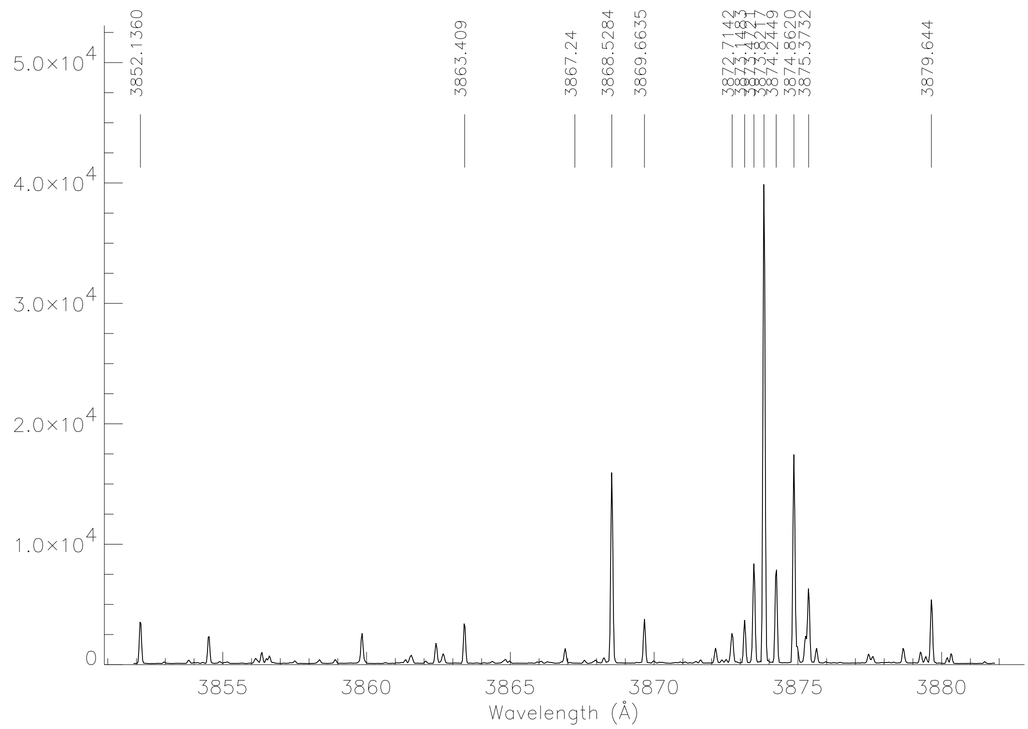
3845
3850
Wavelength (Å)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4.0×10^4
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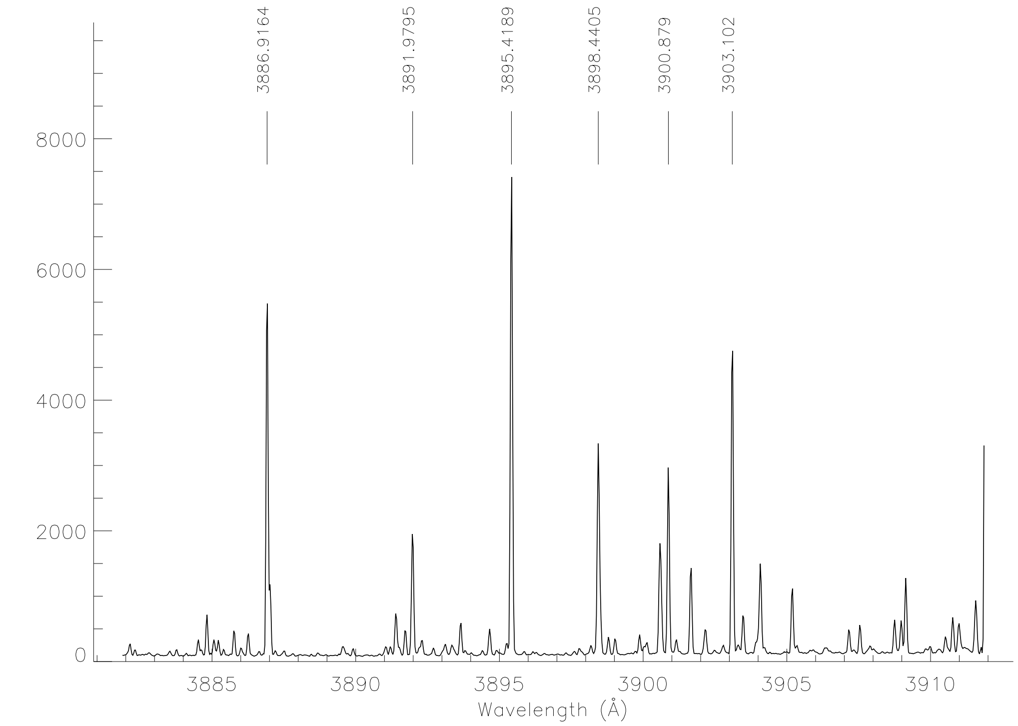
3870
3875
3880
Wavelength (Å)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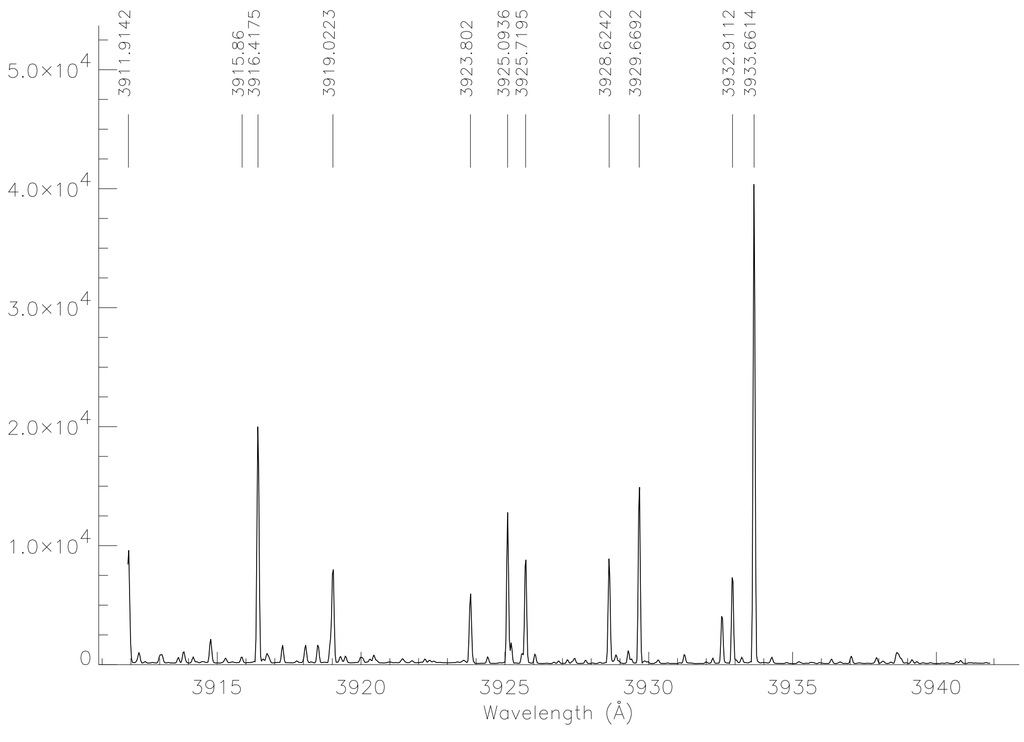
3900
3905
3910
Wavelength (Å)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3933.6614
5.0×10^4
4.0×10^4
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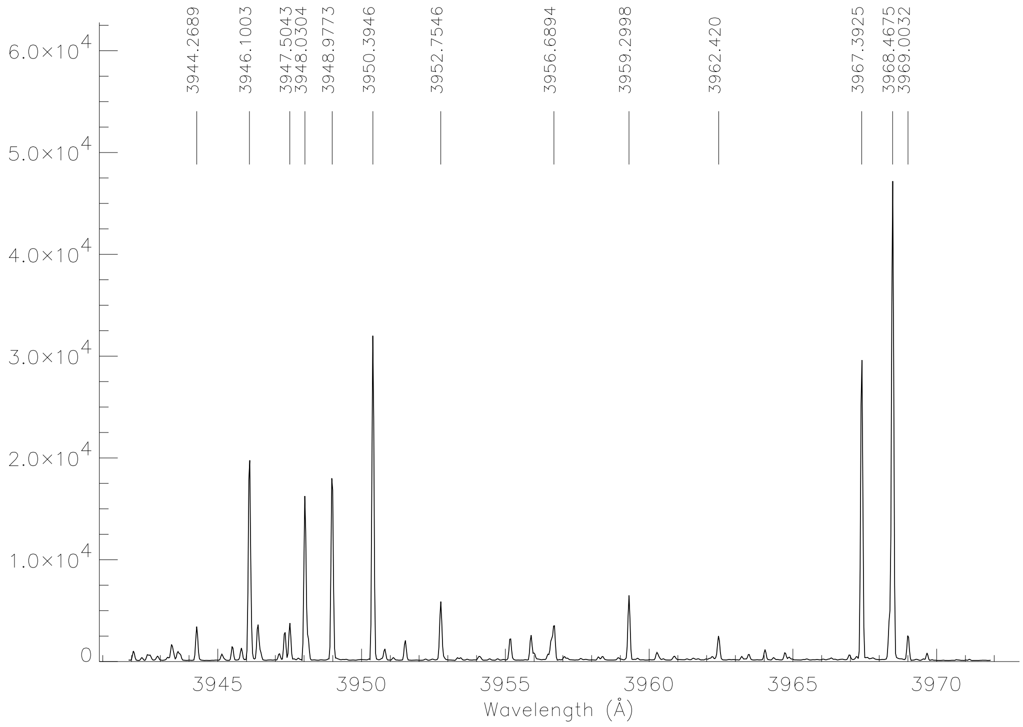
3915
3920
3925
3930
3935
3940
Wavelength (Å)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5.0×10^4
4.0×10^4
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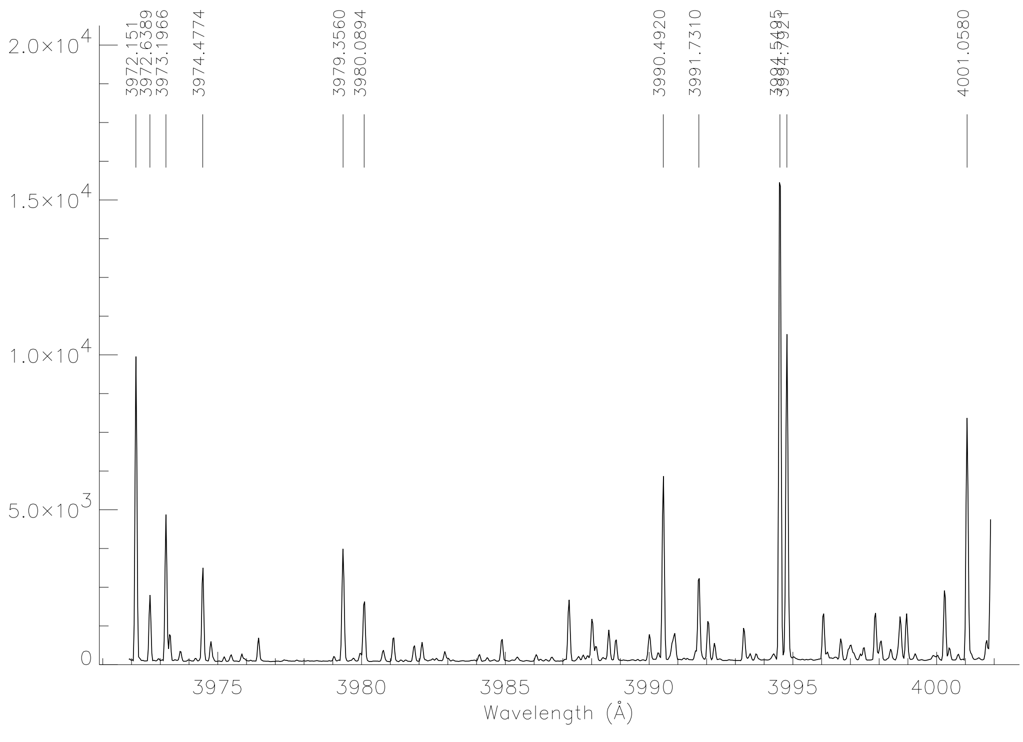
3965
3970
Wavelength (Å)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3994.7921
4001.0580
2.0×10^4
1.5×10^4
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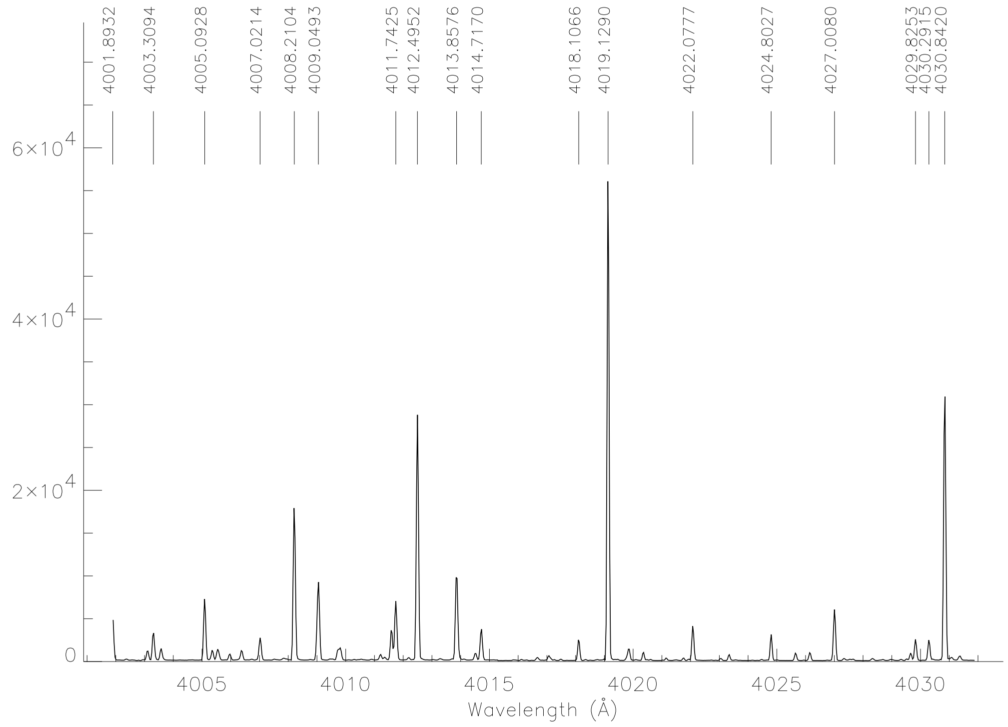
3985
3990
3995
4000
Wavelength (Å)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4014.7170
4018.1066
4019.1290
4022.0777
4024.8027
4027.0080
4029.8253
4030.2915
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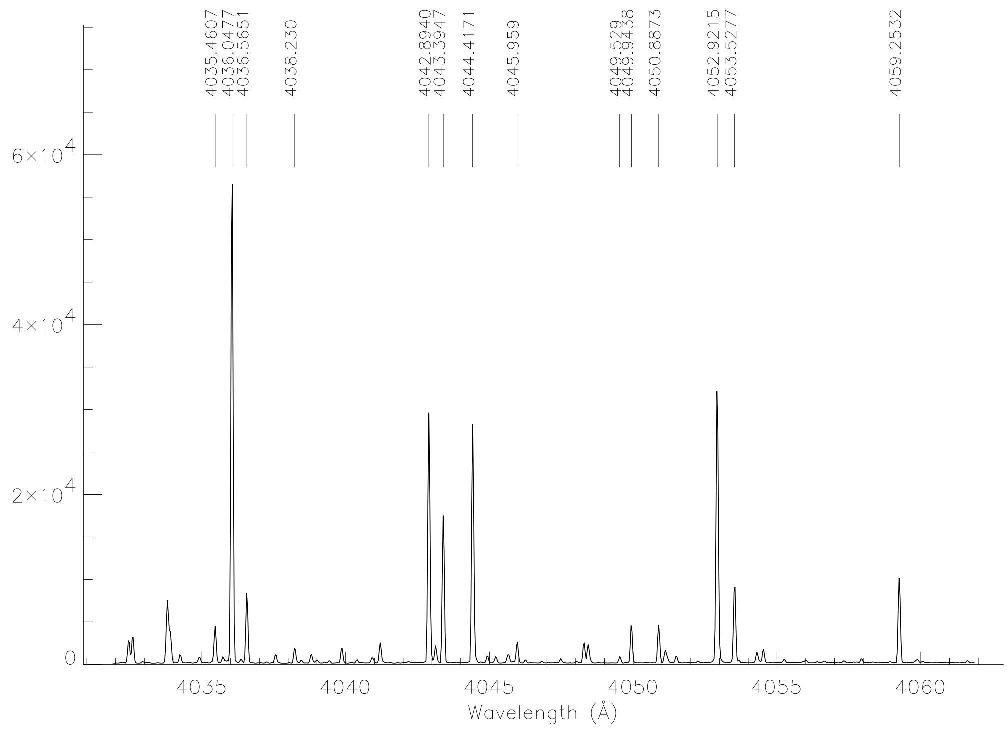
4010
4015
4020
4025
4030
Wavelength (Å)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4053.5277
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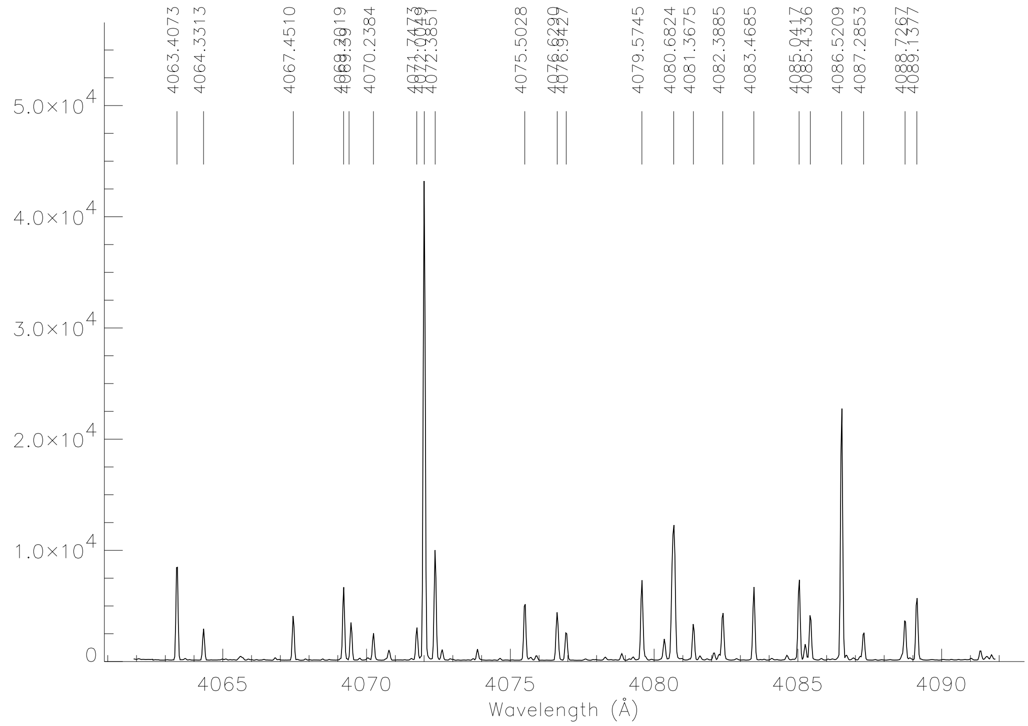
4035
4040
4045
4050
4055
4060
Wavelength (Å)



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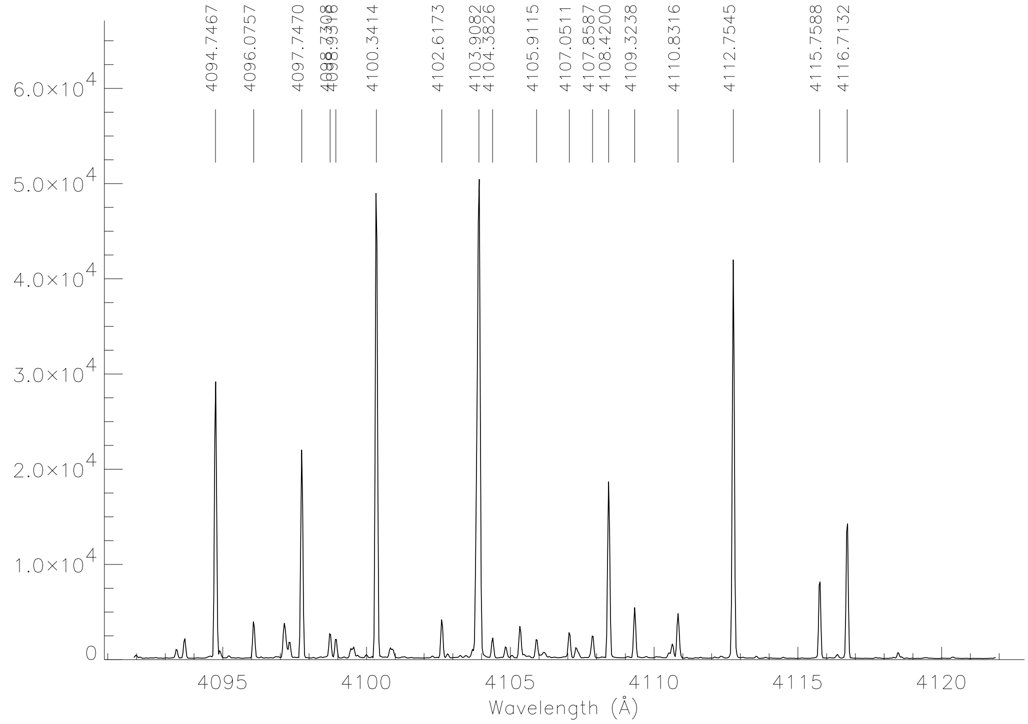
Wavelength (Å)



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4108.4200
4109.3238
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4112.7545
4115.7588
4116.7132
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5.0×10^4
4.0×10^4
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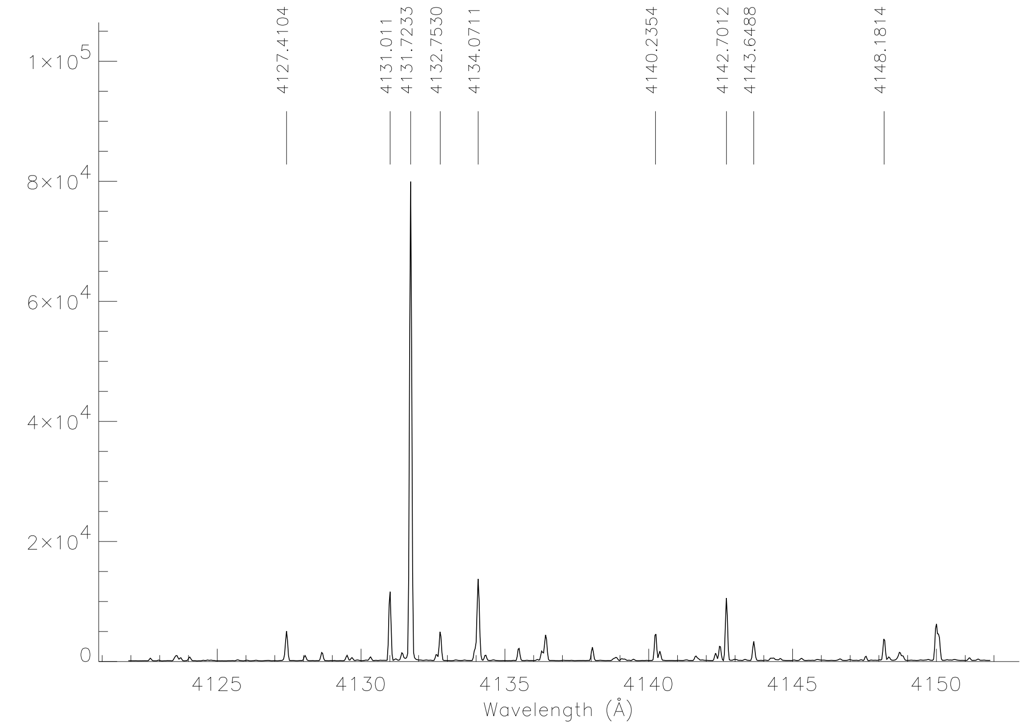
4100
4105
4110
4115
4120
Wavelength (Å)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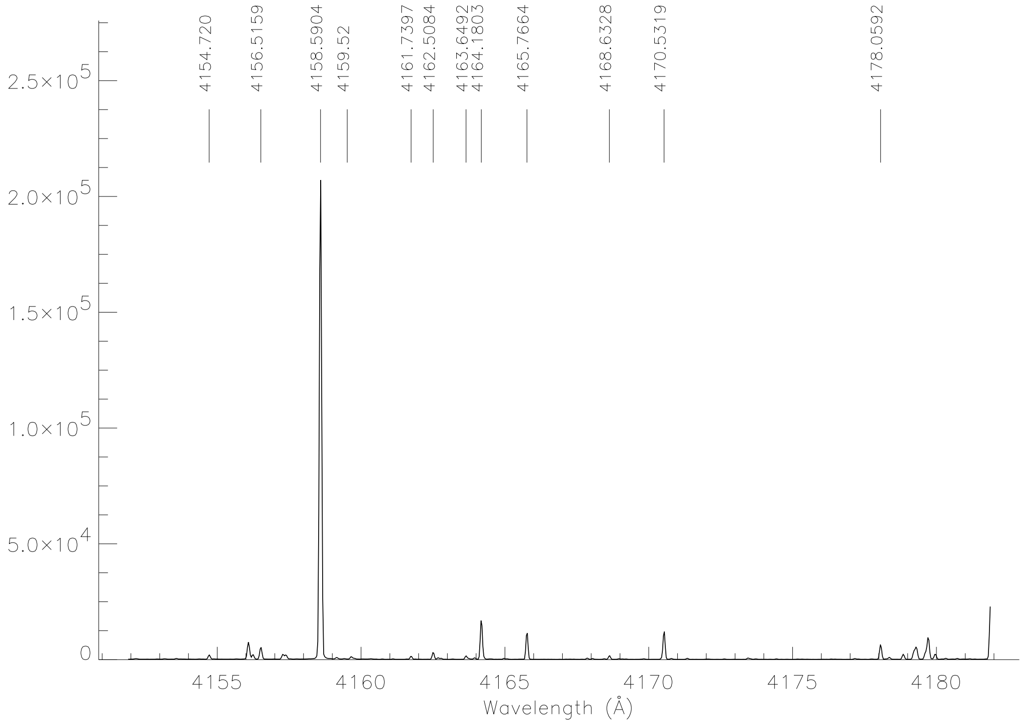
4140
4145
4150
Wavelength (Å)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2.0×10^5
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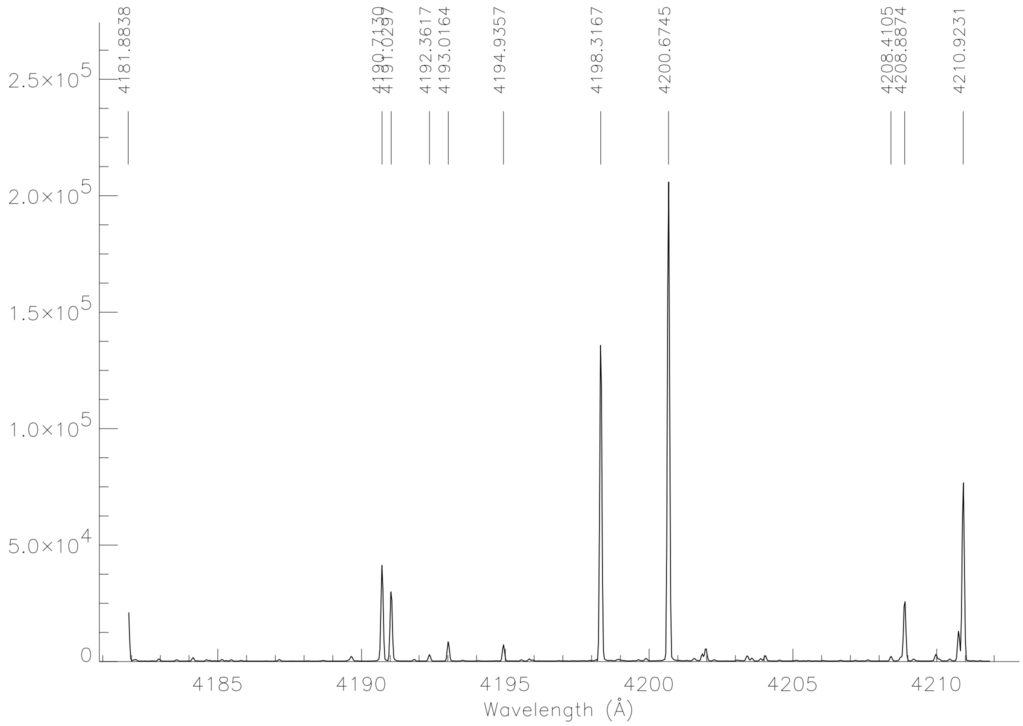
4165
4170
4175
4180
Wavelength (Å)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2.0×10^5
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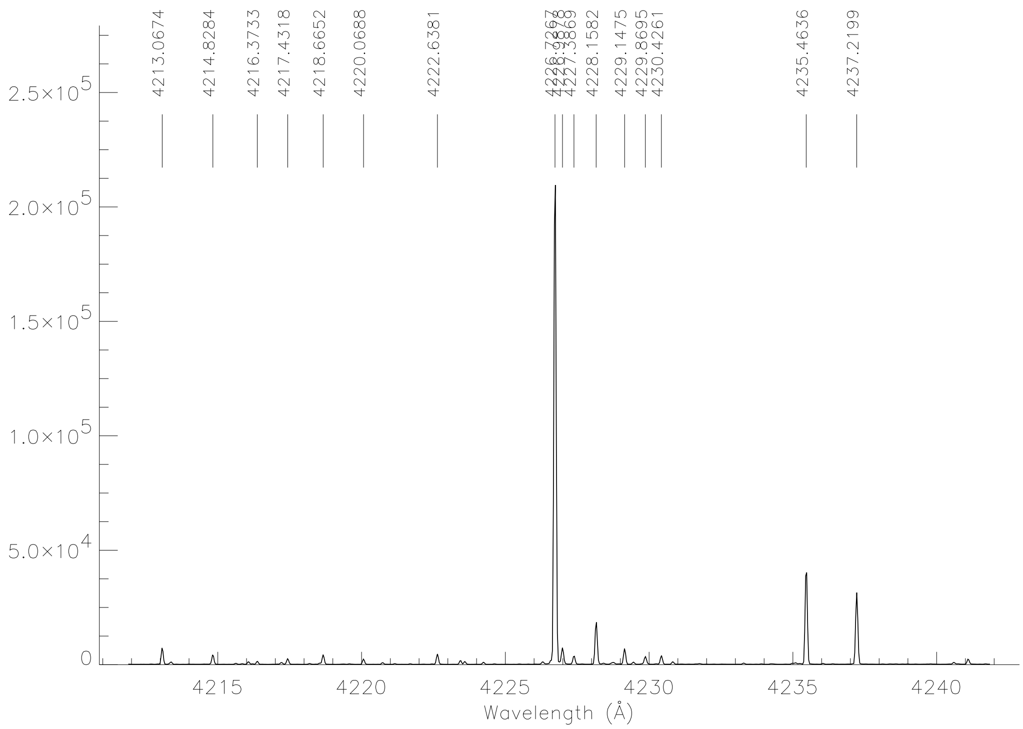
4195
4200
4205
4210
Wavelength (Å)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4230.4261
4235.4636
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2.0×10^5
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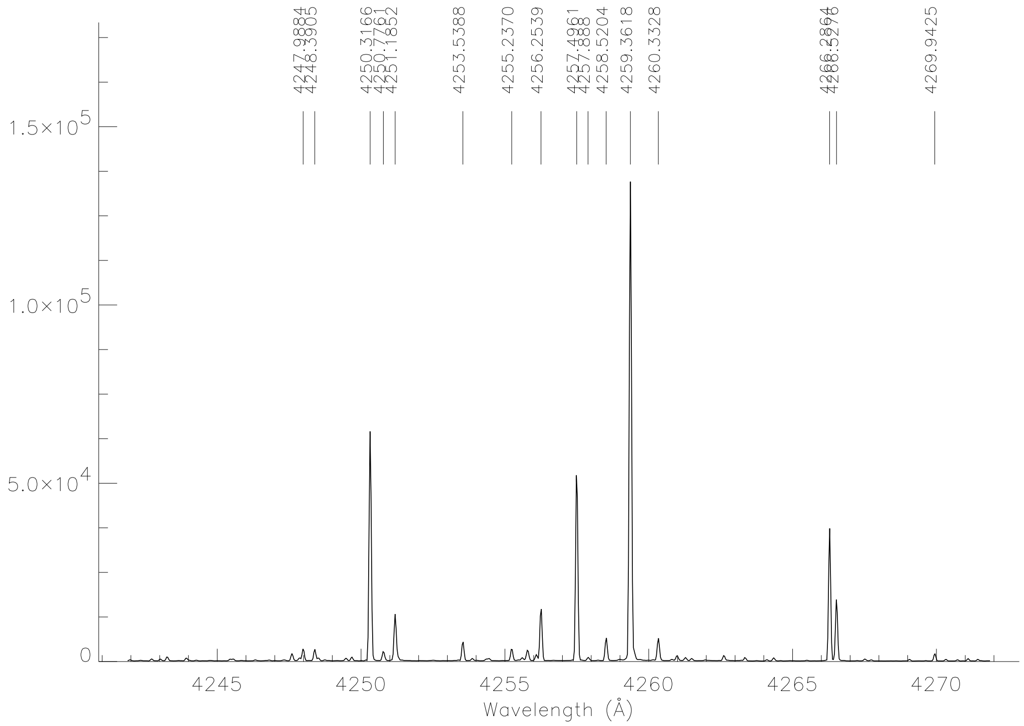
4230
4235
4240
Wavelength (Å)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4260.3328
4266.5276
4269.9425
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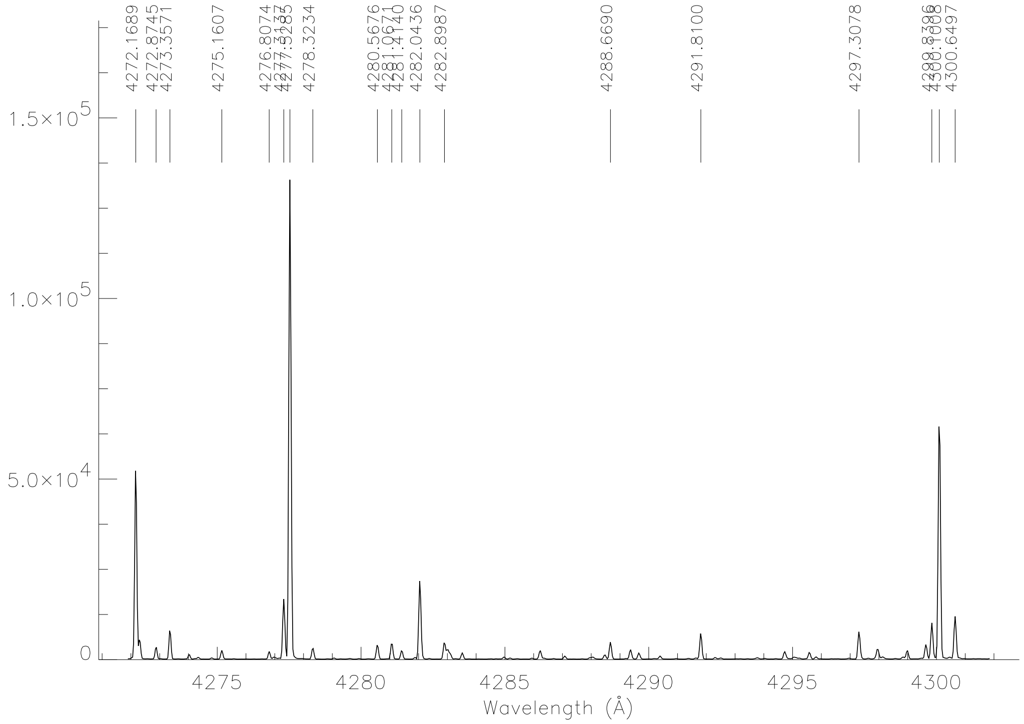
4250
4255
4260
4265
4270
Wavelength (Å)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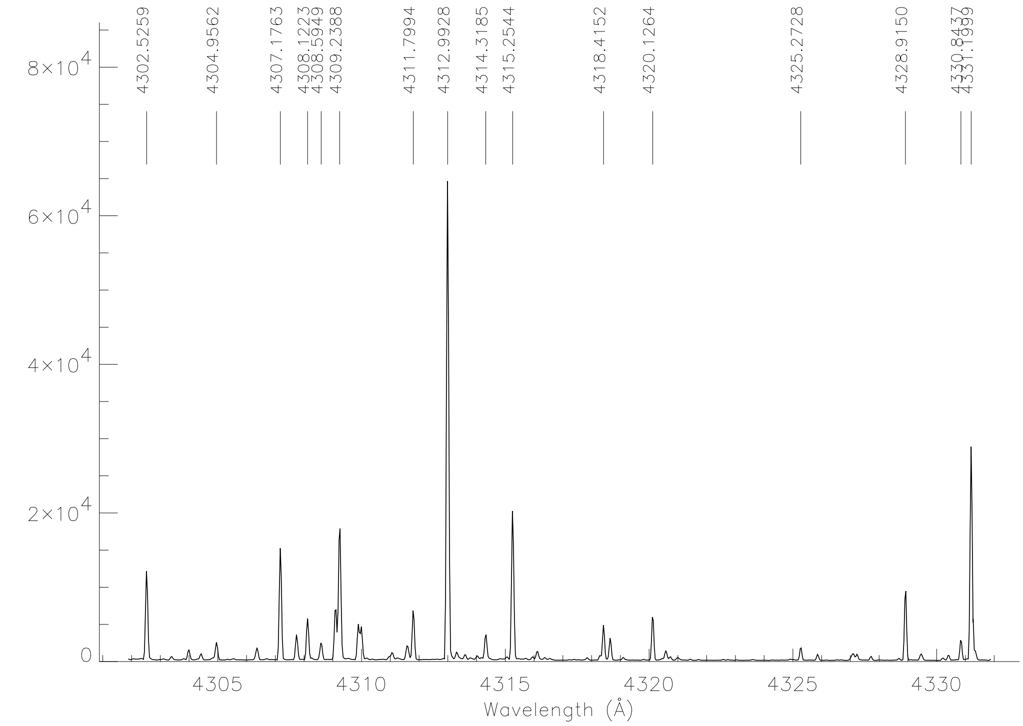
4282.8987
4288.6690
4291.8100
4297.3078
4300.6497
1.5×10^5
1.0×10^5
5.0×10^4
0
4275
4280
4285
4290
4295
4300
Wavelength (Å)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4307.1763
4308.1223
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4309.2388
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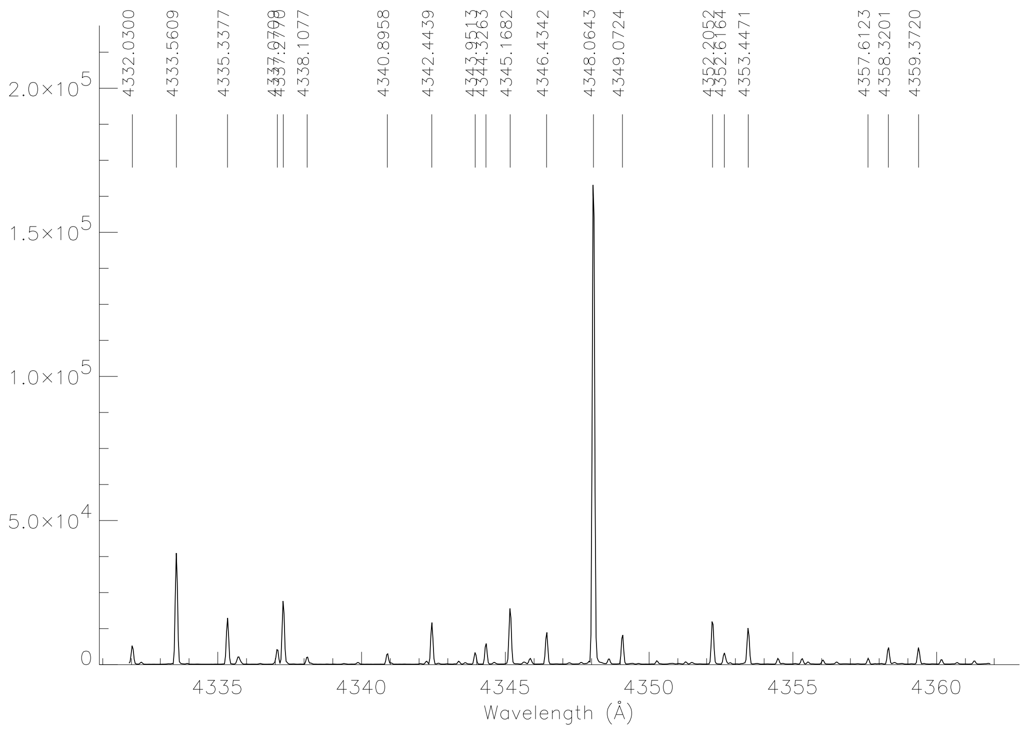
4312.9928
4314.3185
4315.2544
4318.4152
4320.1264
4325.2728
4328.9150
4330.8437
4331.1999
8×10^4
6×10^4
4×10^4
2×10^4
0
4305
4310
4315
4320
4325
4330
Wavelength (Å)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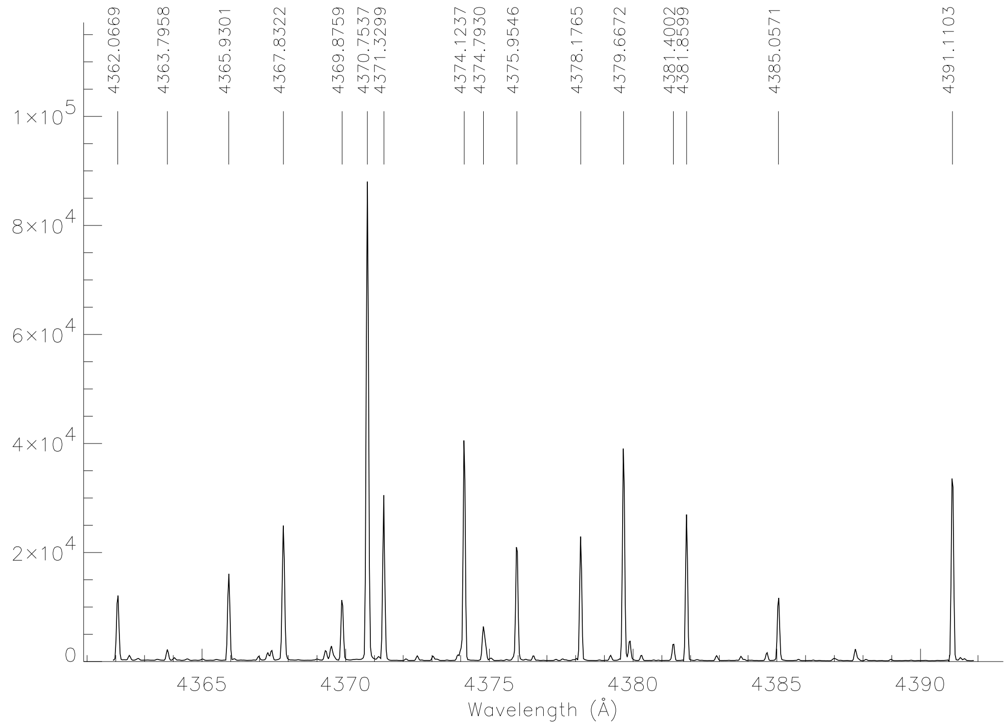
4335.3377
4338.1077
4340.8958
4342.4439
4343.9513
4344.3263
4345.1682
4346.4342
4348.0643
4349.0724
4352.2052
4352.6164
4353.4471
4357.6123
4358.3201
4359.3720
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4335
4340
4345
4350
4355
4360
Wavelength (Å)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4370.7537
4371.3299
4374.1237
4374.7930
4375.9546
4378.1765
4379.6672
4381.4002
4381.8599
4385.0571
4391.1103
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
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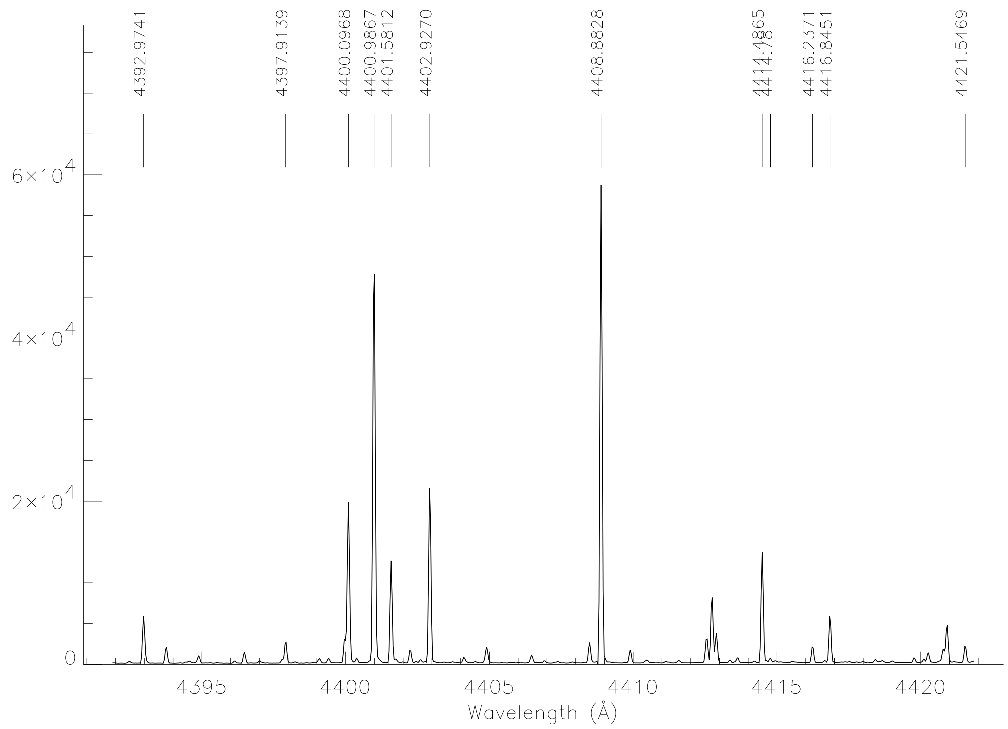
4365
4370
4375
4380
4385
4390
Wavelength (Å)


4392.9741
4397.9139
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4400.9867
4401.5812
4402.9270
4408.8828
4416.2371
4416.8451
4421.5469
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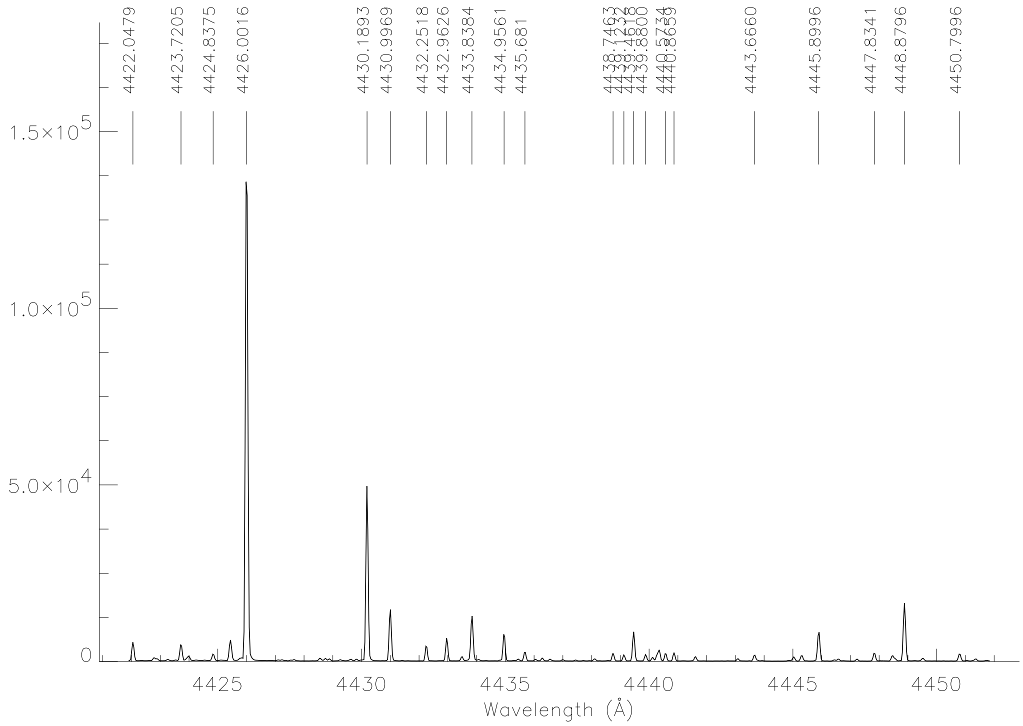
4×10^4
2×10^4
0
4395
4400
4405
4410
4415
4420
Wavelength (Å)



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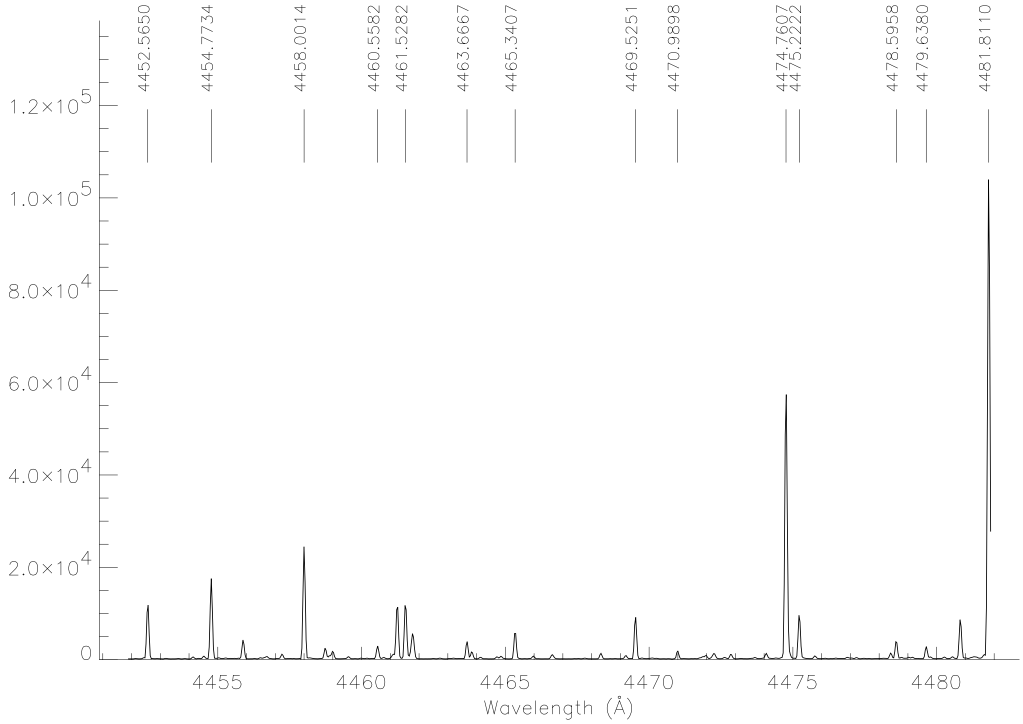
4423.7205
4424.8375
4426.0016
4430.1893
4430.9969
4432.2518
4432.9626
4433.8384
4434.9561
4435.681
4438.7463
4443.6660
4445.8996
4447.8341
4448.8796
4450.7996
1.5×10^5
1.0×10^5
5.0×10^4
0
4425
4430
4435
4440
4445
4450
Wavelength (Å)



4452.5650
4454.7734
4458.0014
4460.5582
4461.5282
4463.6667
4465.3407
4469.5251
4470.9898
4474.7607
4475.2222
4478.5958
4479.6380
4481.8110
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
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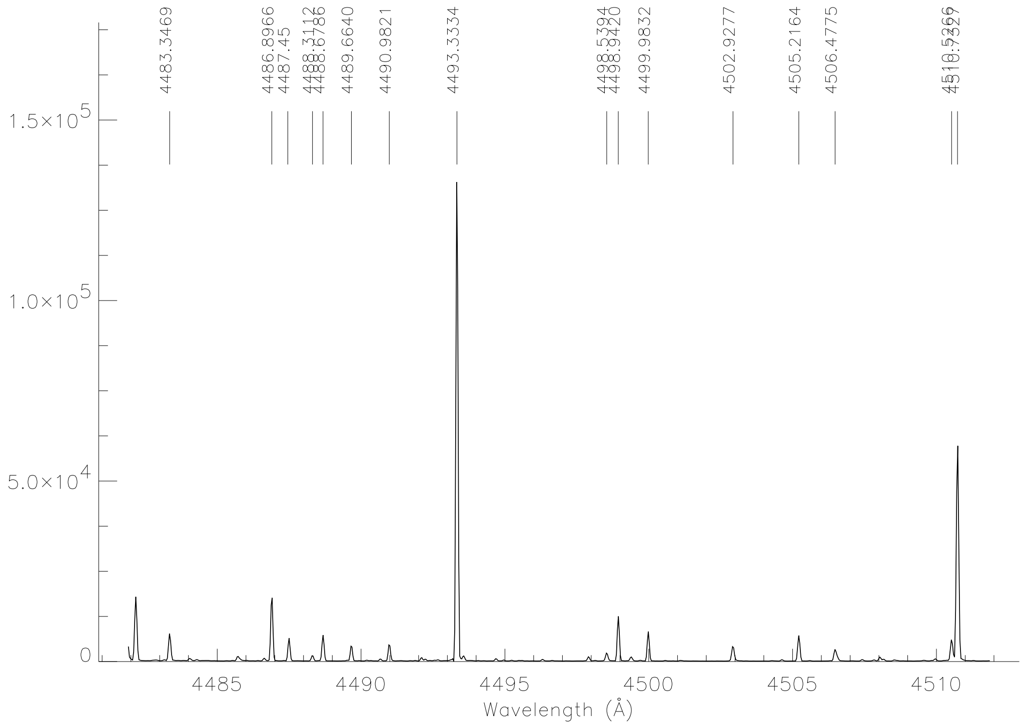
4460
4465
4470
4475
4480
Wavelength (Å)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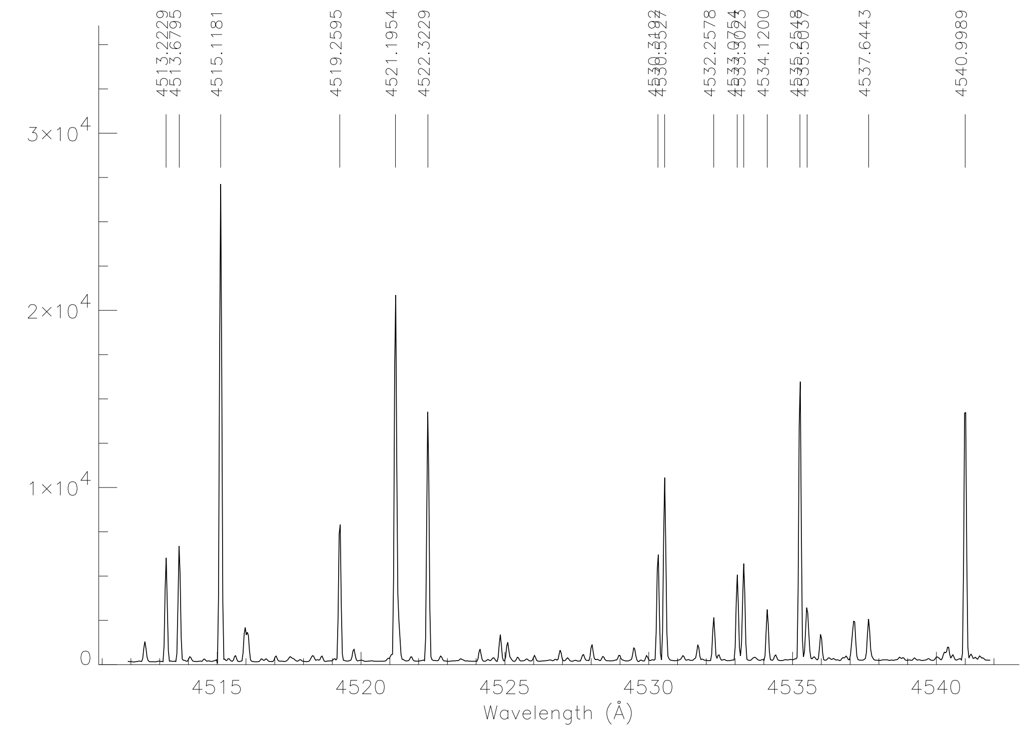
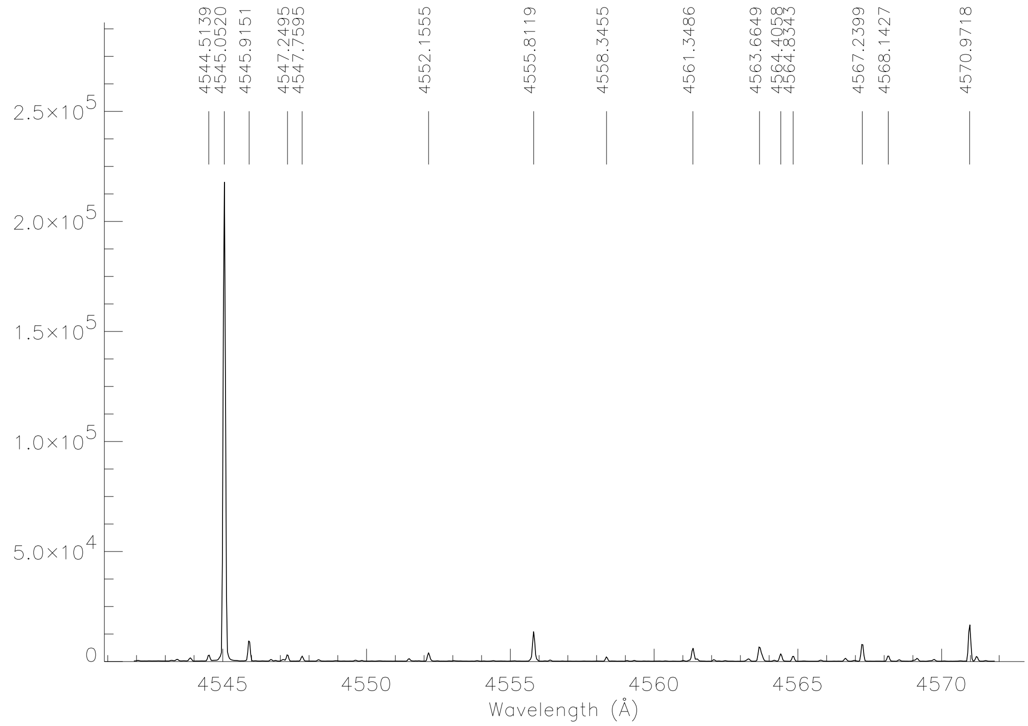
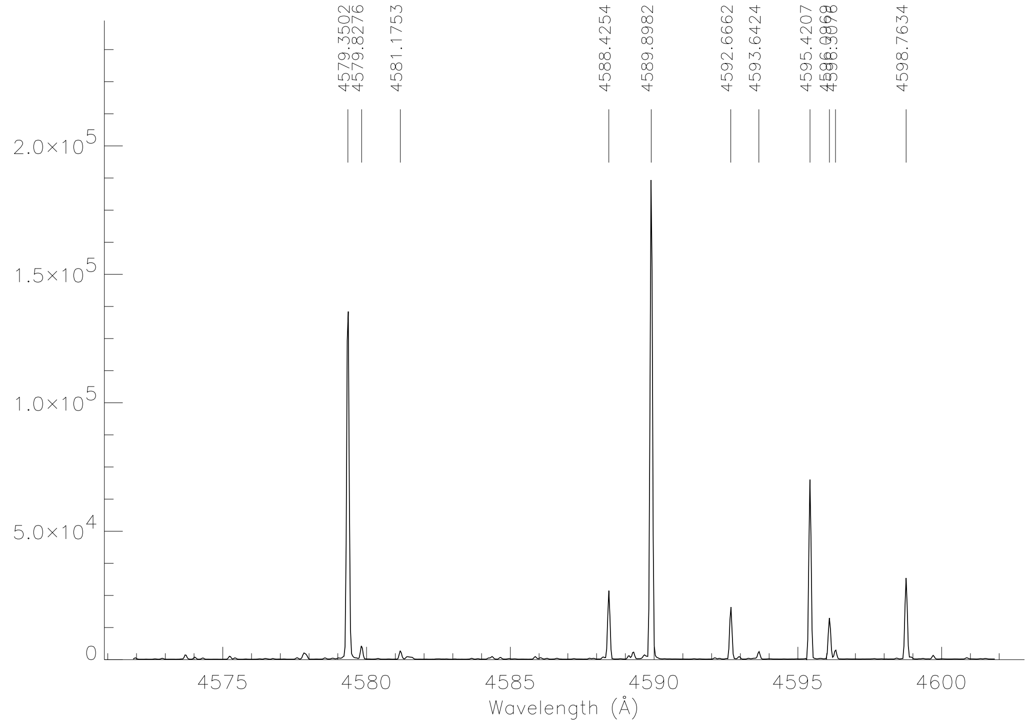
4486.8966
4487.45
4489.6640
4490.9821
4493.3334
4498.9420
4499.9832
4502.9277
4505.2164
4506.4775
1.5×10^5
1.0×10^5
5.0×10^4
0
4485
4490
4495
4500
4505
4510
Wavelength (Å)


4513.2229
4513.6795
4515.1181
4519.2595
4521.1954
4522.3229
4532.2578
4534.1200
4537.6443
4540.9989
3×10^4
2×10^4
1×10^4
0
4515
4520
4525
4530
4535
4540
Wavelength (Å)


4544.5139
4545.0520
4545.9151
4547.2495
4547.7595
4552.1555
4555.8119
4558.3455
4561.3486
4563.6649
4564.4058
4564.8343
4567.2399
4568.1427
4570.9718
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4545
4550
4555
4560
4565
4570
Wavelength (Å)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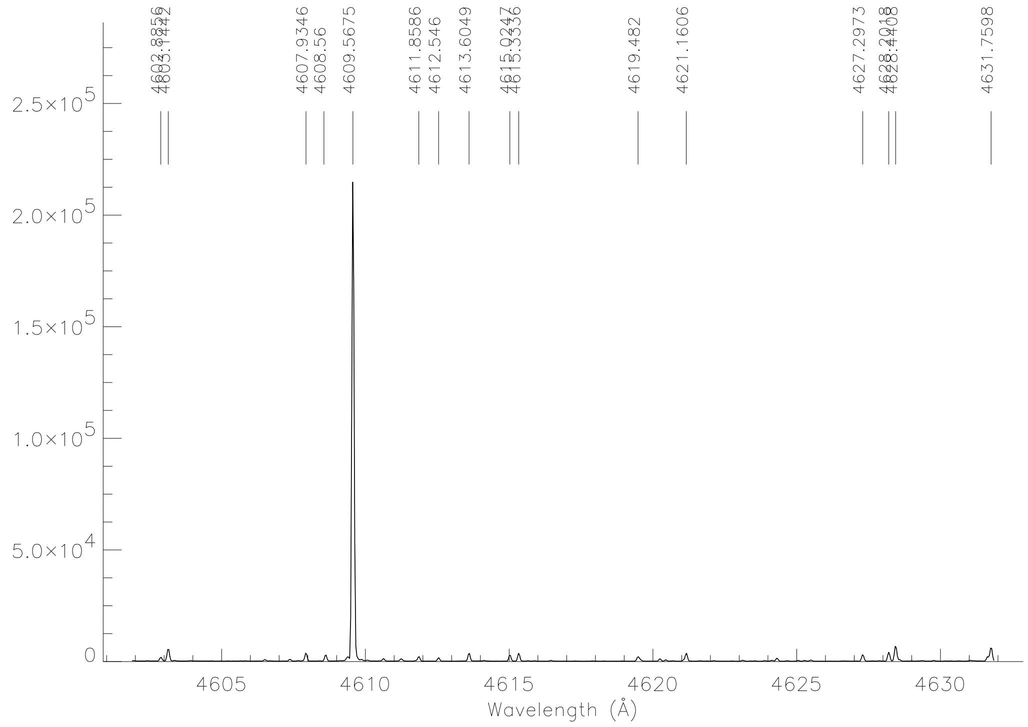
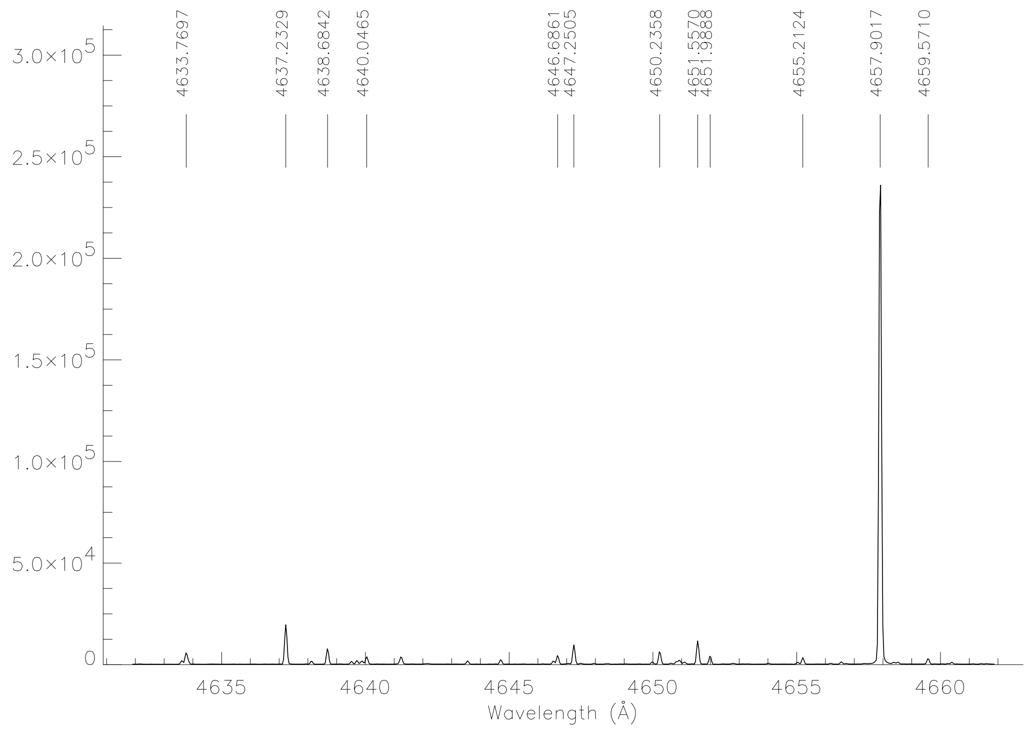
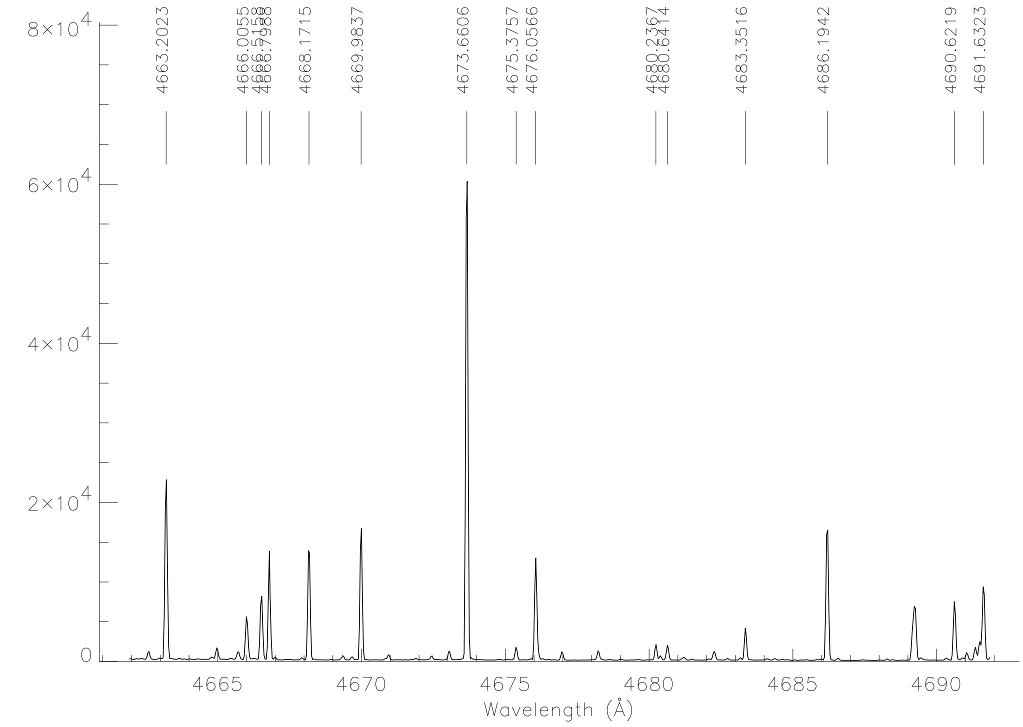
4579.8276
4581.1753
4588.4254
4589.8982
4592.6662
4593.6424
4595.4207
4598.7634
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4575
4580
4585
4590
4595
4600
Wavelength (Å)


4607.9346
4608.56
4609.5675
4611.8586
4612.546
4613.6049
4619.482
4621.1606
4627.2973
4631.7598
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4605
4610
4615
4620
4625
4630
Wavelength (Å)


4633.7697
4637.2329
4638.6842
4640.0465
4646.6861
4647.2505
4650.2358
4651.5570
4651.9888
4655.2124
4657.9017
4659.5710
3.0×10^5
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4635
4640
4645
4650
4655
4660
Wavelength (Å)



8×10^4
6×10^4
4×10^4
2×10^4
0
4663.2023
4666.0055
4668.1715
4669.9837
4673.6606
4675.3757
4676.0566
4683.3516
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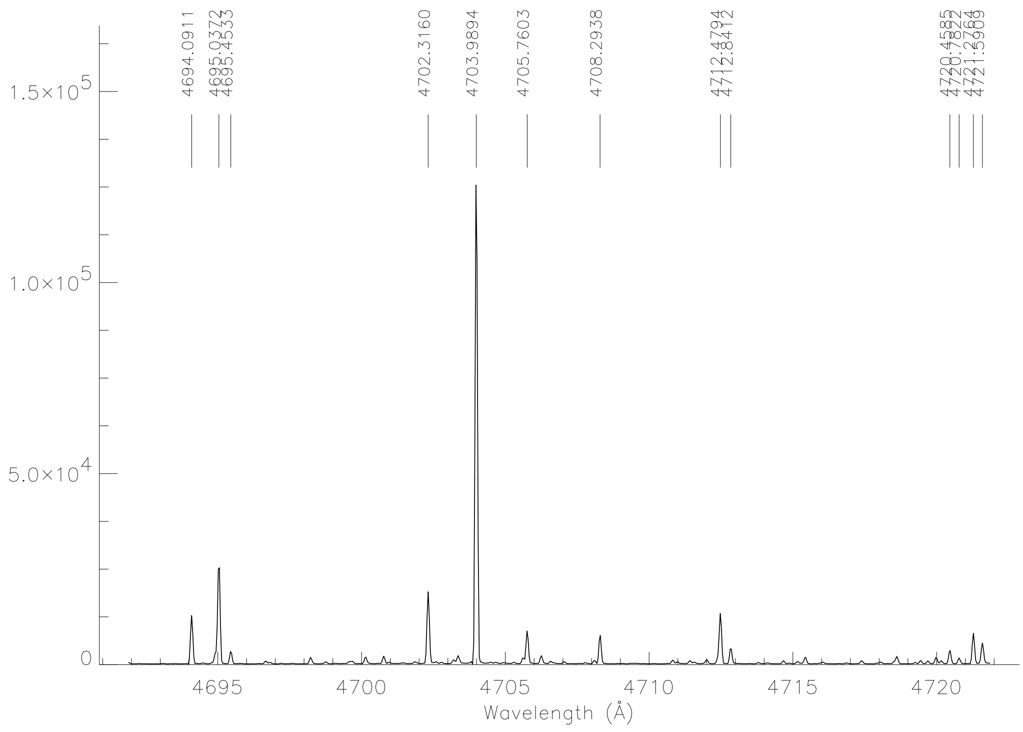
4690.6219
4691.6323
4665
4670
4675
4680
4685
4690
Wavelength (Å)



1.5×10^5
1.0×10^5
5.0×10^4
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4694.0911
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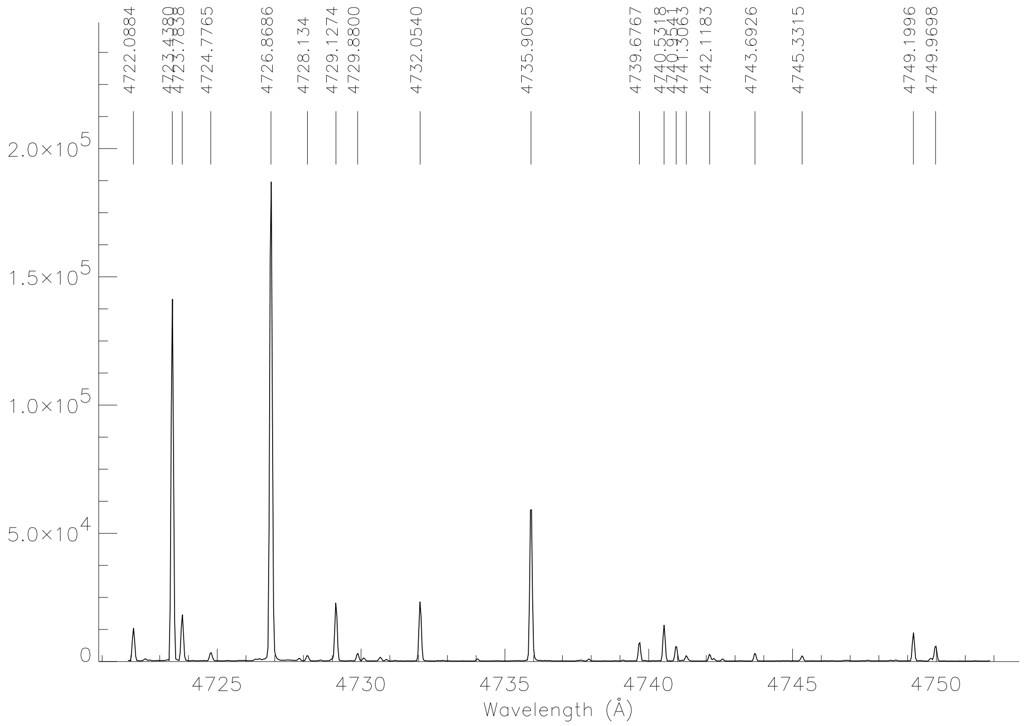
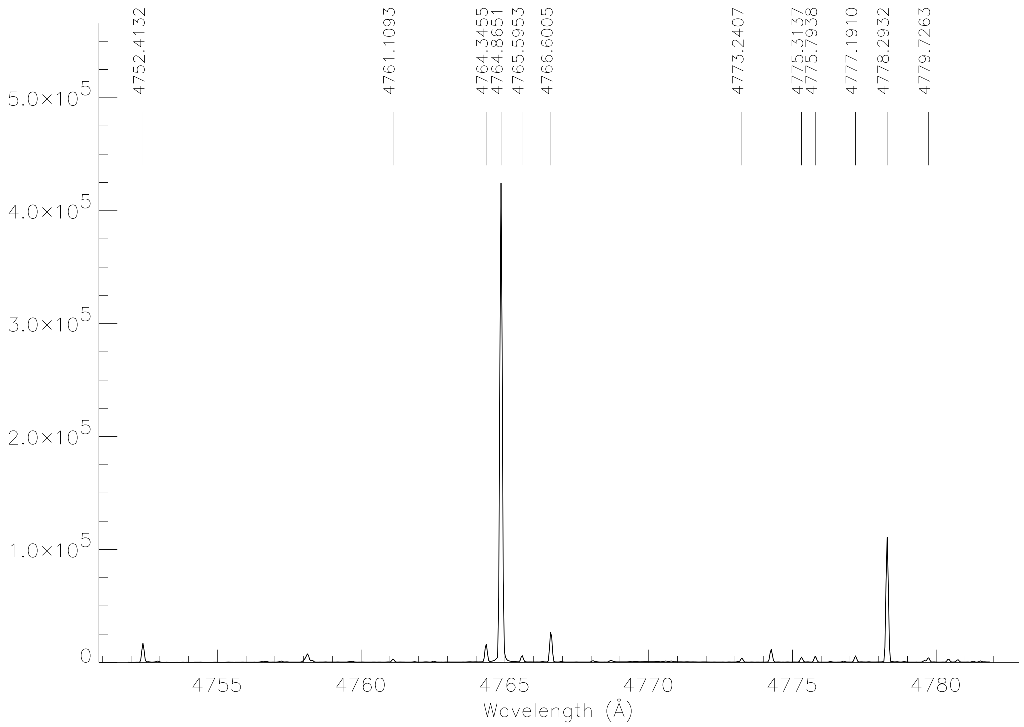
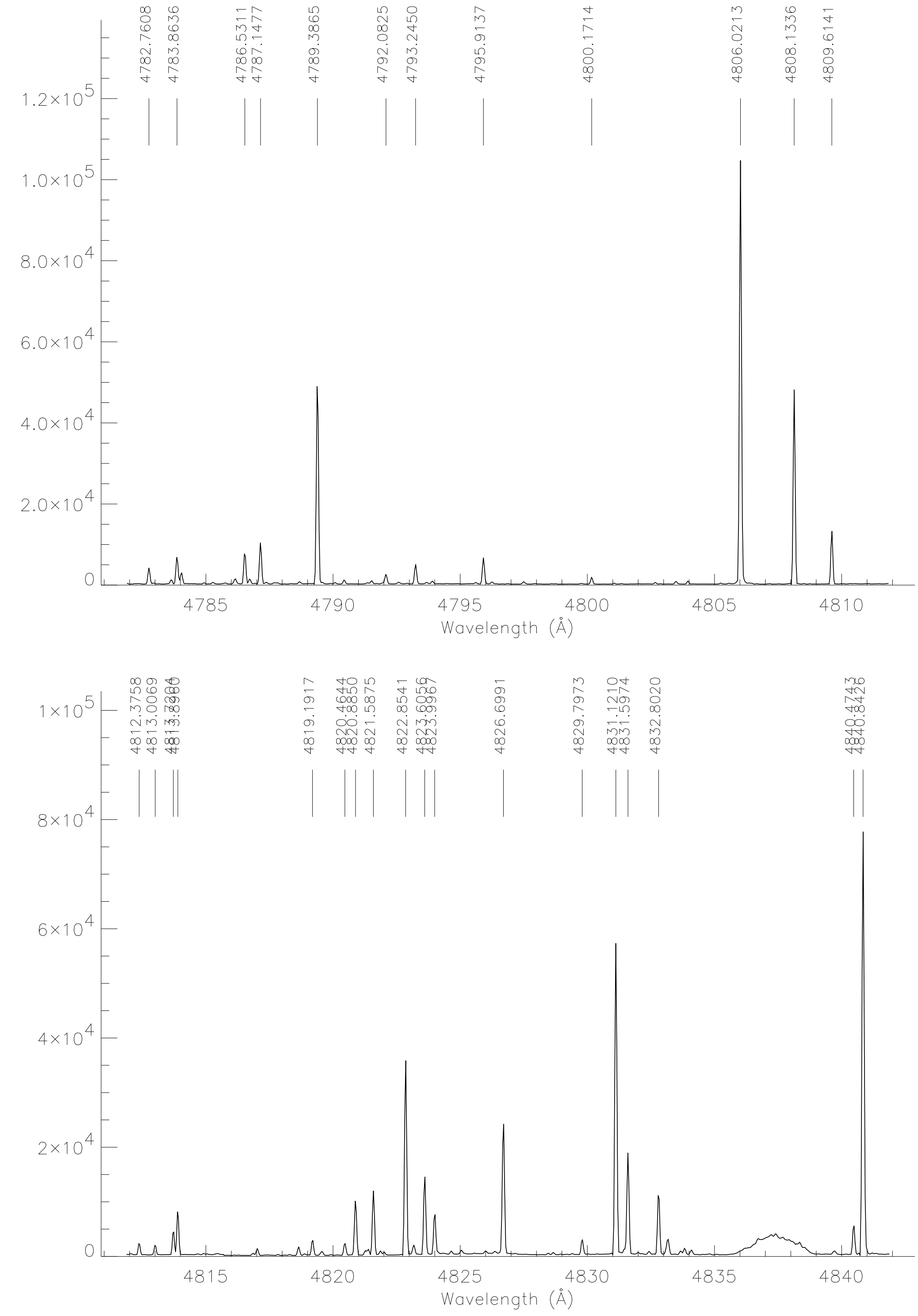
4705.7603
4708.2938
4695
4700
4705
4710
4715
4720
Wavelength (Å)

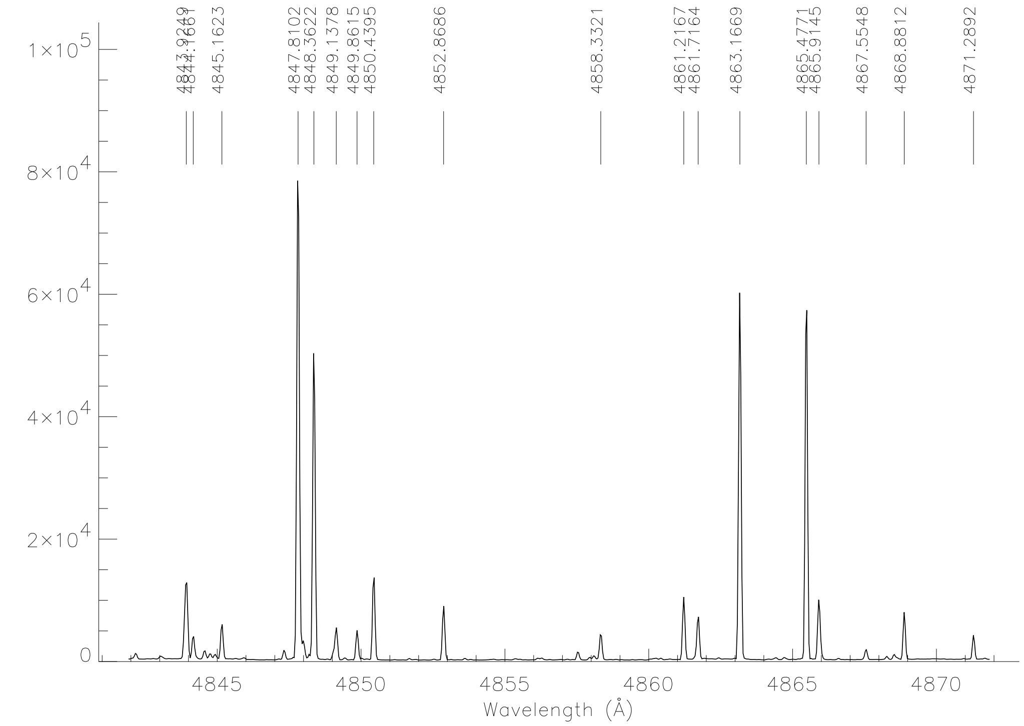


4722.0884
4724.7765
4726.8686
4728.134
4729.1274
4729.8800
4732.0540
4735.9065
4739.6767
4742.1183
4743.6926
4745.3315
4749.1996
4749.9698
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
4725
4730
4735
4740
4745
4750
Wavelength (Å)



4752.4132
4761.1093
4764.3455
4764.8651
4765.5953
4766.6005
4773.2407
4775.3137
4775.7938
4777.1910
4778.2932
4779.7263
5.0×10^5
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
4755
4760
4765
4770
4775
4780
Wavelength (Å)


4782.7608
4783.8636
4786.5311
4787.1477
4789.3865
4792.0825
4793.2450
4795.9137
4800.1714
4806.0213
4808.1336
4809.6141
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
4785
4790
4795
4800
4805
4810
Wavelength (Å)
4812.3758
4813.0069
4819.1917
4820.4644
4820.8850
4821.5875
4822.8541
4823.6056
4823.9967
4826.6991
4829.7973
4831.1210
4831.5974
4832.8020
4840.4743
4840.8426
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
4815
4820
4825
4830
4835
4840
Wavelength (Å)


4843.9249
4844.1661
4845.1623
4847.8102
4848.3622
4849.1378
4849.8615
4850.4395
4852.8686
4858.3321
4861.2167
4861.7164
4863.1669
4865.4771
4865.9145
4867.5548
4868.8812
4871.2892
1×10^5
8×10^4
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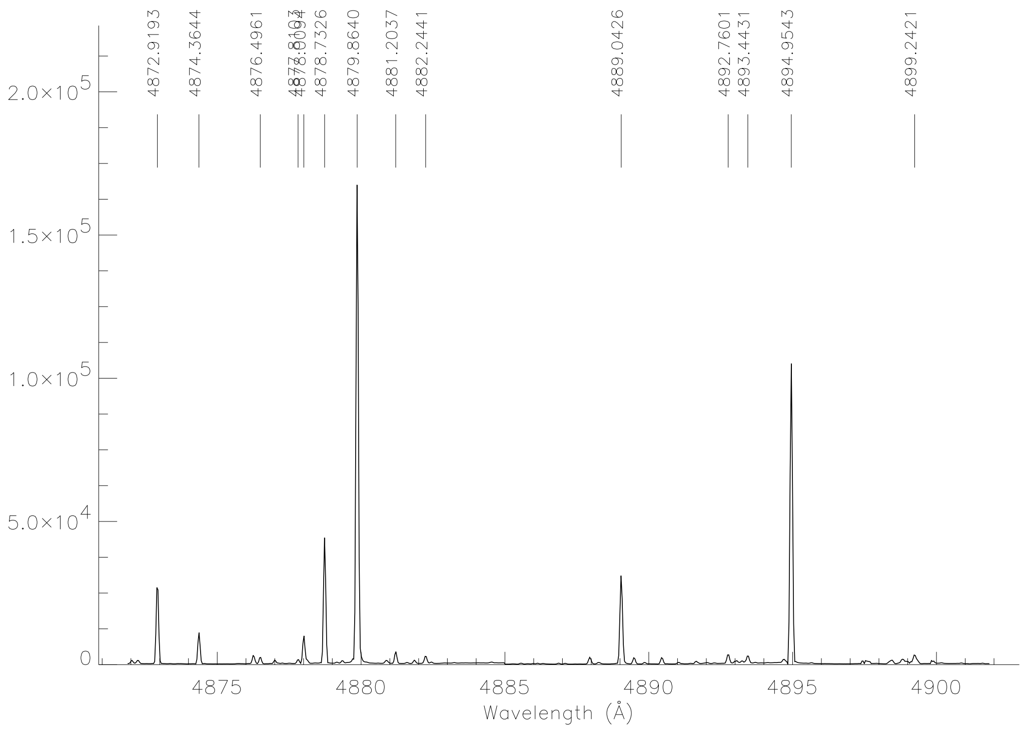
4×10^4
2×10^4
0
4845
4850
4855
4860
4865
4870
Wavelength (Å)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4878.7326
4879.8640
4881.2037
4882.2441
4889.0426
4892.7601
4893.4431
4894.9543
4899.2421
2.0×10^5
1.5×10^5
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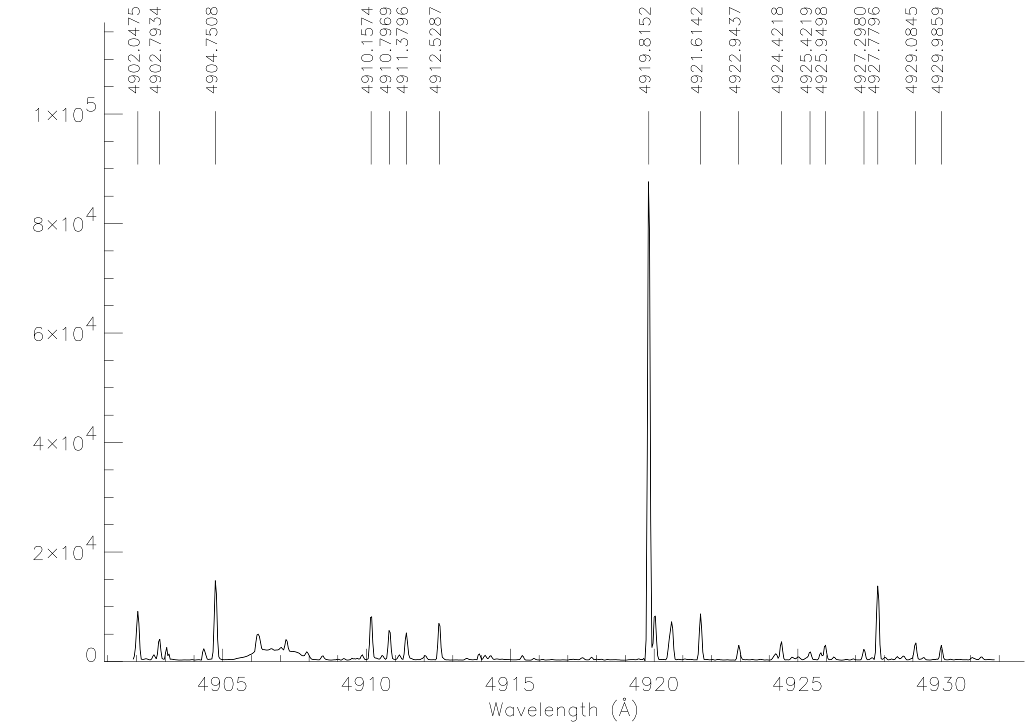
5.0×10^4
0
4875
4880
4885
4890
4895
4900
Wavelength (Å)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4902.7934
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4910.7969
4911.3796
4912.5287
4919.8152
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4922.9437
4924.4218
4925.4219
4925.9498
4927.2980
4927.7796
4929.0845
4929.9859
1×10^5
8×10^4
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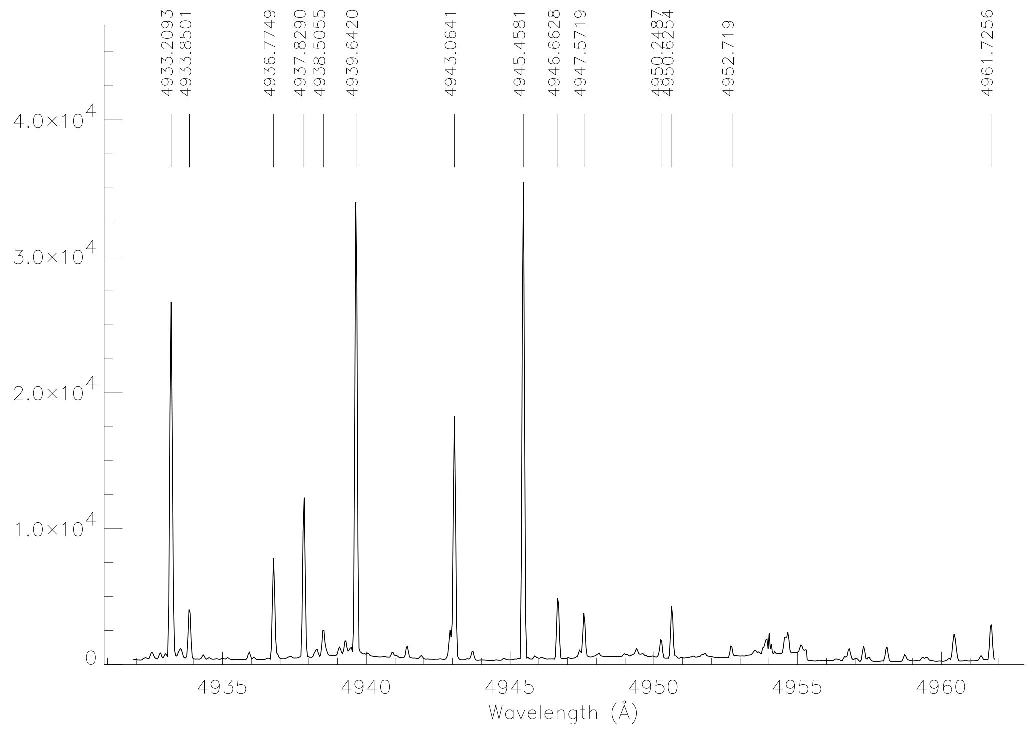
4×10^4
2×10^4
0
4905
4910
4915
4920
4925
4930
Wavelength (Å)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4945.4581
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4947.5719
4950.2487
4950.6254
4952.719
4961.7256
4.0×10^4
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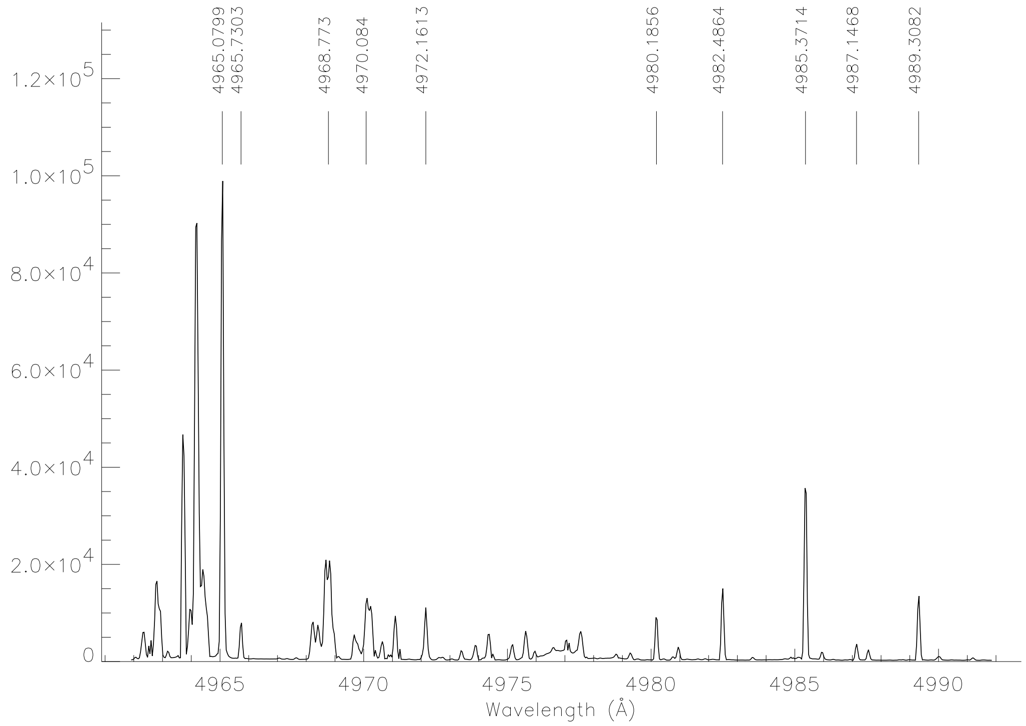
1.0×10^4
0
4935
4940
4945
4950
4955
4960
Wavelength (Å)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4970.084
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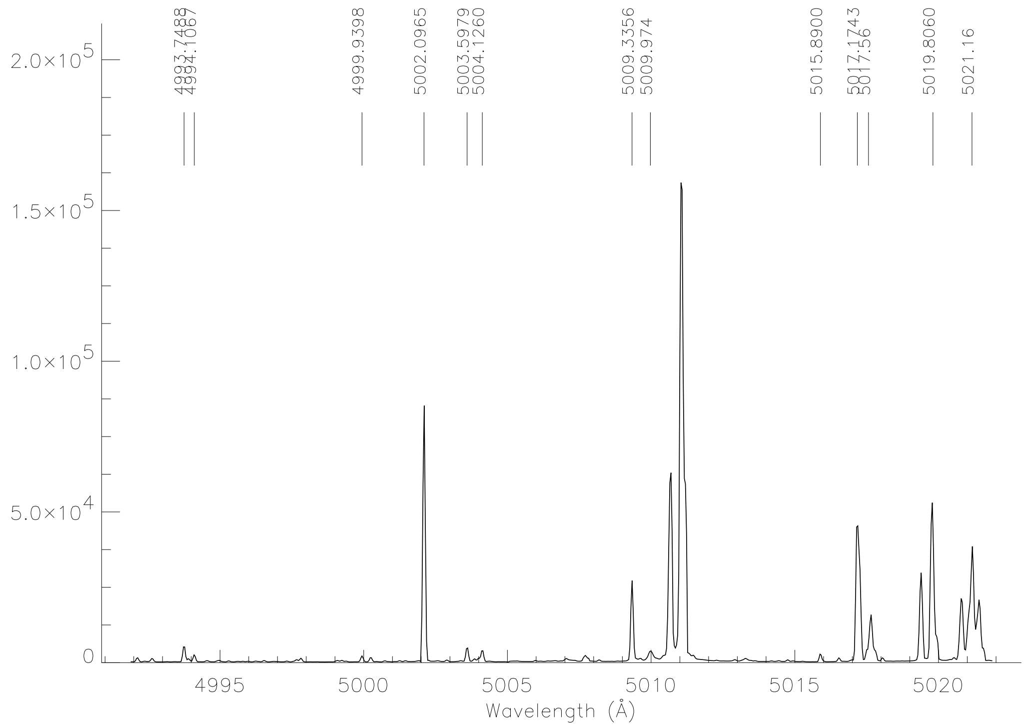
4980.1856
4982.4864
4985.3714
4987.1468
4989.3082
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
4965
4970
4975
4980
4985
4990
Wavelength (Å)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5004.1260
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5009.974
5015.8900
5017.1743
5017.56
5019.8060
5021.16
2.0×10^5
1.5×10^5
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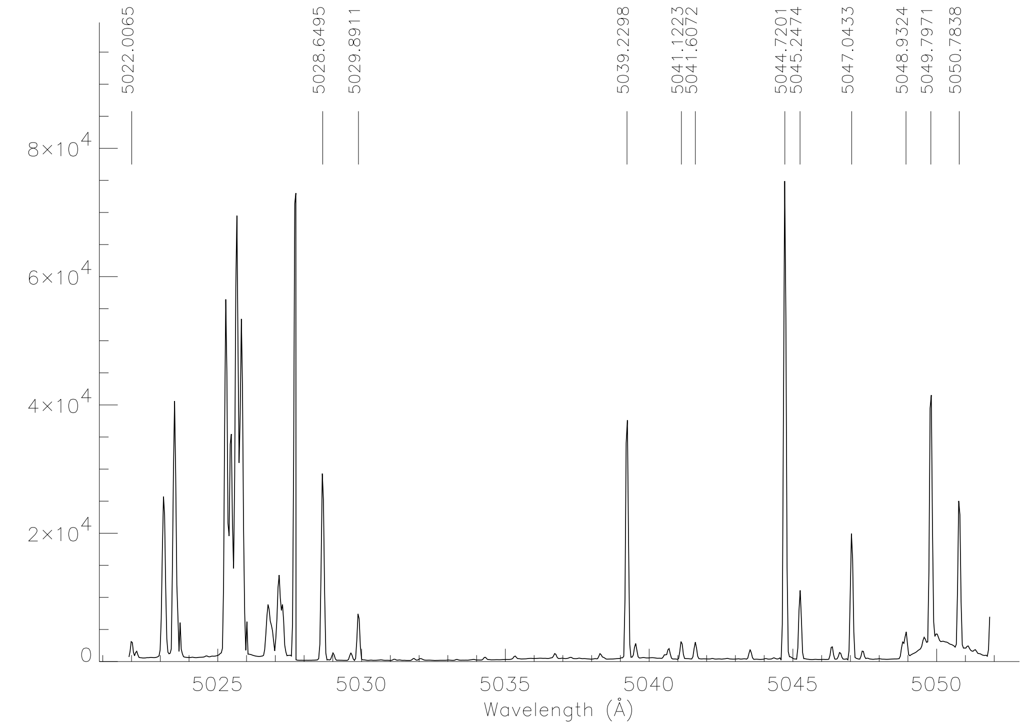
5.0×10^4
0
4995
5000
5005
5010
5015
5020
Wavelength (Å)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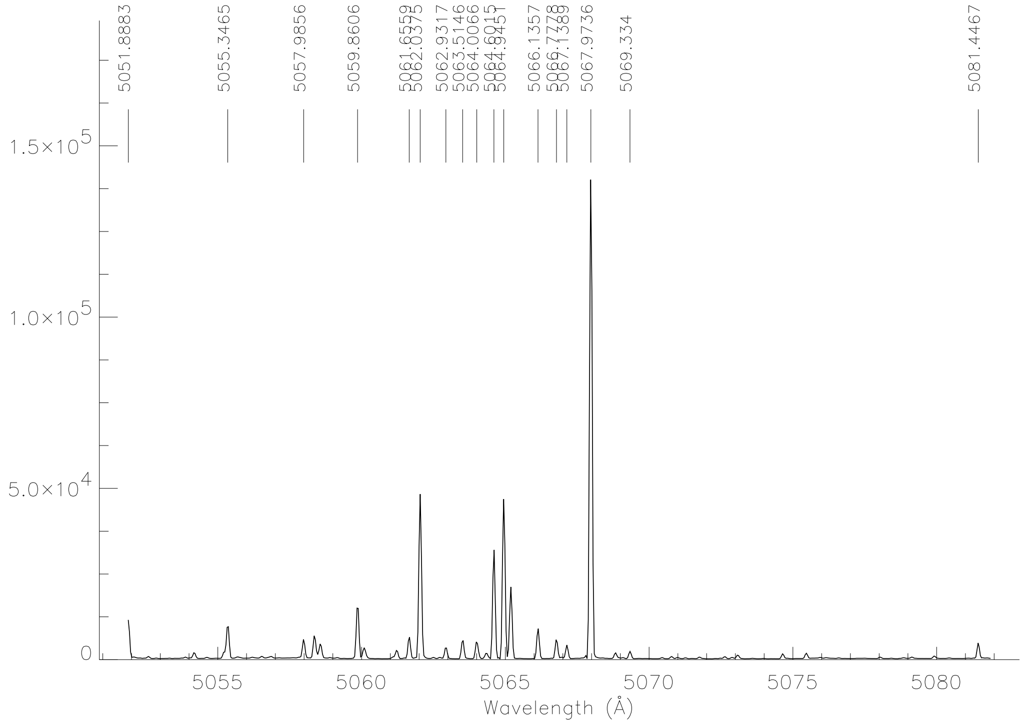
5039.2298
5041.1223
5041.6072
5044.7201
5045.2474
5047.0433
5048.9324
5049.7971
5050.7838
8×10^4
6×10^4
4×10^4
2×10^4
0
5025
5030
5035
5040
5045
5050
Wavelength (Å)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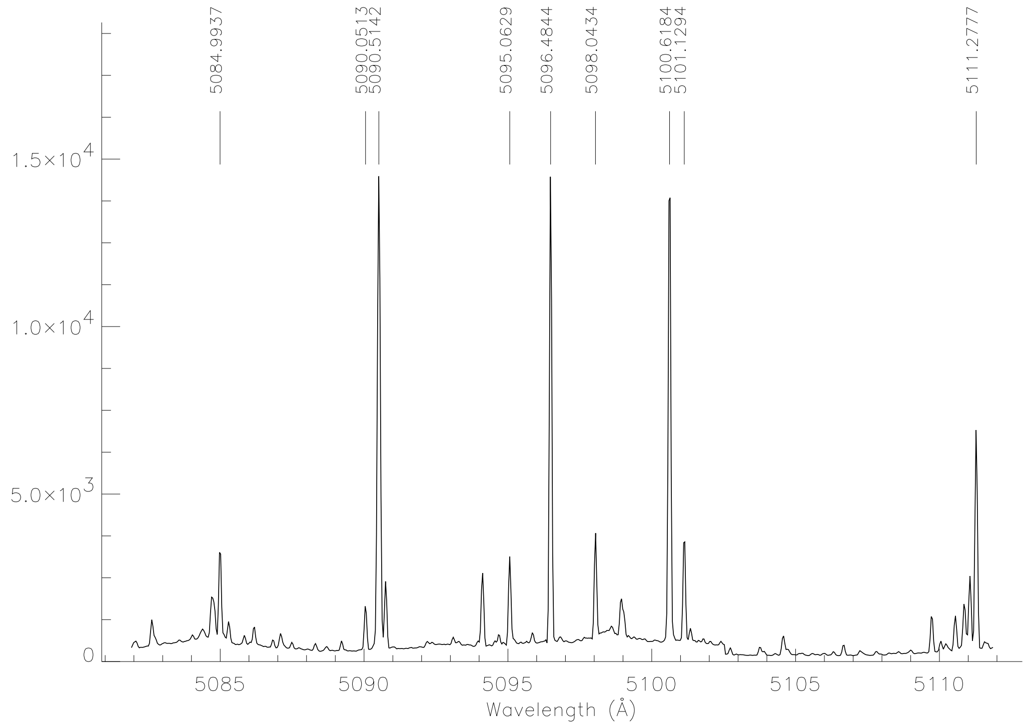
5064.0066
5064.6015
5064.9451
5066.1357
5066.7728
5067.1389
5067.9736
5069.334
5081.4467
1.5×10^5
1.0×10^5
5.0×10^4
0
5055
5060
5065
5070
5075
5080
Wavelength (Å)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5090.5142
5095.0629
5096.4844
5098.0434
5100.6184
5101.1294
5111.2777
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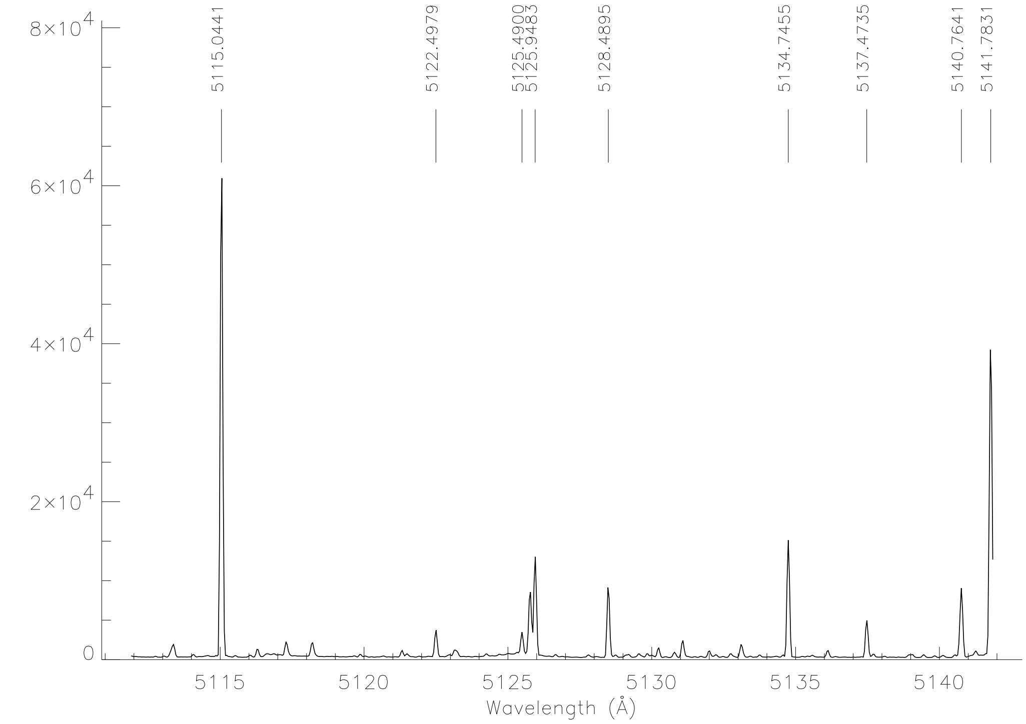
1.0×10^4
5.0×10^3
0
5085
5090
5095
5100
5105
5110
Wavelength (Å)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5125.4900
5125.9483
5128.4895
5134.7455
5137.4735
5140.7641
5141.7831
8×10^4
6×10^4
4×10^4
2×10^4
0
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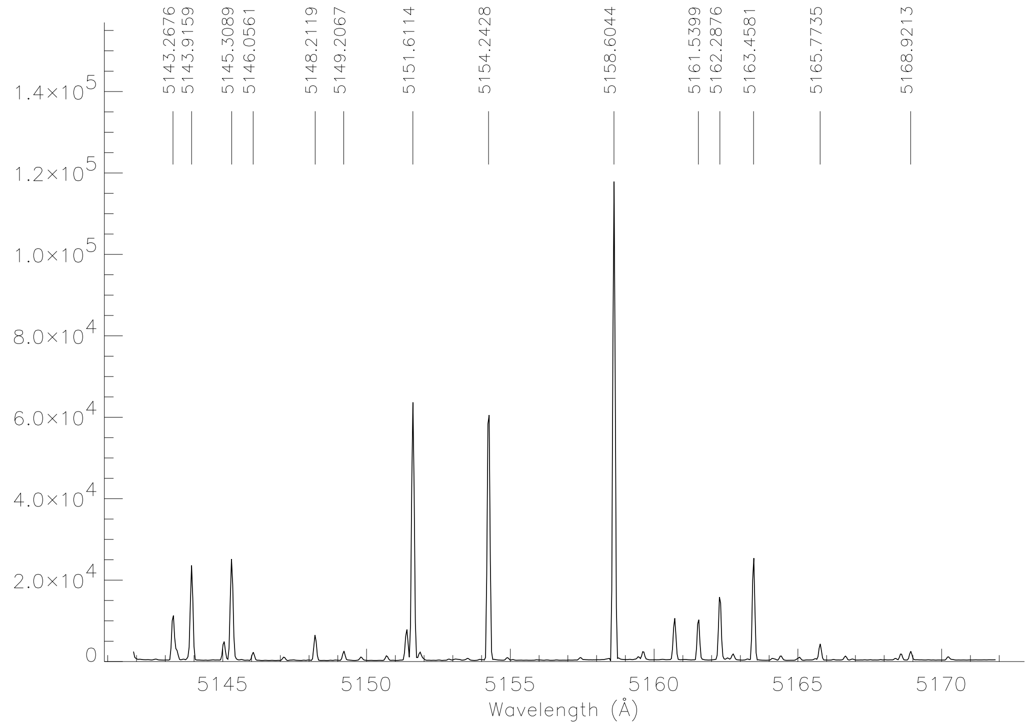
5120
5125
5130
5135
5140
Wavelength (Å)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5149.2067
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5154.2428
5158.6044
5161.5399
5162.2876
5163.4581
5165.7735
5168.9213
1.4×10^5
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
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2.0×10^4
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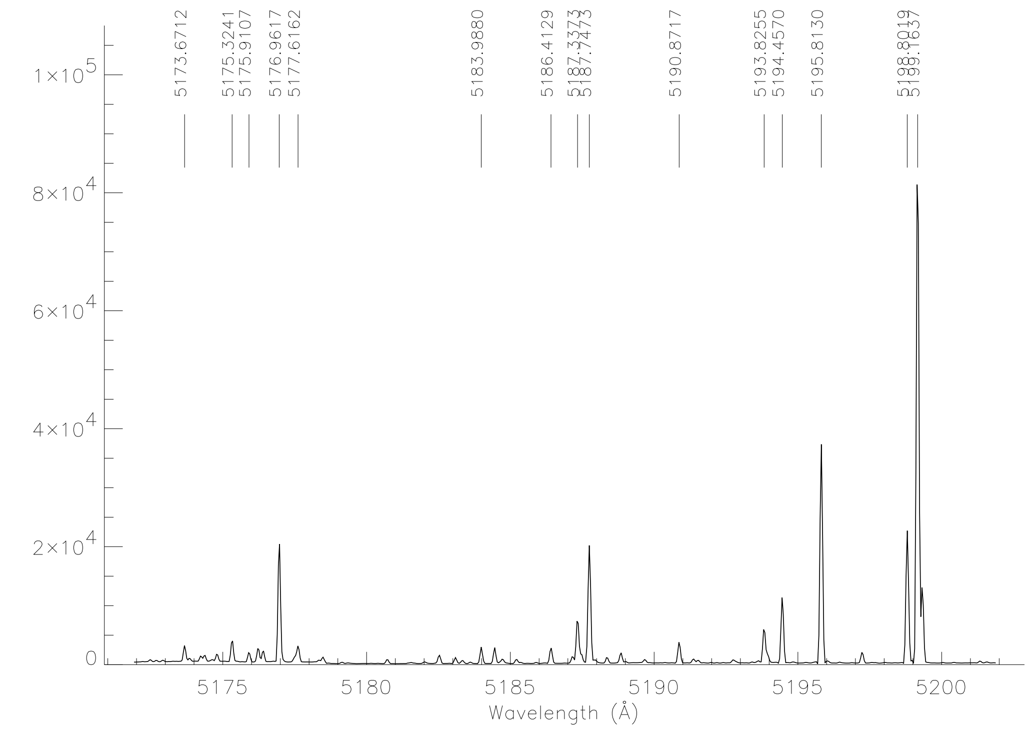
5145
5150
5155
5160
5165
5170
Wavelength (Å)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5177.6162
5183.9880
5186.4129
5187.3373
5187.7473
5190.8717
5193.8255
5194.4570
5195.8130
5198.8019
5199.1637
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
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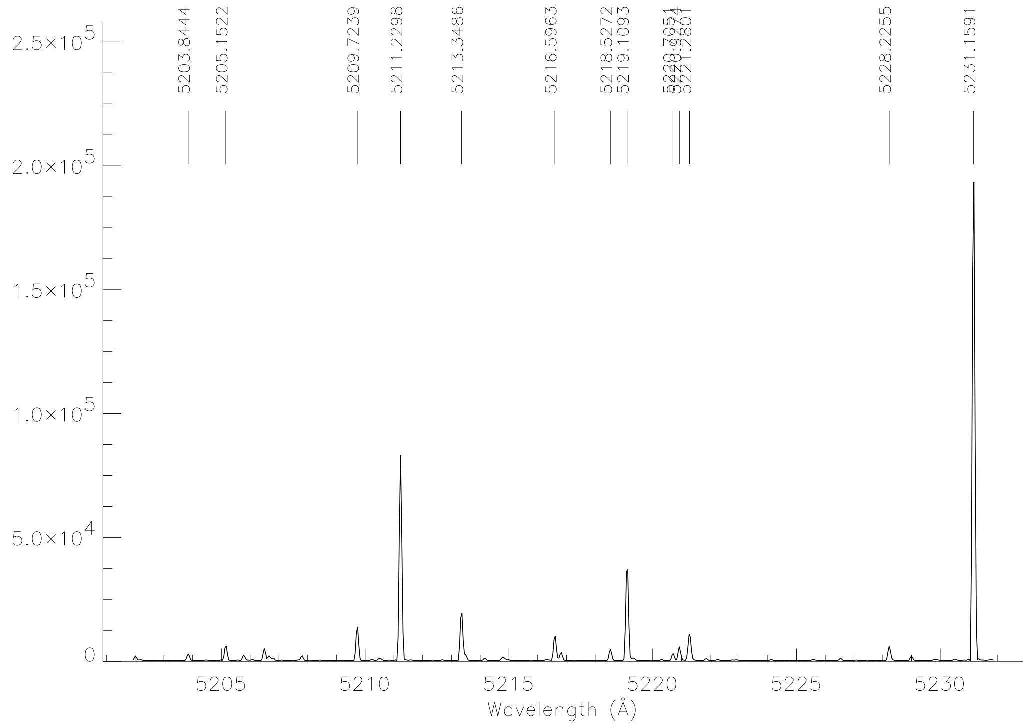
5180
5185
5190
5195
5200
Wavelength (Å)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5209.7239
5211.2298
5213.3486
5216.5963
5218.5272
5219.1093
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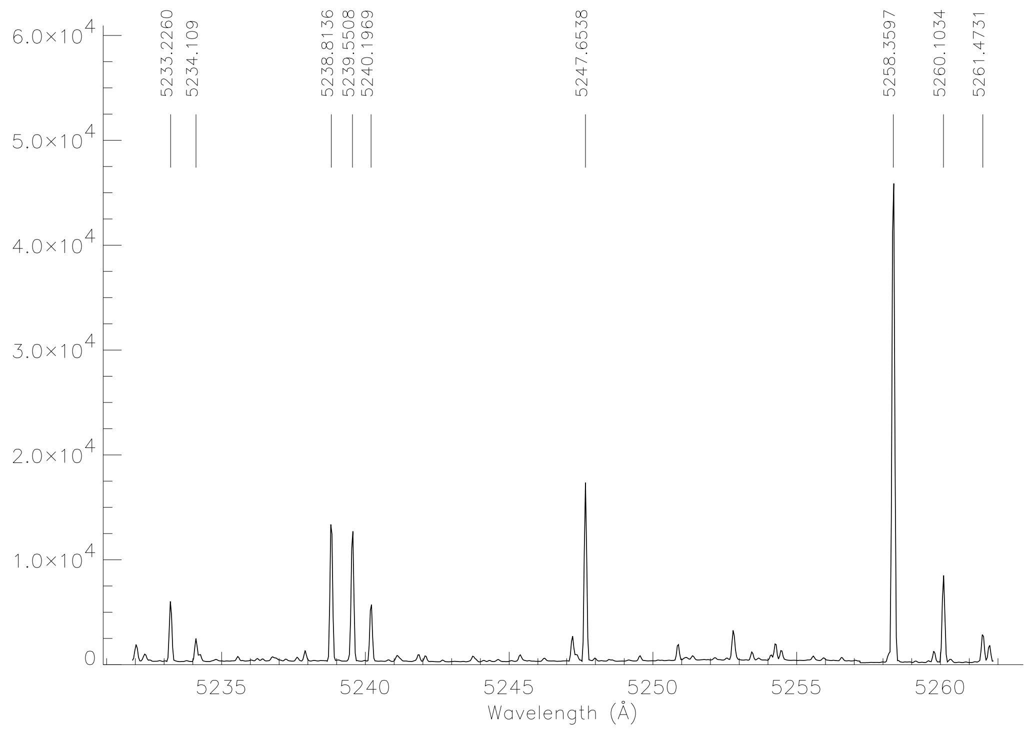
5220.9274
5221.2801
5228.2255
5231.1591
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
5205
5210
5215
5220
5225
5230
Wavelength (Å)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5239.5508
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5247.6538
5258.3597
5260.1034
5261.4731
6.0×10^4
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
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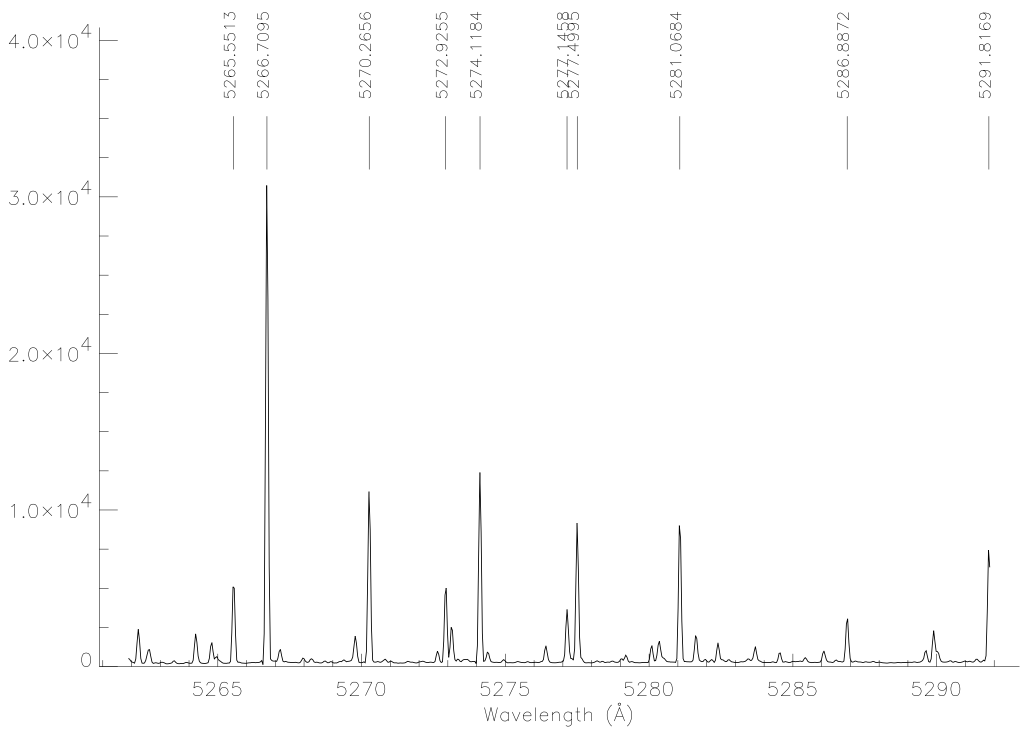
5235
5240
5245
5250
5255
5260
Wavelength (Å)



4.0×10^4
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2.0×10^4
1.0×10^4
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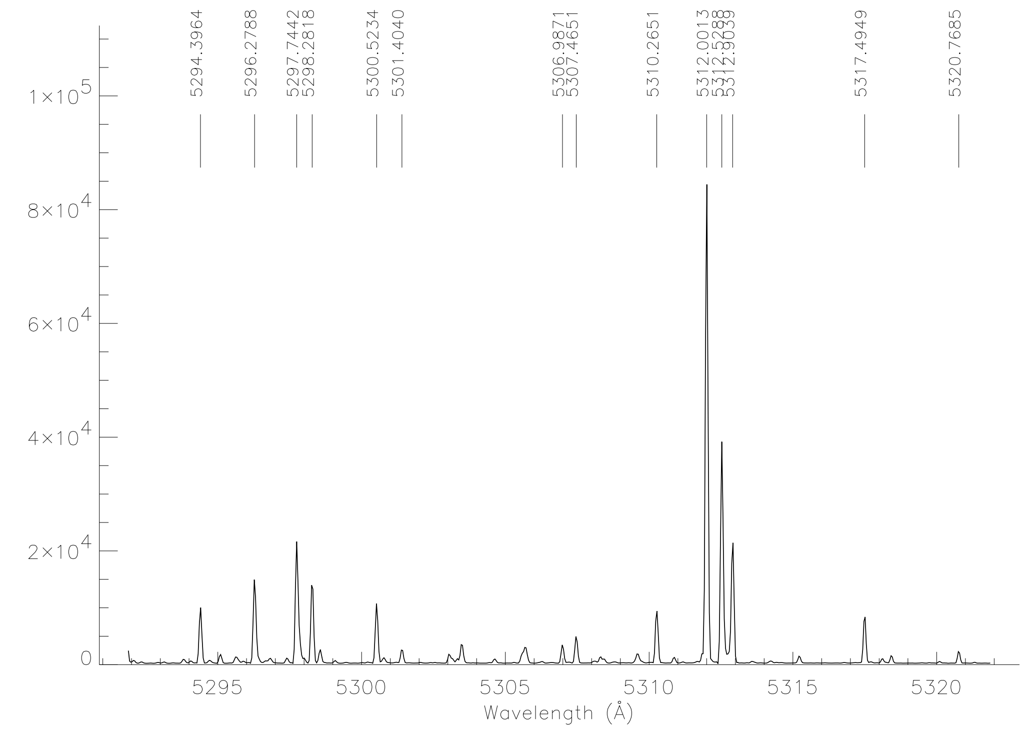
5266.7095
5270.2656
5272.9255
5274.1184
5277.1458
5281.0684
5286.8872
5291.8169
5265
5270
5275
5280
5285
5290
Wavelength (Å)



1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
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5297.7442
5298.2818
5300.5234
5301.4040
5306.9871
5307.4651
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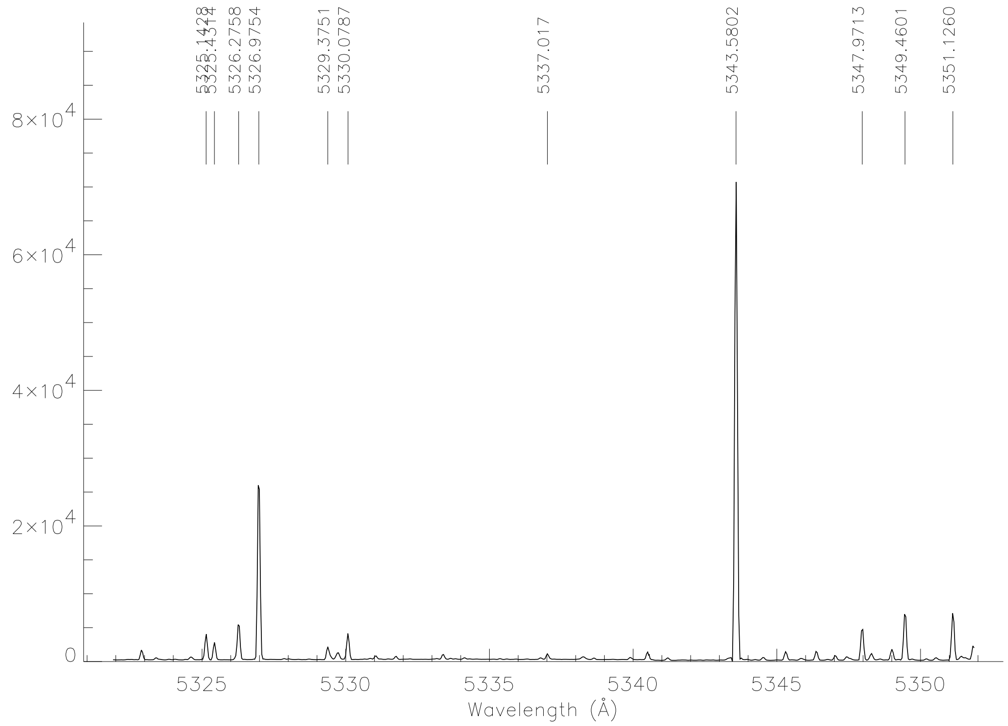
5317.4949
5320.7685
5295
5300
5305
5310
5315
5320
Wavelength (Å)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5325.4314
5326.2758
5326.9754
5329.3751
5330.0787
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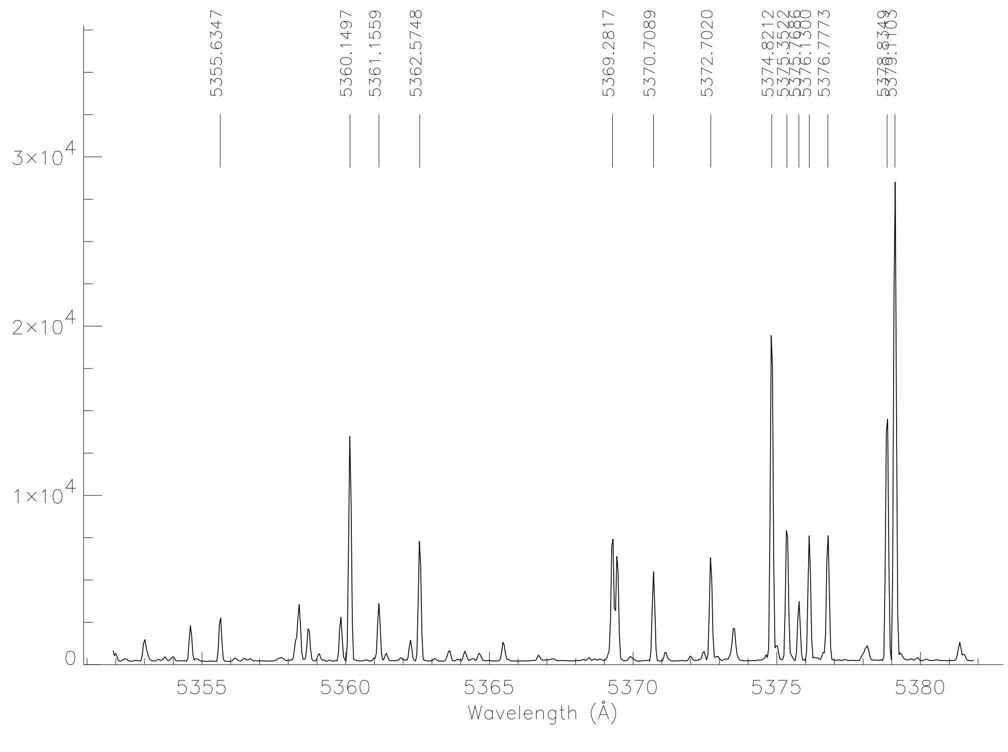
5343.5802
5347.9713
5349.4601
5351.1260
8×10^4
6×10^4
4×10^4
2×10^4
0
5325
5330
5335
5340
5345
5350
Wavelength (Å)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5360.1497
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5370.7089
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5374.8212
5376.1300
5376.7773
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1×10^4
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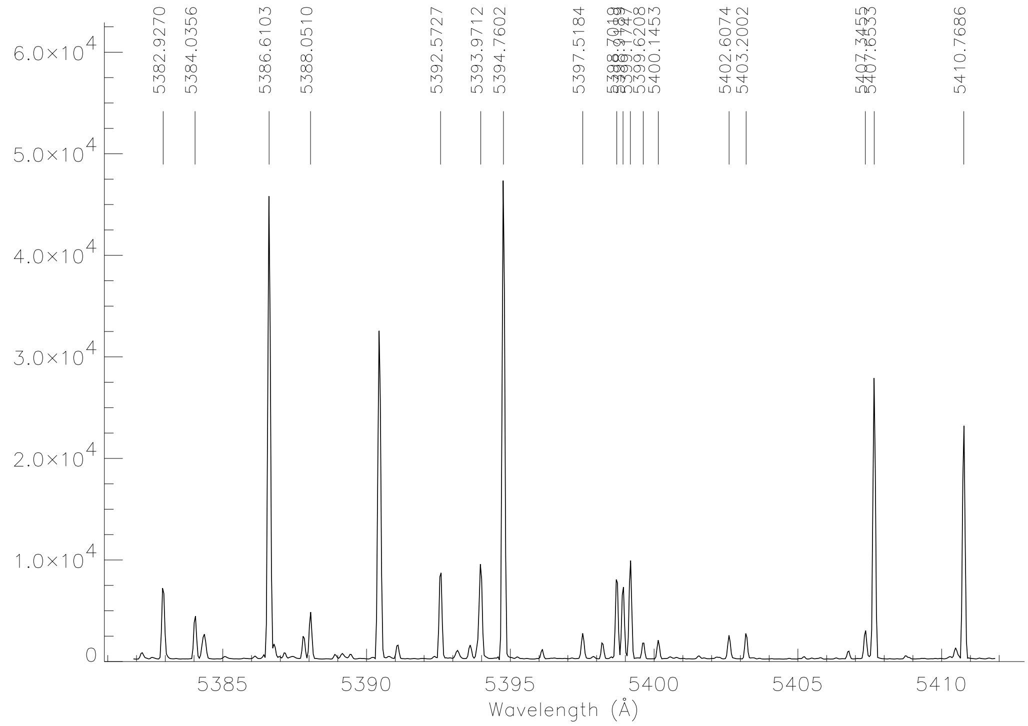
5360
5365
5370
5375
5380
Wavelength (Å)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5392.5727
5393.9712
5394.7602
5397.5184
5399.6208
5400.1453
5402.6074
5403.2002
5410.7686
6.0×10^4
5.0×10^4
4.0×10^4
3.0×10^4
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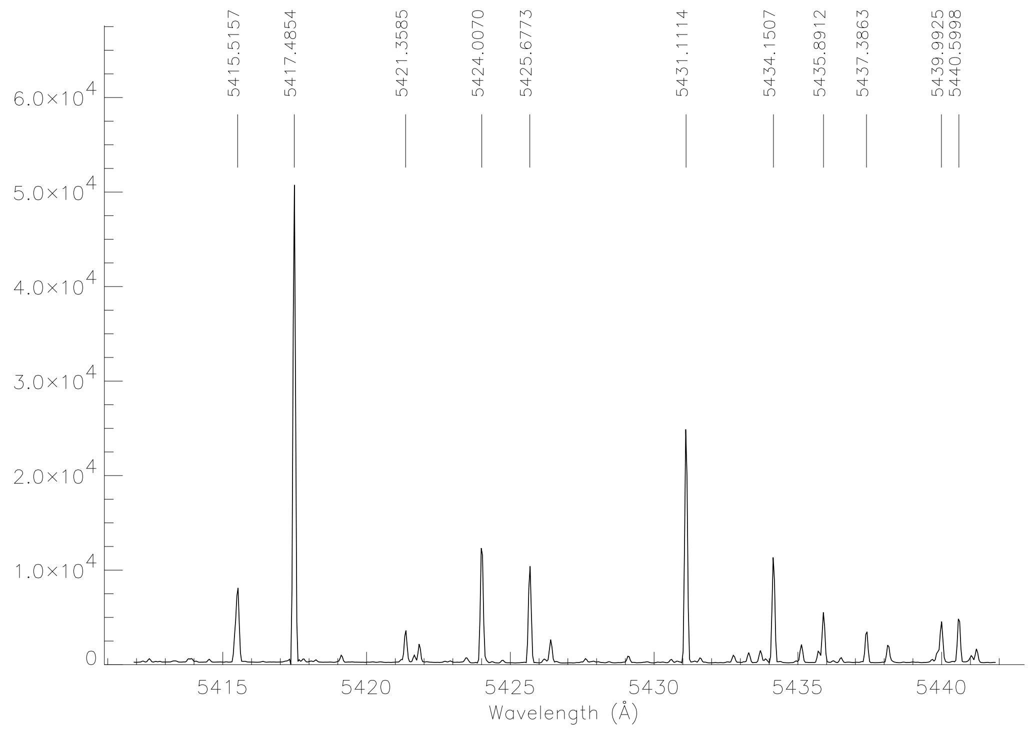
1.0×10^4
0
5385
5390
5395
5400
5405
5410
Wavelength (Å)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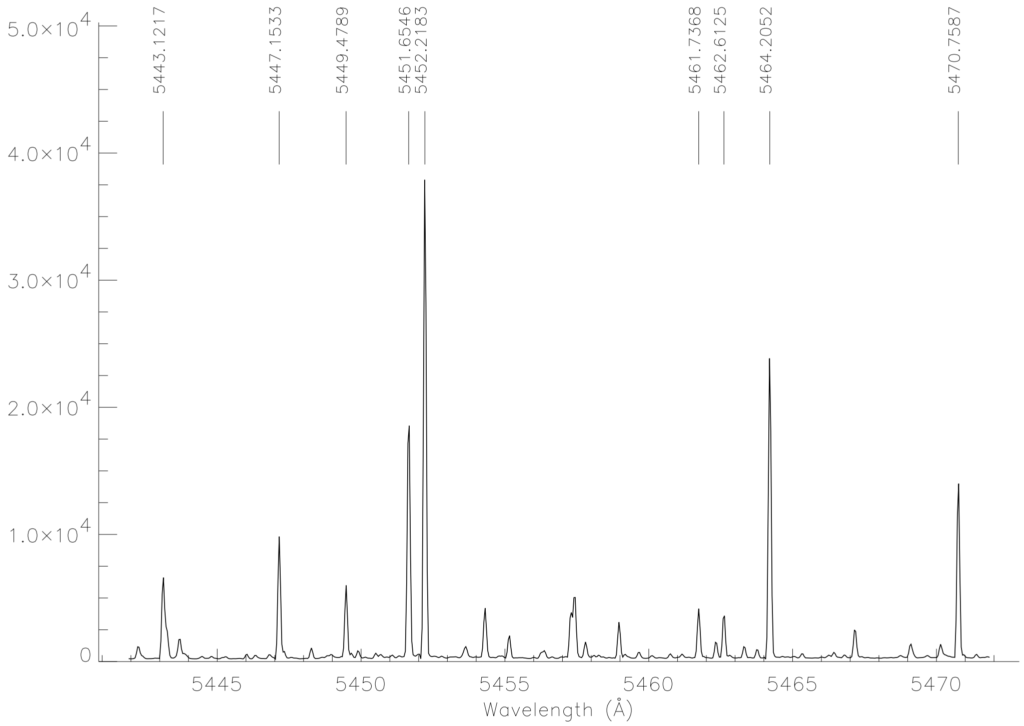
5417.4854
5421.3585
5424.0070
5425.6773
5431.1114
5434.1507
5435.8912
5437.3863
5439.9925
5440.5998
6.0×10^4
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
5415
5420
5425
5430
5435
5440
Wavelength (Å)


5443.1217
5447.1533
5449.4789
5451.6546
5452.2183
5461.7368
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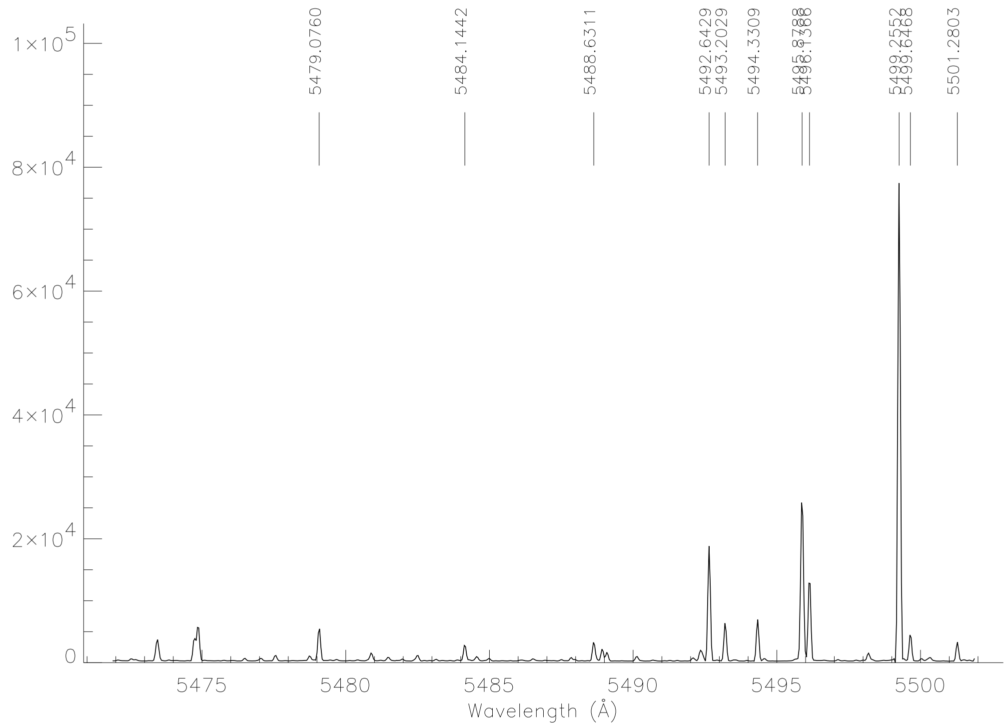
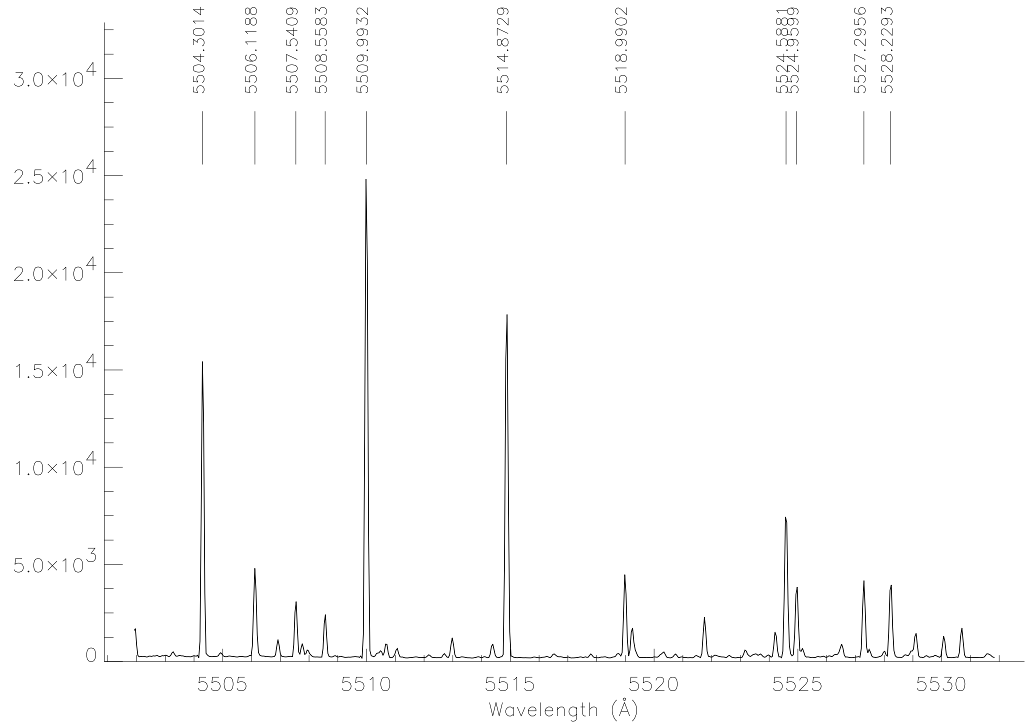
5464.2052
5470.7587
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
5445
5450
5455
5460
5465
5470
Wavelength (Å)


5479.0760
5484.1442
5488.6311
5492.6429
5493.2029
5494.3309
5495.8788
5496.1368
5499.2552
5499.6468
5501.2803
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
5475
5480
5485
5490
5495
5500
Wavelength (Å)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5506.1188
5507.5409
5508.5583
5509.9932
5514.8729
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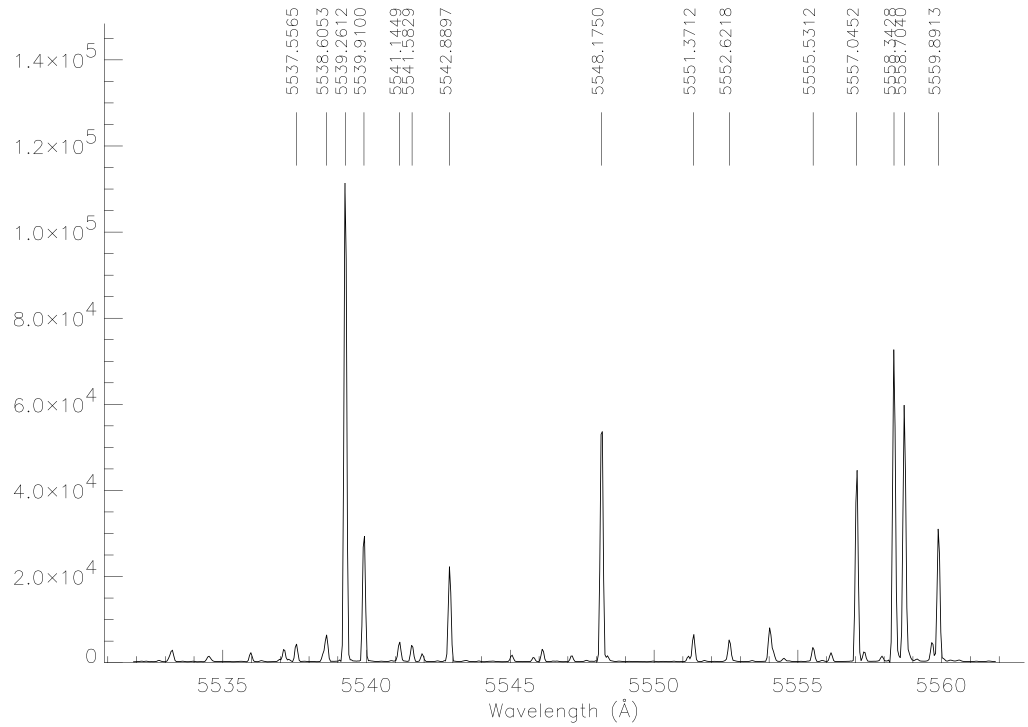
5524.5881
5524.9599
5527.2956
5528.2293
3.0×10^4
2.5×10^4
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
0
5505
5510
5515
5520
5525
5530
Wavelength (Å)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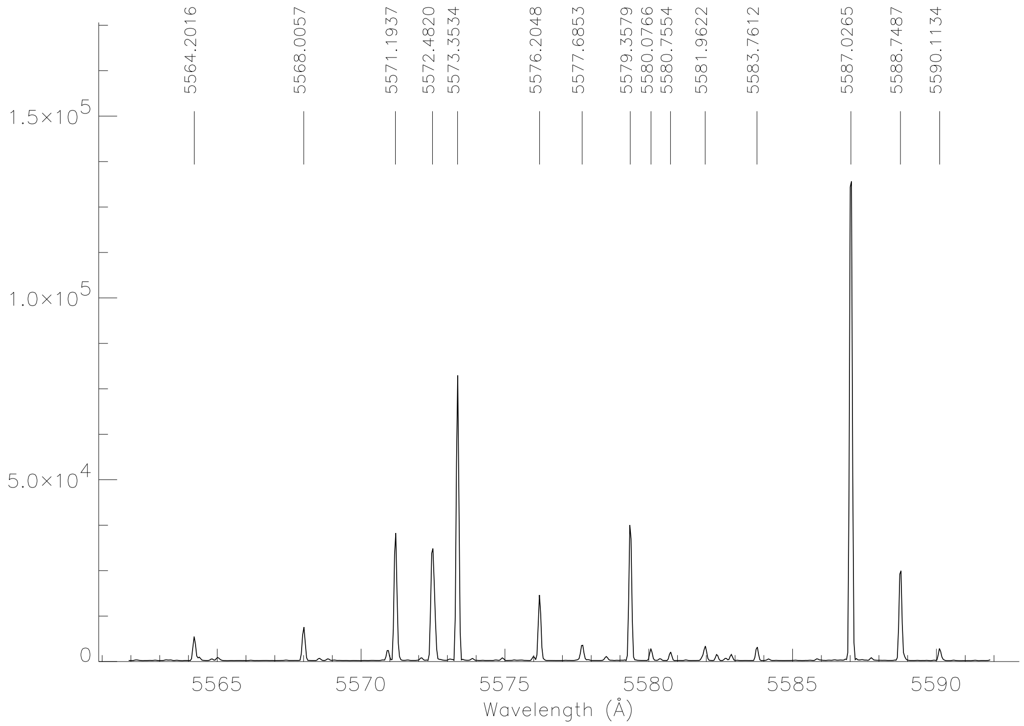
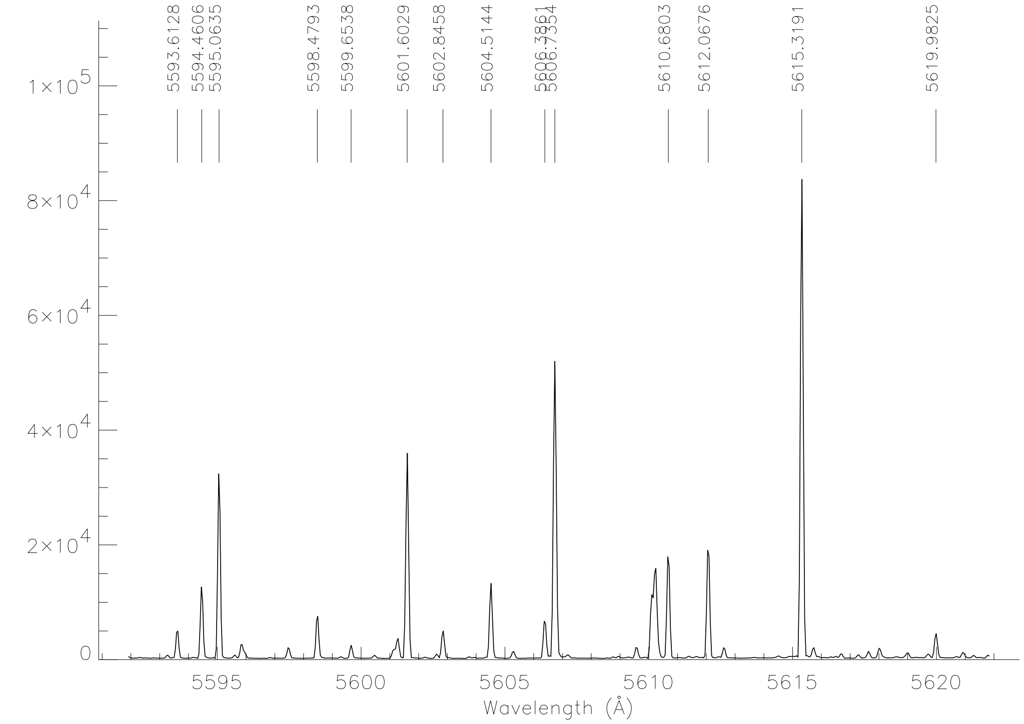
5539.2612
5539.9100
5541.1449
5541.5829
5542.8897
5548.1750
5551.3712
5552.6218
5555.5312
5557.0452
5558.3428
5558.7040
5559.8913
1.4×10^5
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
5535
5540
5545
5550
5555
5560
Wavelength (Å)



5564.2016
5568.0057
5571.1937
5572.4820
5573.3534
5576.2048
5577.6853
5579.3579
5580.0766
5580.7554
5581.9622
5583.7612
5587.0265
5588.7487
5590.1134
1.5×10^5
1.0×10^5
5.0×10^4
0
5565
5570
5575
5580
5585
5590
Wavelength (Å)



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5594.4606
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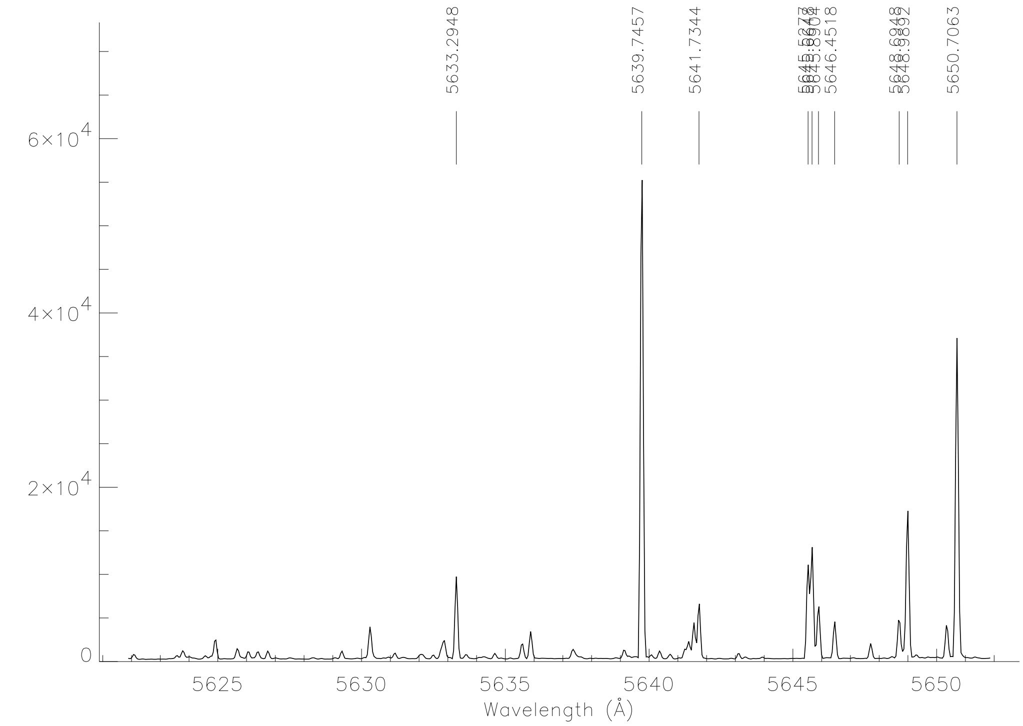
5598.4793
5599.6538
5601.6029
5602.8458
5604.5144
5606.3861
5606.7354
5610.6803
5612.0676
5615.3191
5619.9825
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
5595
5600
5605
5610
5615
5620
Wavelength (Å)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5639.7457
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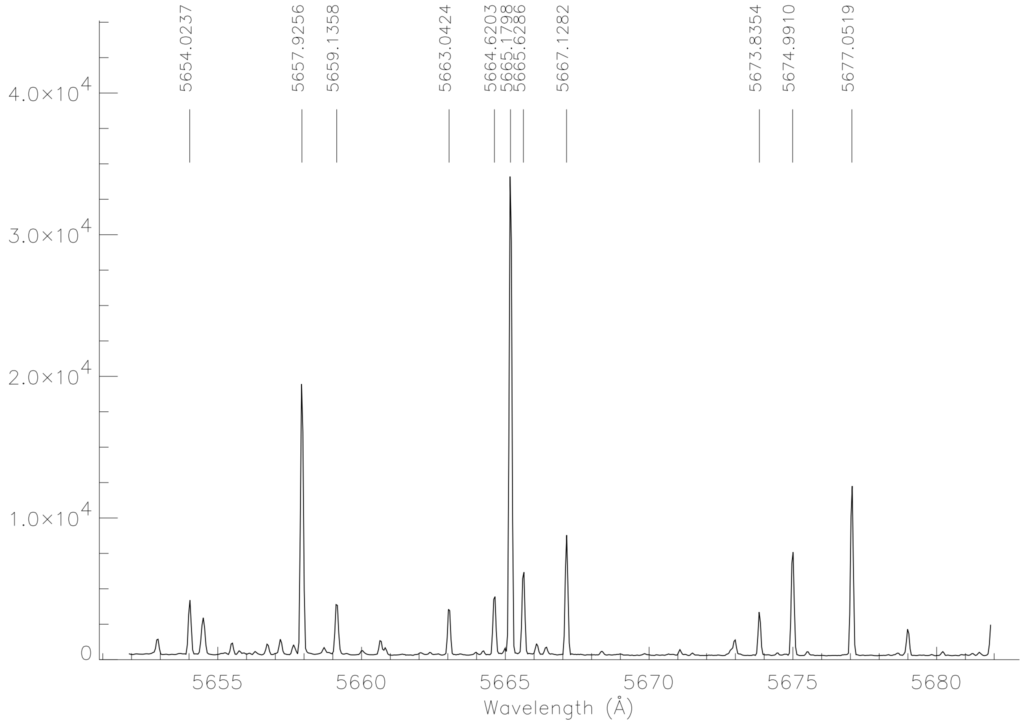
5645.5273
5645.6640
5645.8904
5646.4518
5648.6948
5648.9832
5650.7063
6×10^4
4×10^4
2×10^4
0
5625
5630
5635
5640
5645
5650
Wavelength (Å)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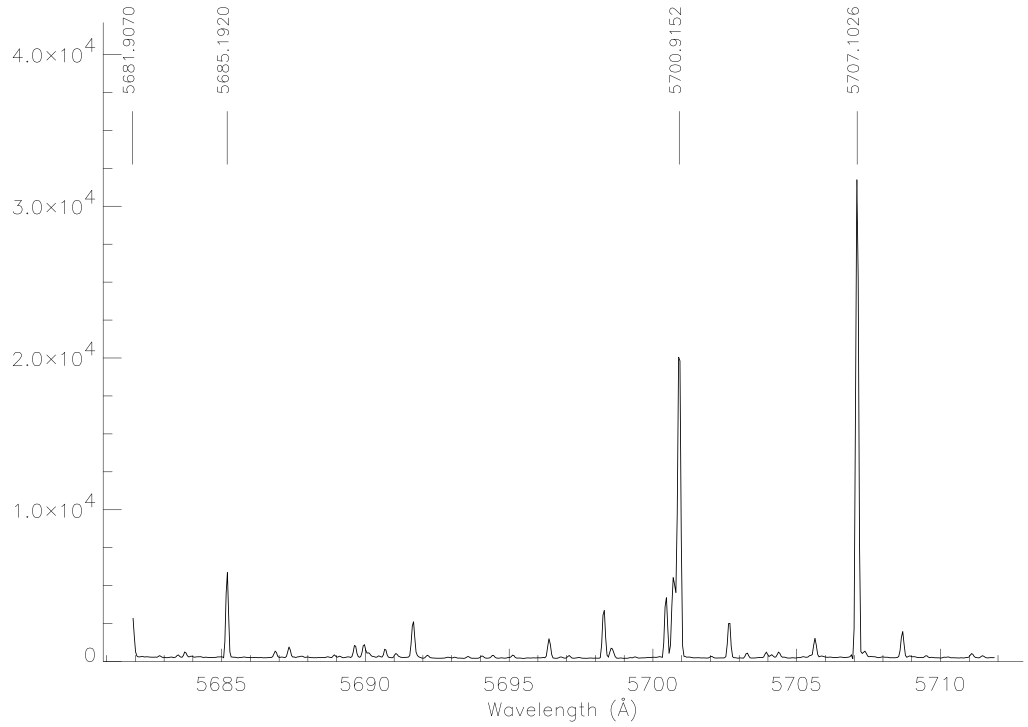
5657.9256
5659.1358
5663.0424
5664.6203
5665.1798
5665.6286
5667.1282
5673.8354
5674.9910
5677.0519
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
5655
5660
5665
5670
5675
5680
Wavelength (Å)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1.0×10^4
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5685
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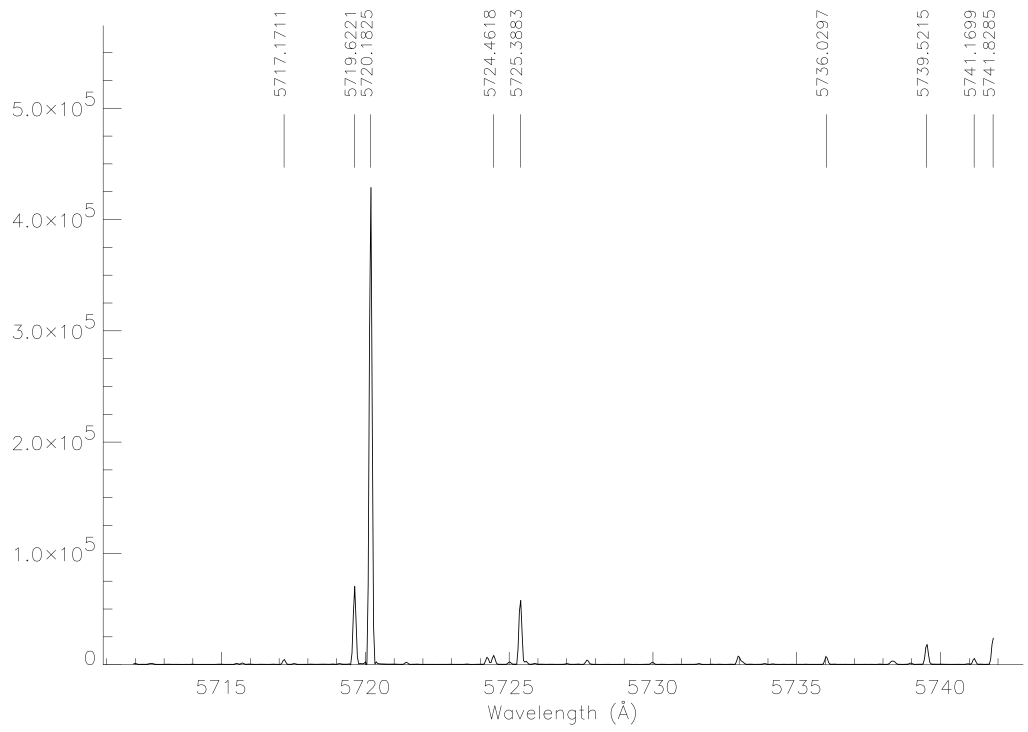
5695
5700
5705
5710
Wavelength (Å)


5717.1711
5719.6221
5720.1825
5724.4618
5725.3883
5736.0297
5739.5215
5741.1699
5741.8285
5.0×10^5
4.0×10^5
3.0×10^5
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1.0×10^5
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5715
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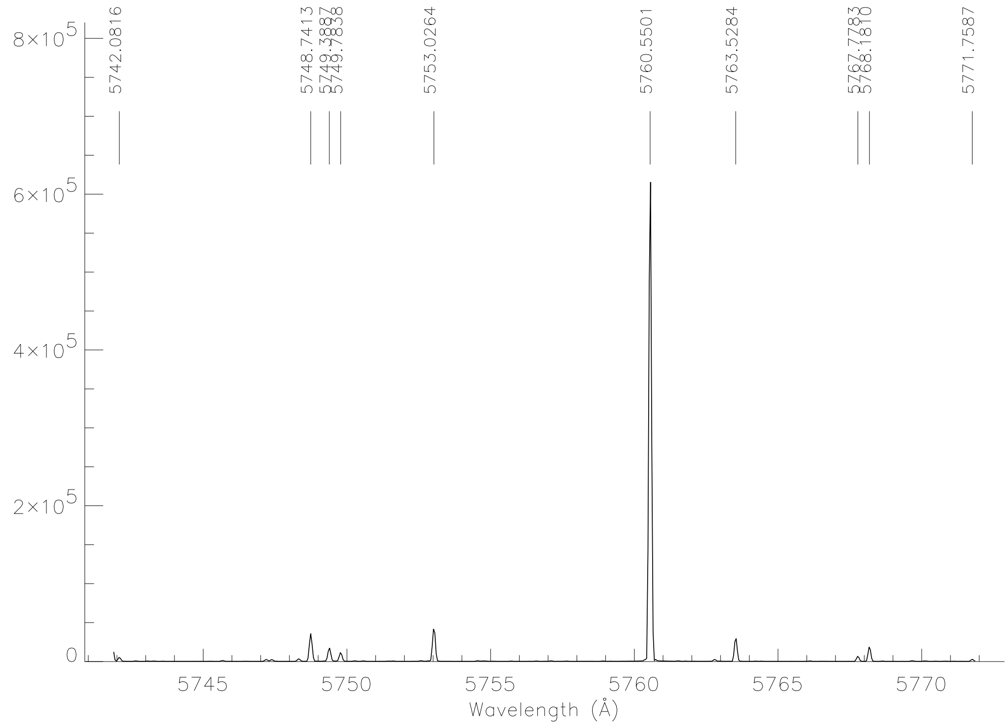
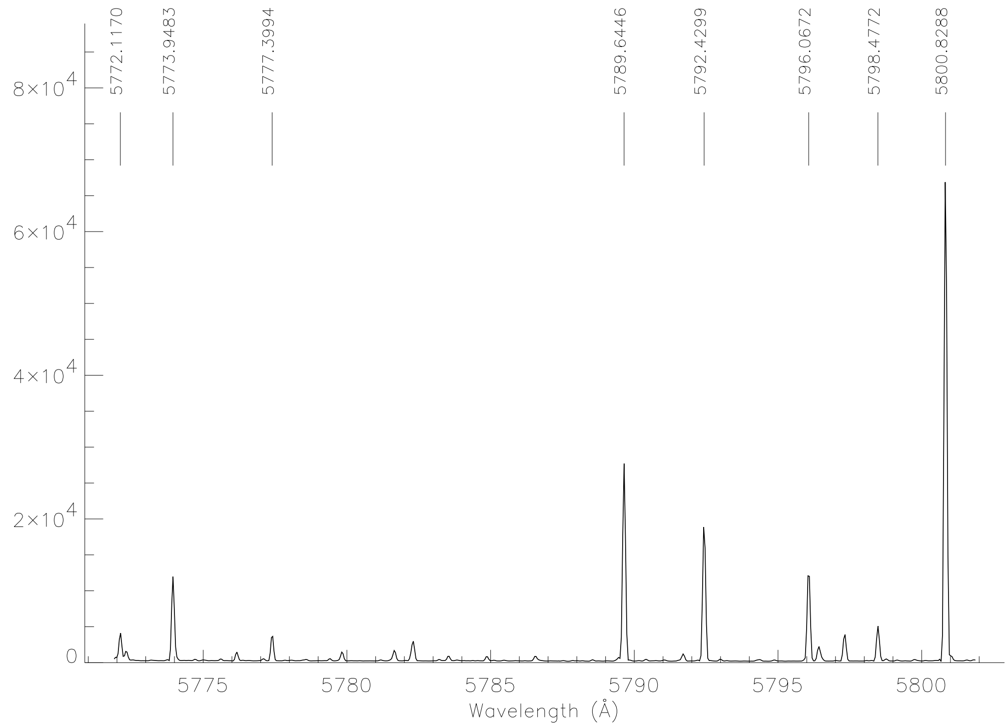
5725
5730
5735
5740
Wavelength (Å)



5742.0816
5748.7413
5749.3887
5749.7858
5753.0264
5760.5501
5763.5284
5767.7783
5768.1810
5771.7587
8×10^5
6×10^5
4×10^5
2×10^5
0
5745
5750
5755
5760
5765
5770
Wavelength (Å)



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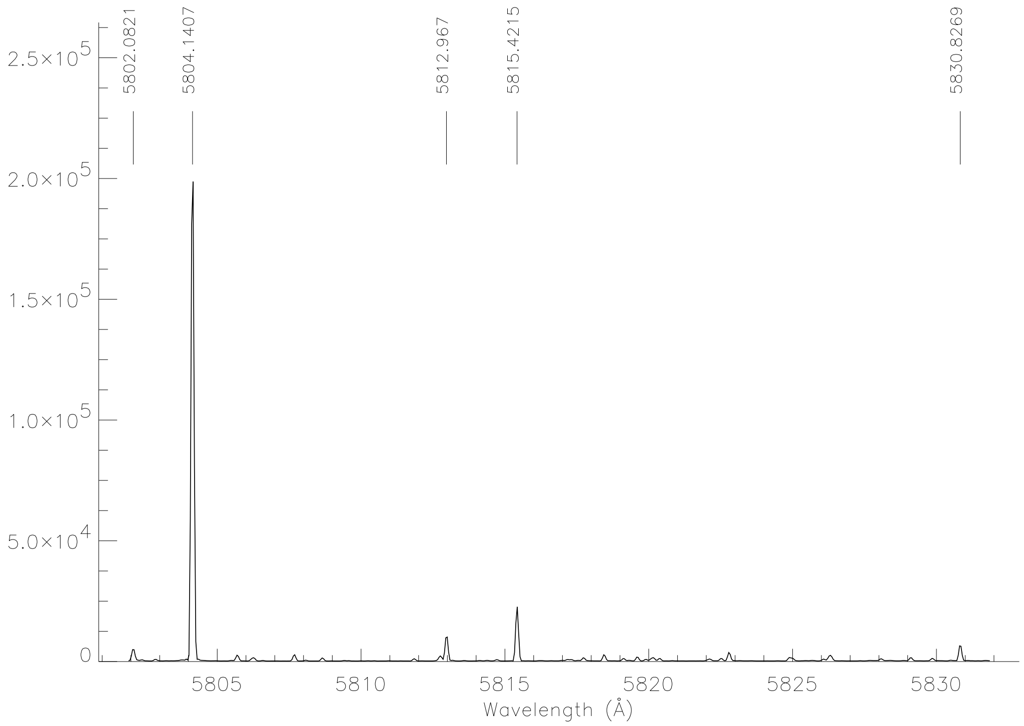
5773.9483
5777.3994
5789.6446
5792.4299
5796.0672
5798.4772
5800.8288
8×10^4
6×10^4
4×10^4
2×10^4
0
5775
5780
5785
5790
5795
5800
Wavelength (Å)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2.0×10^5
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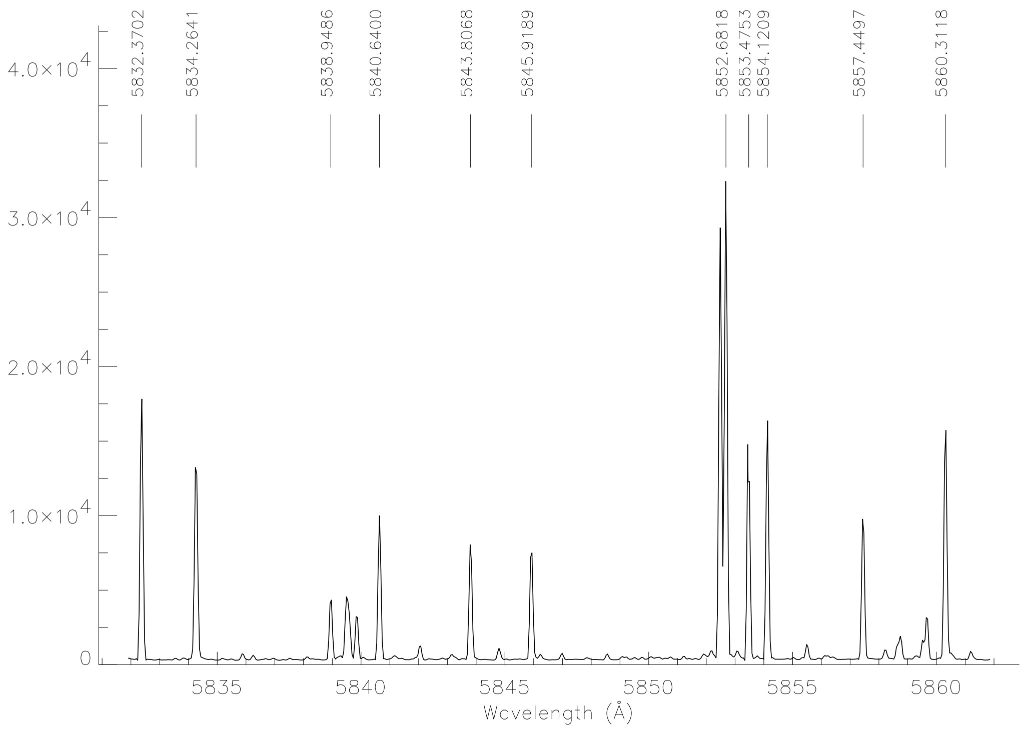
5810
5815
5820
5825
5830
Wavelength (Å)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5843.8068
5845.9189
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5853.4753
5854.1209
5857.4497
5860.3118
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
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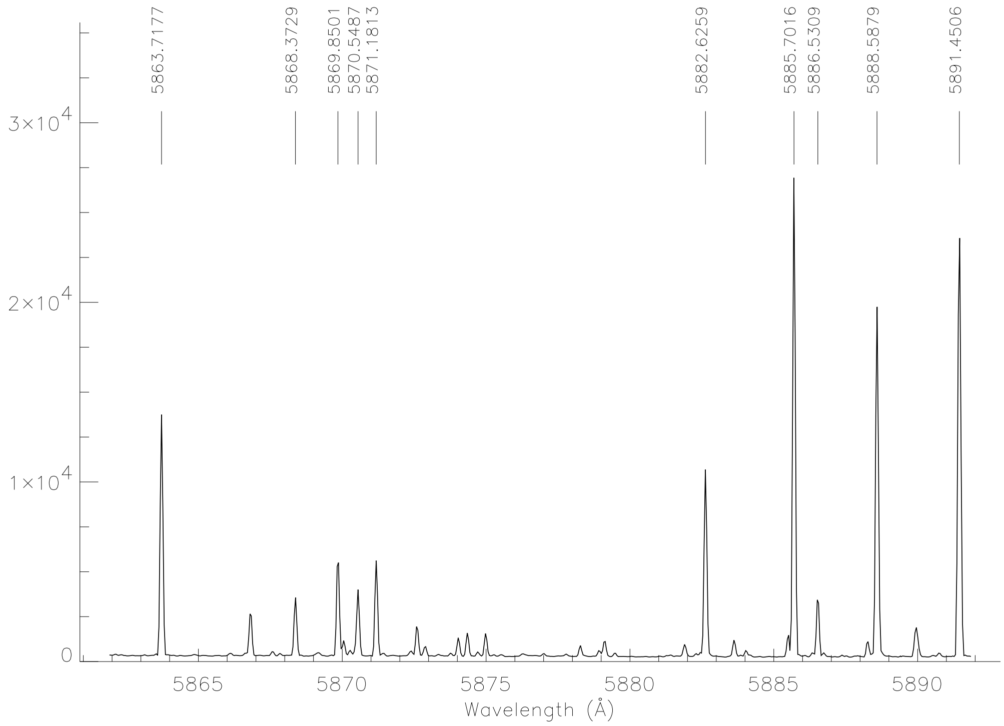
5840
5845
5850
5855
5860
Wavelength (Å)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5870.5487
5871.1813
5882.6259
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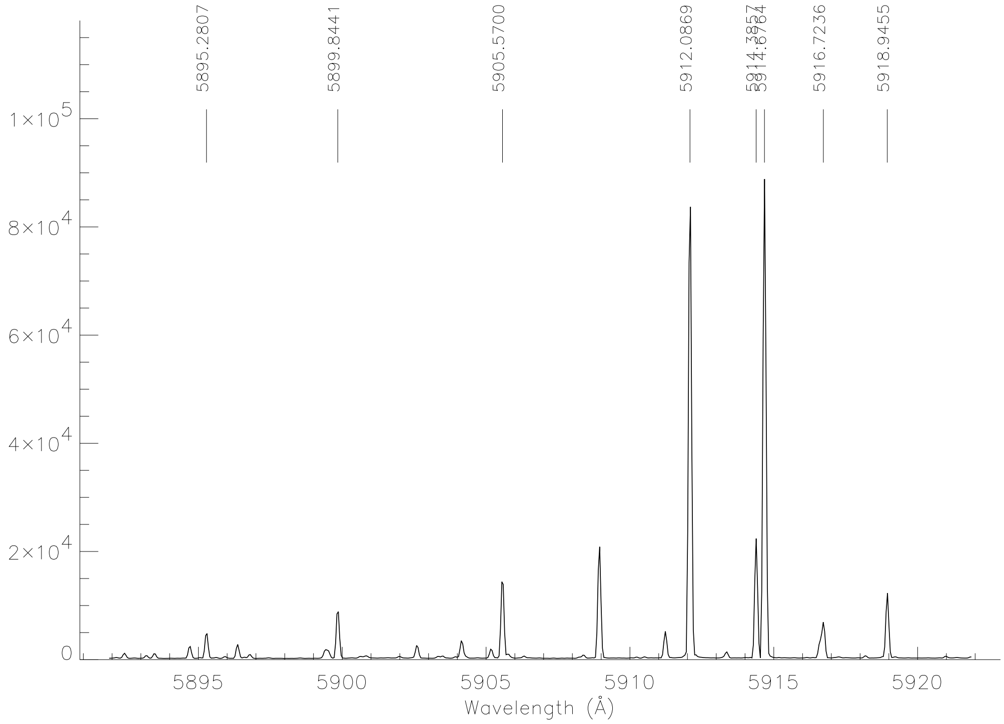
5886.5309
5888.5879
5891.4506
3×10⁴
2×10⁴
1×10⁴
0
5865
5870
5875
5880
5885
5890
Wavelength (Å)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5914.6764
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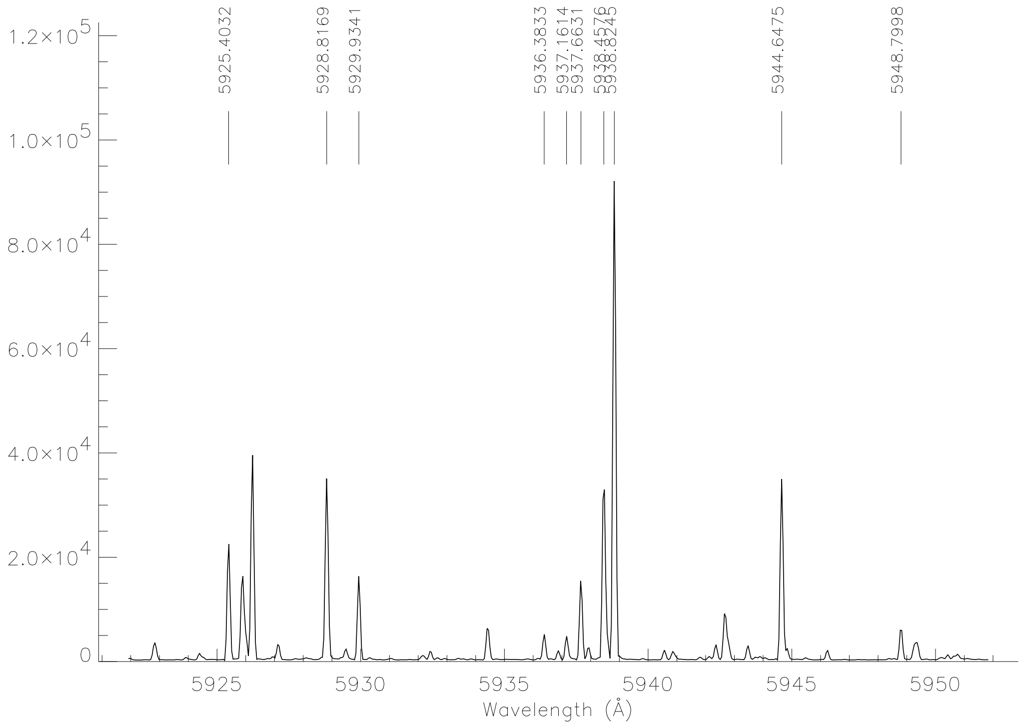
5918.9455
1×10⁵
8×10⁴
6×10⁴
4×10⁴
2×10⁴
0
5895
5900
5905
5910
5915
5920
Wavelength (Å)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5937.6631
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5938.8245
5944.6475
5948.7998
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
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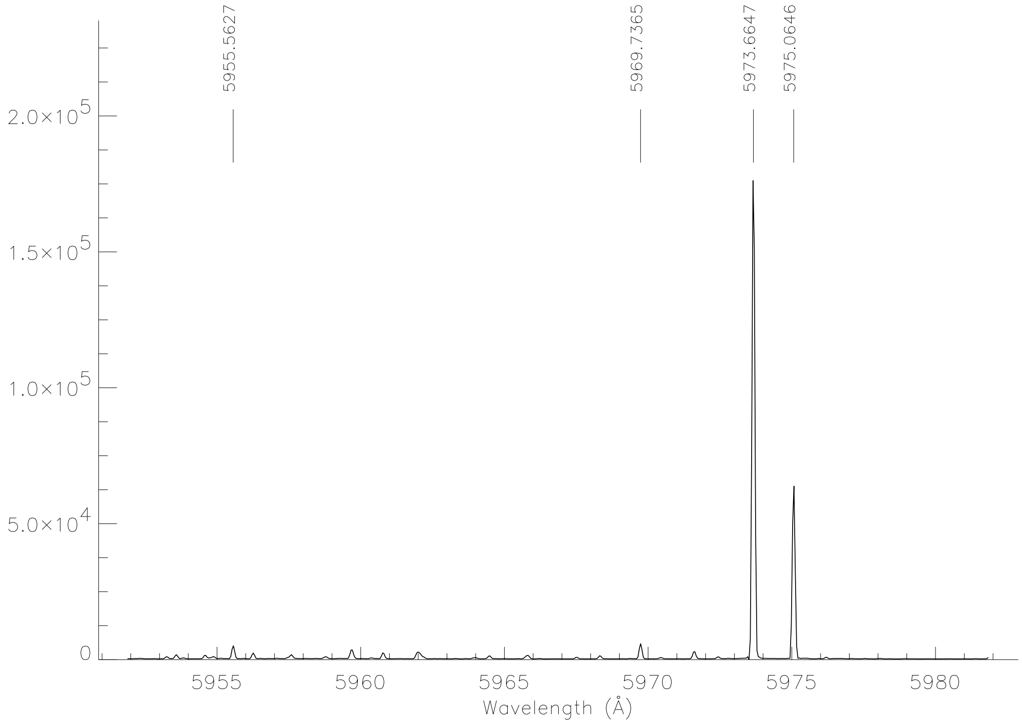
5930
5935
5940
5945
5950
Wavelength (Å)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5.0×10^4
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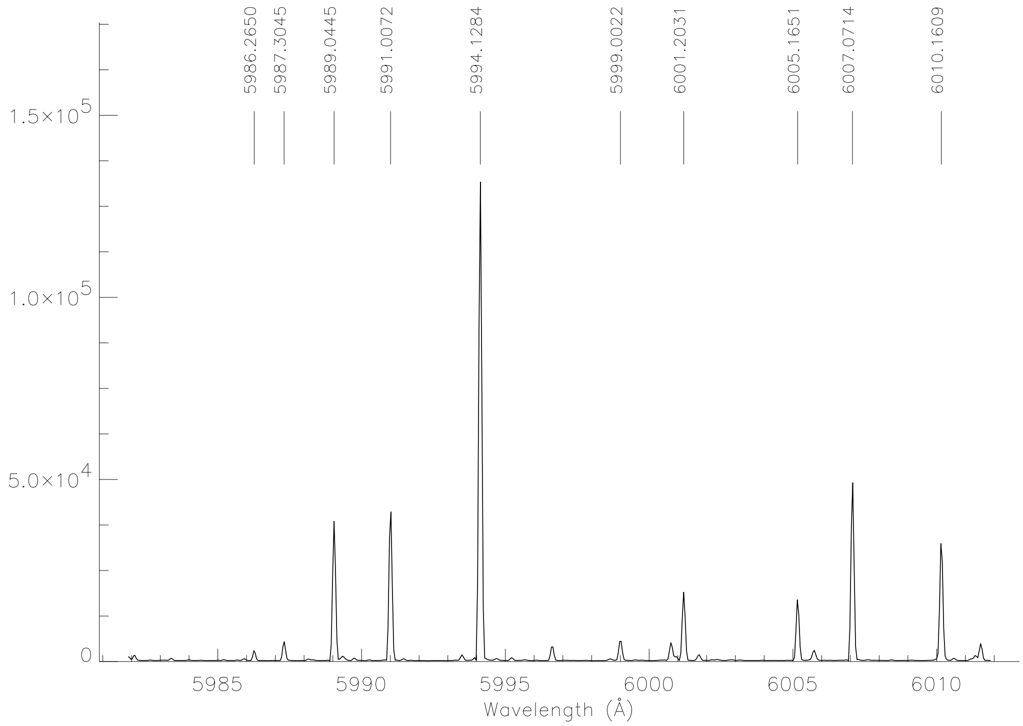
5960
5965
5970
5975
5980
Wavelength (Å)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5989.0445
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5994.1284
5999.0022
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6005.1651
6007.0714
6010.1609
1.5×10^5
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5.0×10^4
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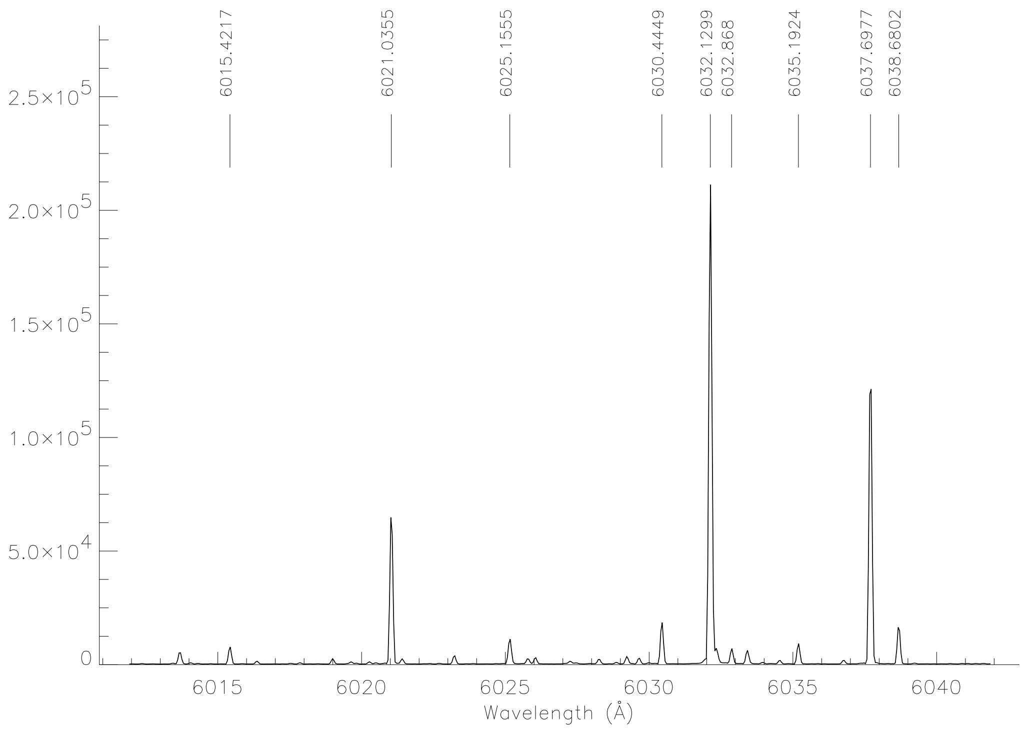
5985
5990
5995
6000
6005
6010
Wavelength (Å)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6032.868
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6037.6977
6038.6802
2.5×10^5
2.0×10^5
1.5×10^5
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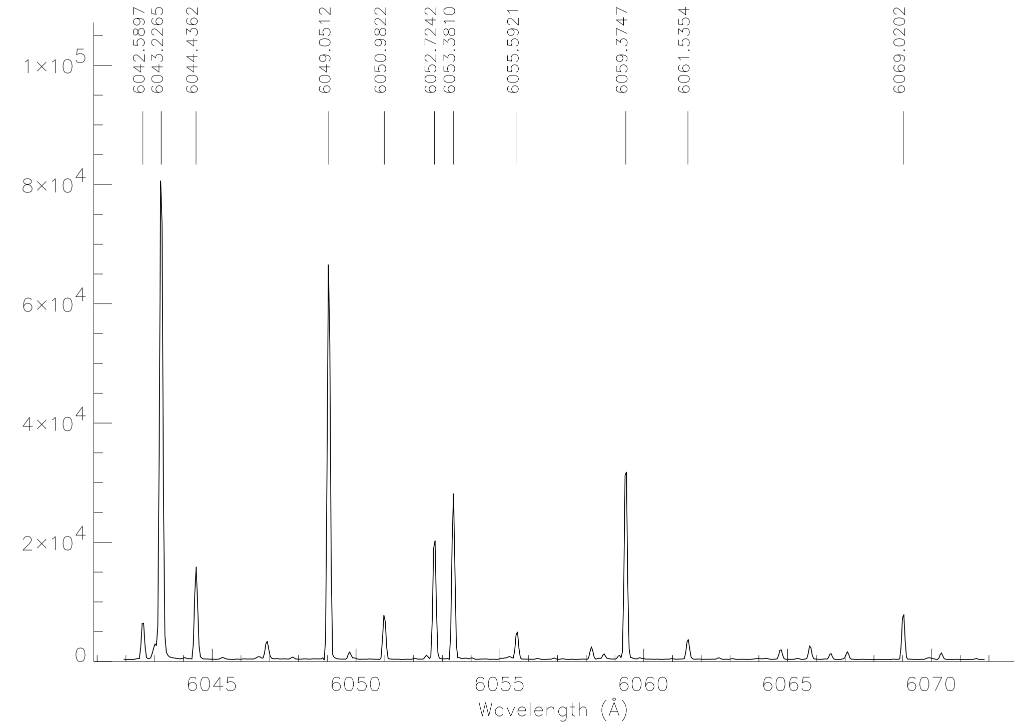
5.0×10^4
0
6015
6020
6025
6030
6035
6040
Wavelength (Å)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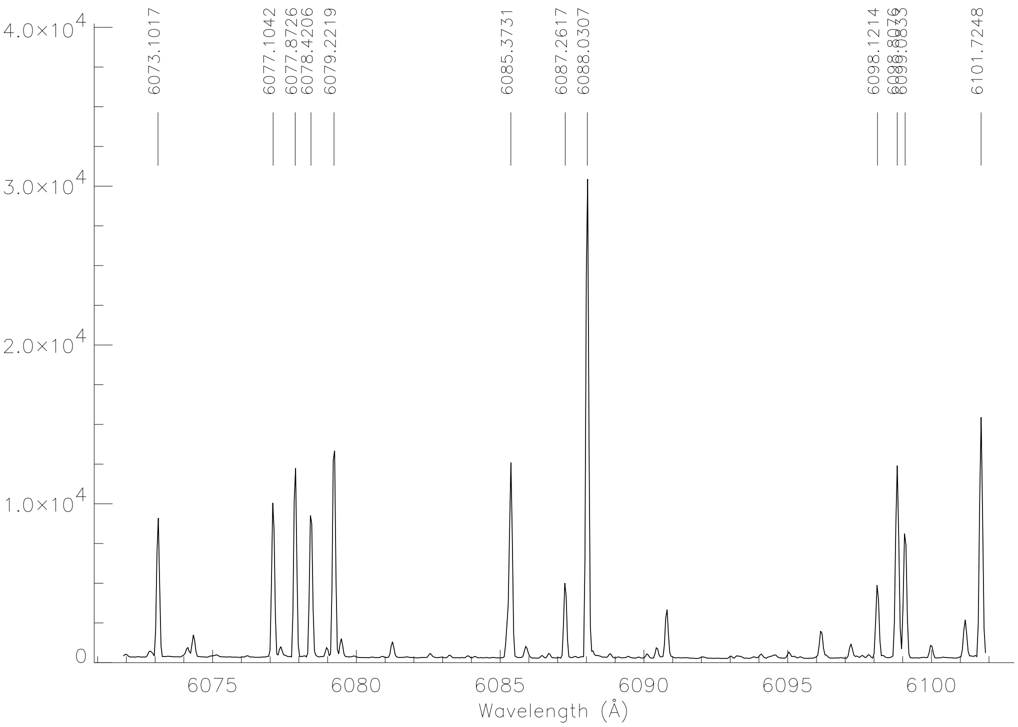
6052.7242
6053.3810
6055.5921
6059.3747
6061.5354
6069.0202
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
6045
6050
6055
6060
6065
6070
Wavelength (Å)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6079.2219
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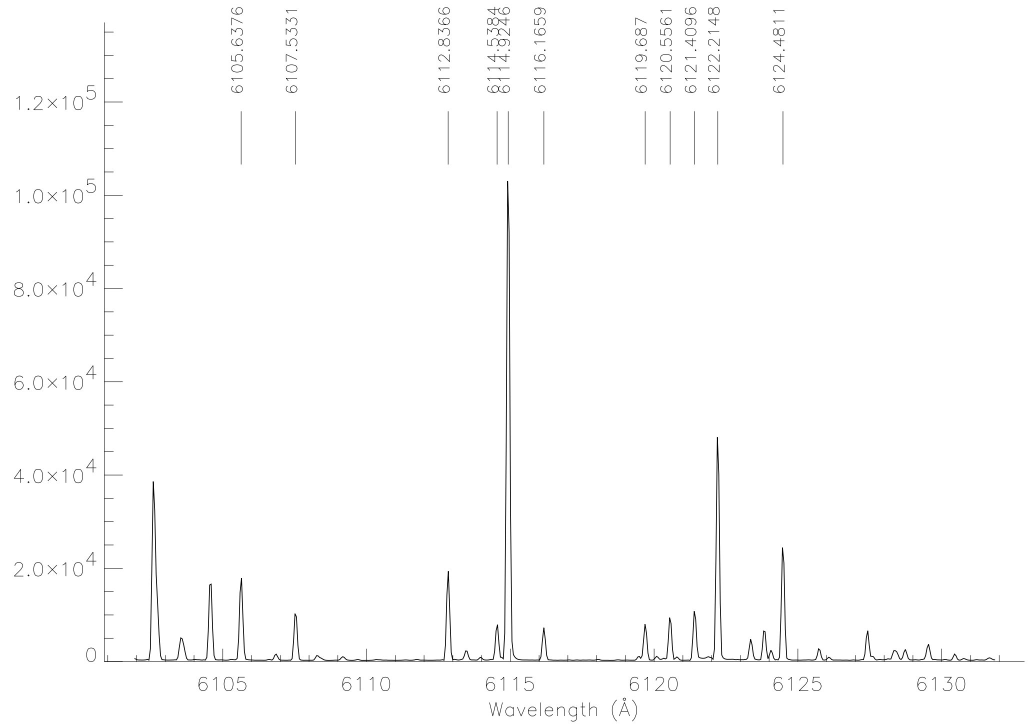
6087.2617
6088.0307
6098.1214
6101.7248
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
6075
6080
6085
6090
6095
6100
Wavelength (Å)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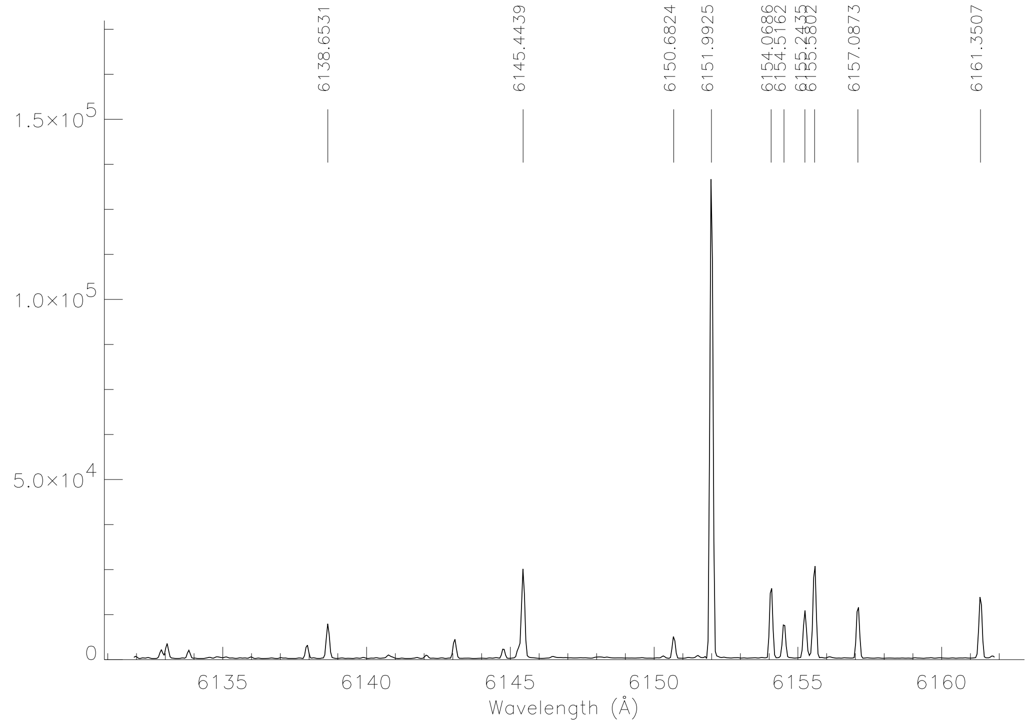
6114.5384
6114.9246
6116.1659
6119.687
6120.5561
6121.4096
6122.2148
6124.4811
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
6105
6110
6115
6120
6125
6130
Wavelength (Å)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6145.4439
6150.6824
6151.9925
6154.0686
6154.5162
6155.2435
6155.5802
6157.0873
6161.3507
1.5×10^5
1.0×10^5
5.0×10^4
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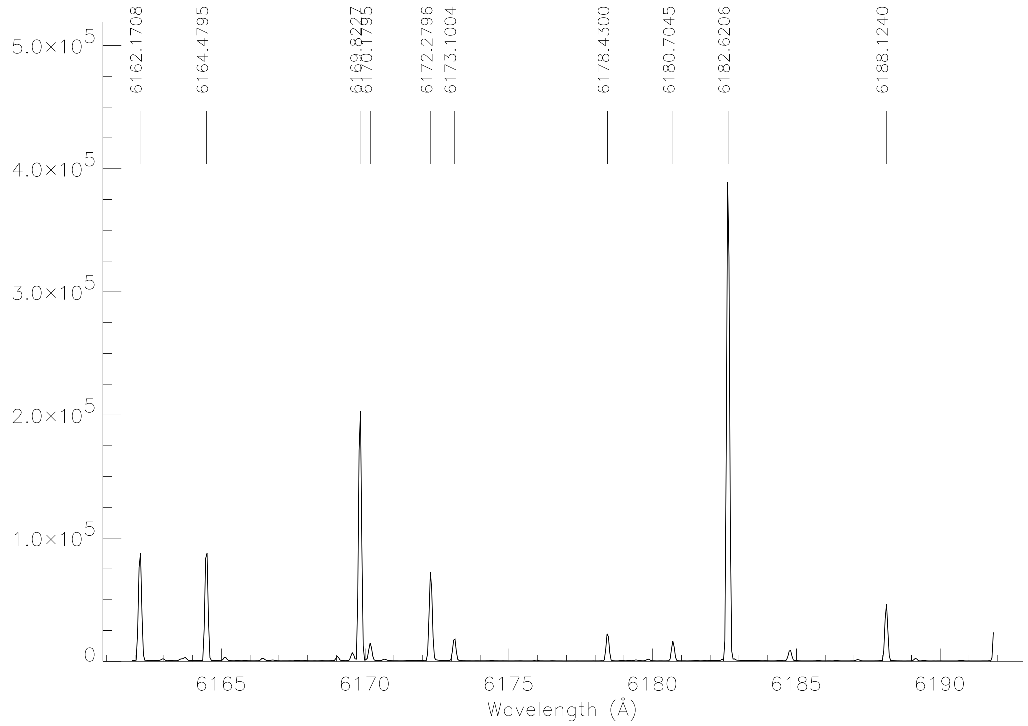
6135
6140
6145
6150
6155
6160
Wavelength (Å)



6162.1708
6164.4795
6169.8227
6170.1795
6172.2796
6173.1004
6178.4300
6180.7045
6182.6206
6188.1240
5.0×10^5
4.0×10^5
3.0×10^5
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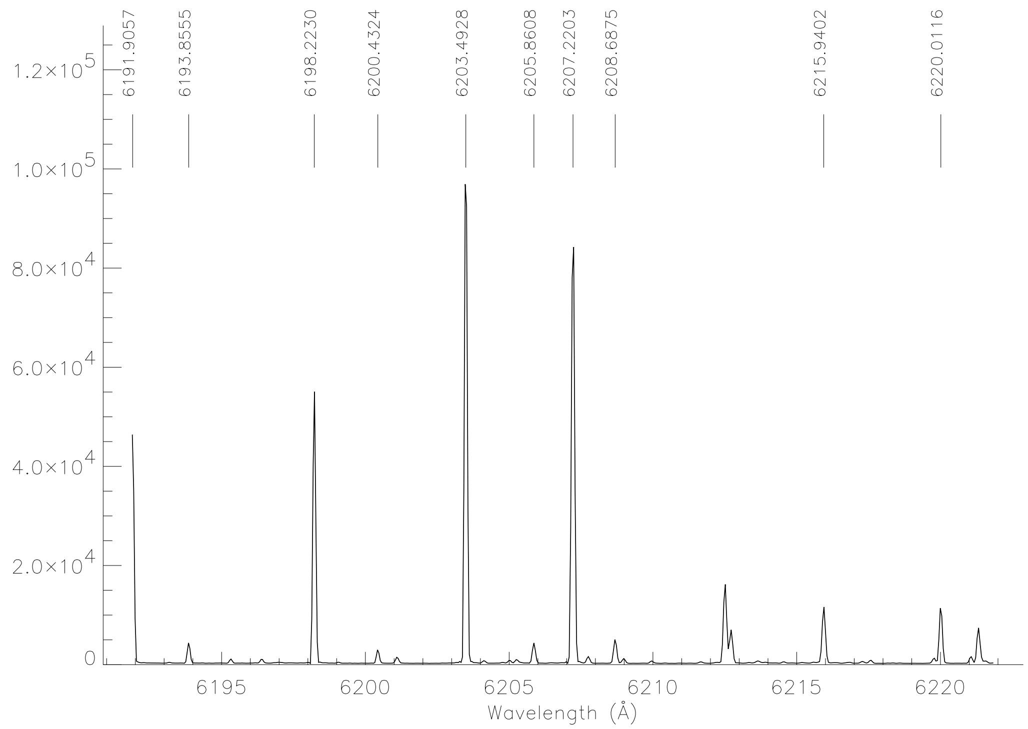
1.0×10^5
0
6165
6170
6175
6180
6185
6190
Wavelength (Å)



6191.9057
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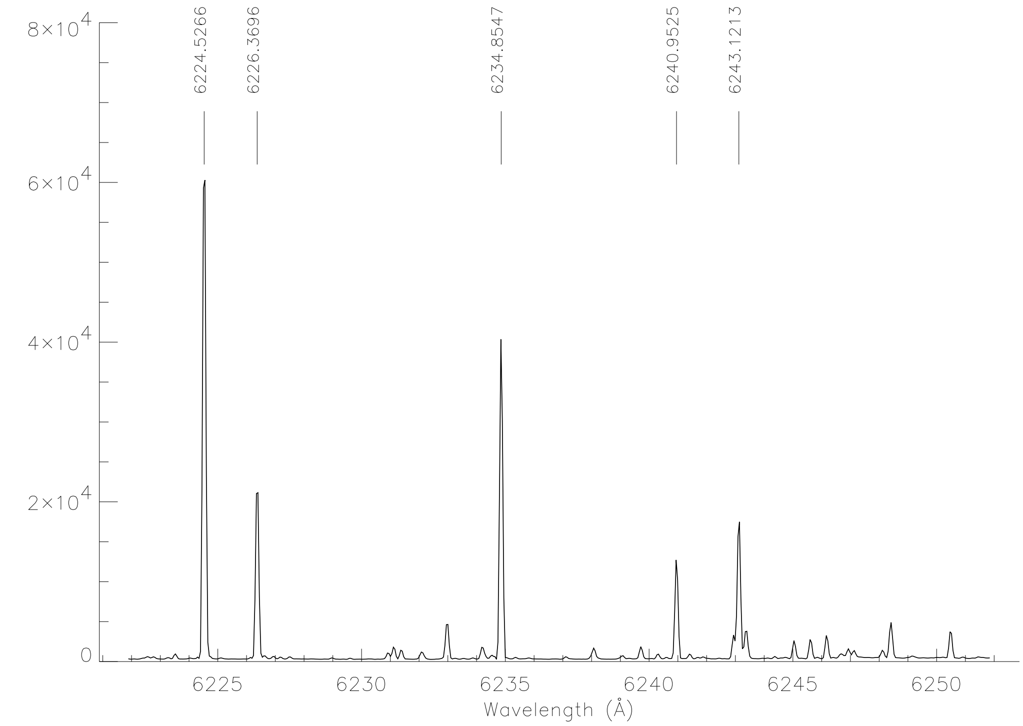
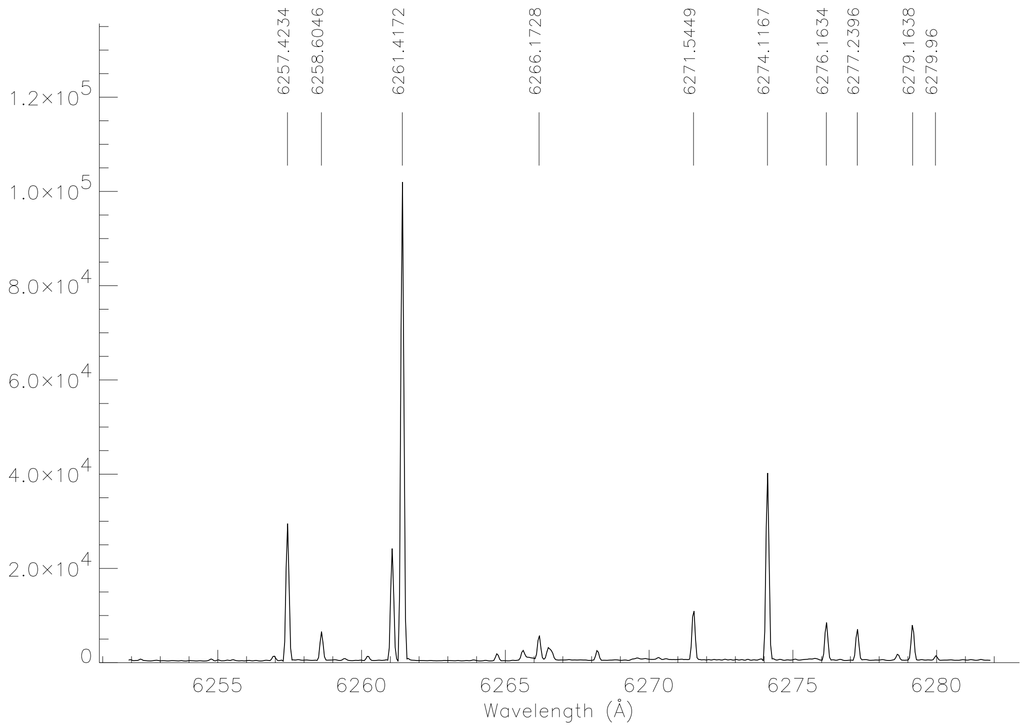
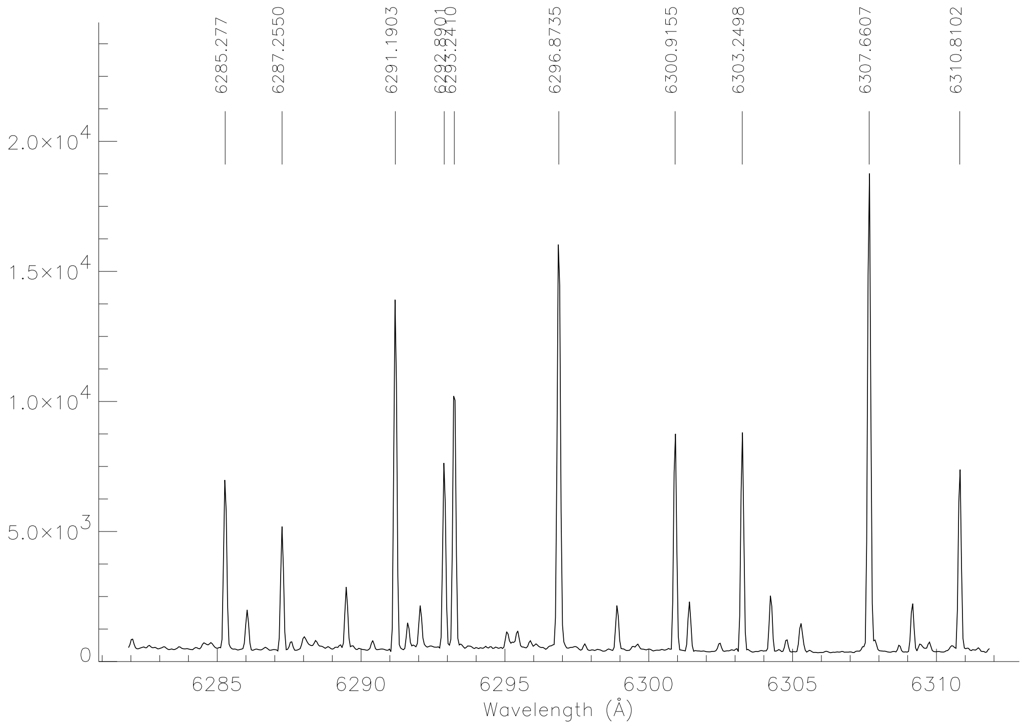
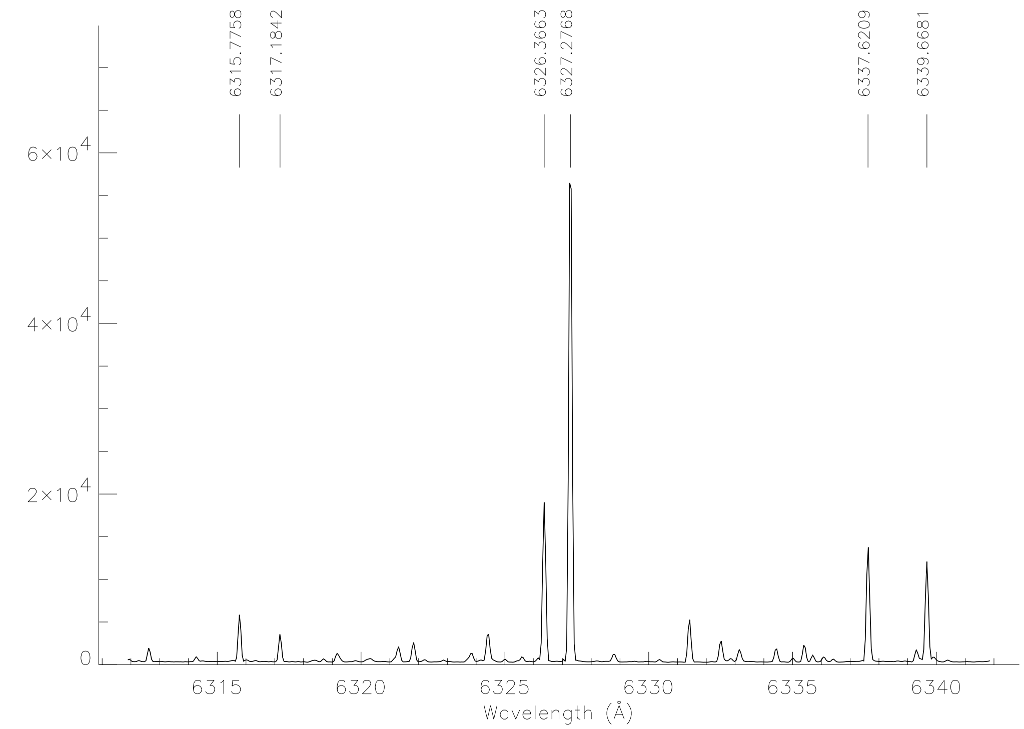
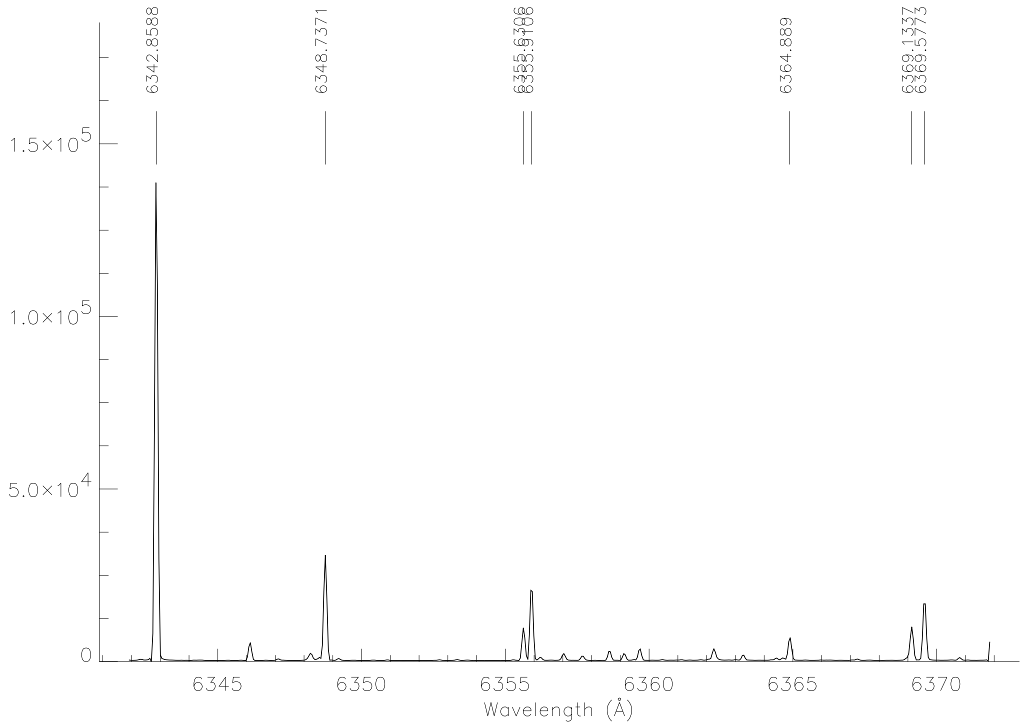
6198.2230
6200.4324
6203.4928
6205.8608
6207.2203
6208.6875
6215.9402
6220.0116
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
6195
6200
6205
6210
6215
6220
Wavelength (Å)

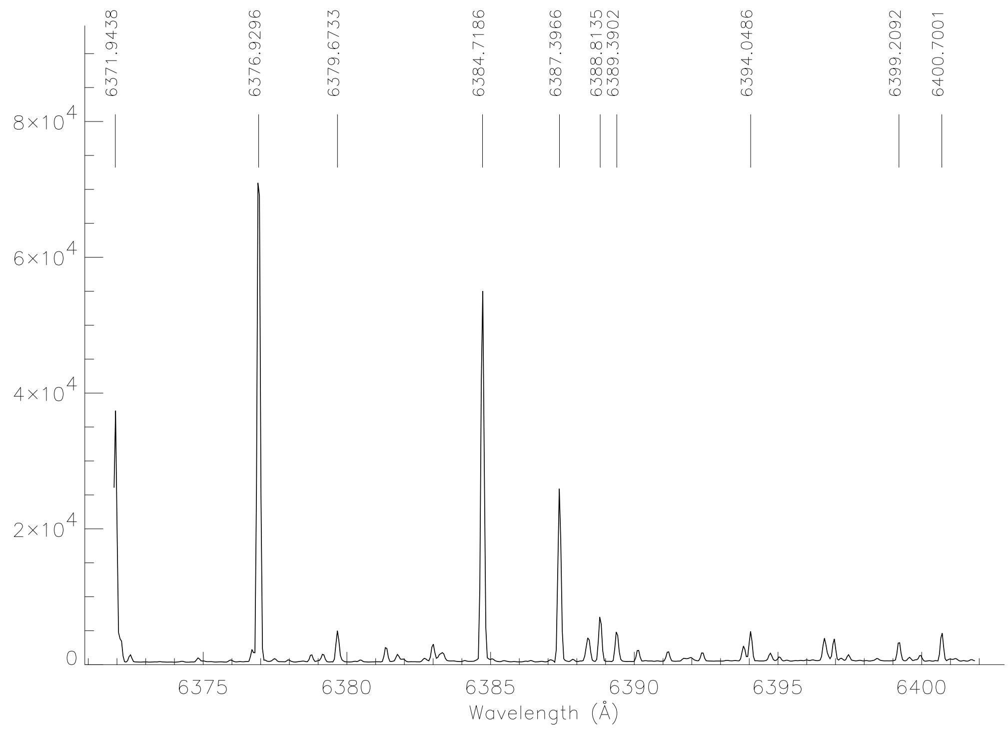

6224.5266
6226.3696
6234.8547
6240.9525
6243.1213
8×10^4
6×10^4
4×10^4
2×10^4
0
6225
6230
6235
6240
6245
6250
Wavelength (Å)


6257.4234
6258.6046
6261.4172
6266.1728
6271.5449
6274.1167
6276.1634
6277.2396
6279.1638
6279.96
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
6255
6260
6265
6270
6275
6280
Wavelength (Å)


6285.277
6287.2550
6291.1903
6292.8901
6293.2410
6296.8735
6300.9155
6303.2498
6307.6607
6310.8102
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
0
6285
6290
6295
6300
6305
6310
Wavelength (Å)


6315.7758
6317.1842
6326.3663
6327.2768
6337.6209
6339.6681
6×10^4
4×10^4
2×10^4
0
6315
6320
6325
6330
6335
6340
Wavelength (Å)


6342.8588
6348.7371
6355.6306
6355.9106
6364.889
6369.1337
6369.5773
1.5×10^5
1.0×10^5
5.0×10^4
0
6345
6350
6355
6360
6365
6370
Wavelength (Å)


6371.9438
6376.9296
6379.6733
6384.7186
6387.3966
6388.8135
6389.3902
6394.0486
6399.2092
6400.7001
8×10^4
6×10^4
4×10^4
2×10^4
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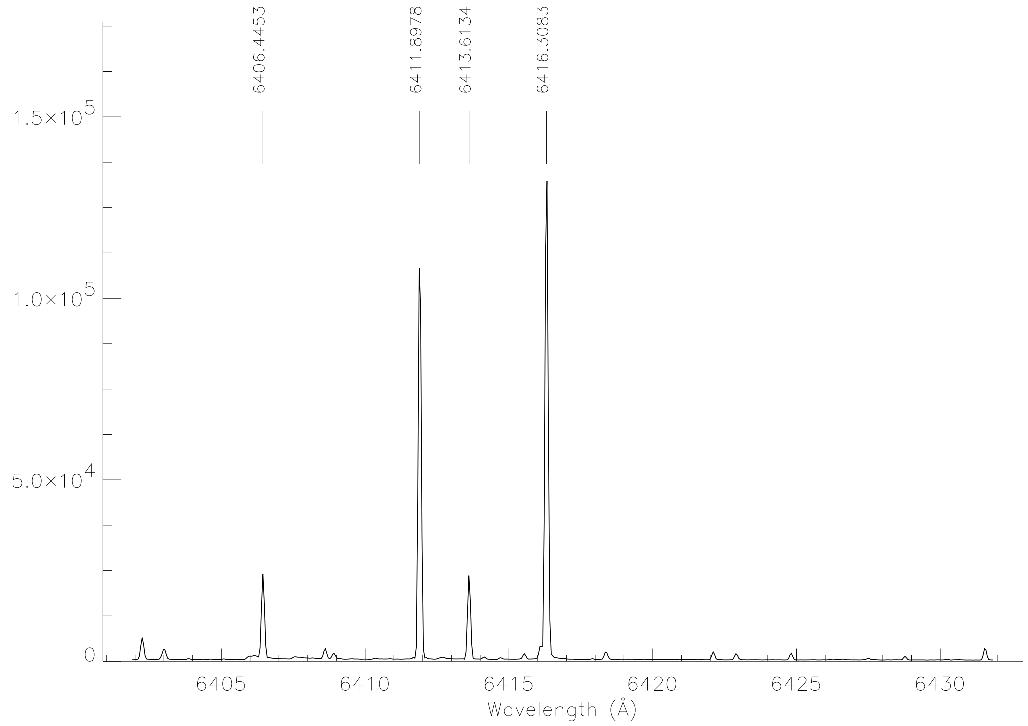
6375
6380
6385
6390
6395
6400
Wavelength (Å)


6406.4453
6411.8978
6413.6134
6416.3083
1.5×10^5
1.0×10^5
5.0×10^4
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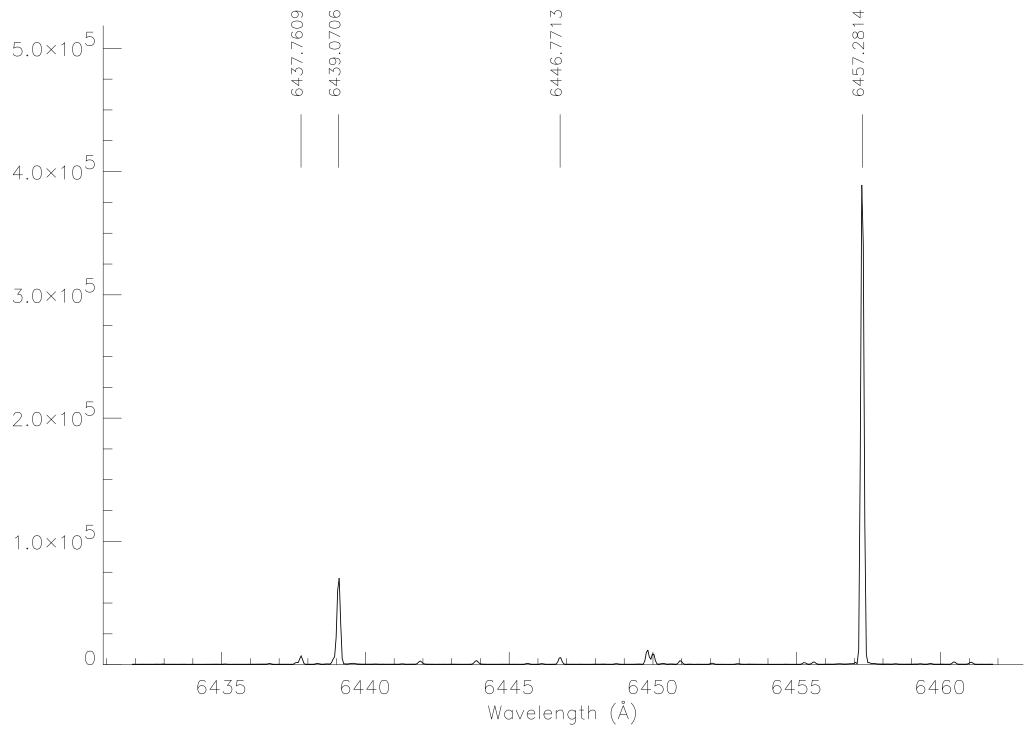
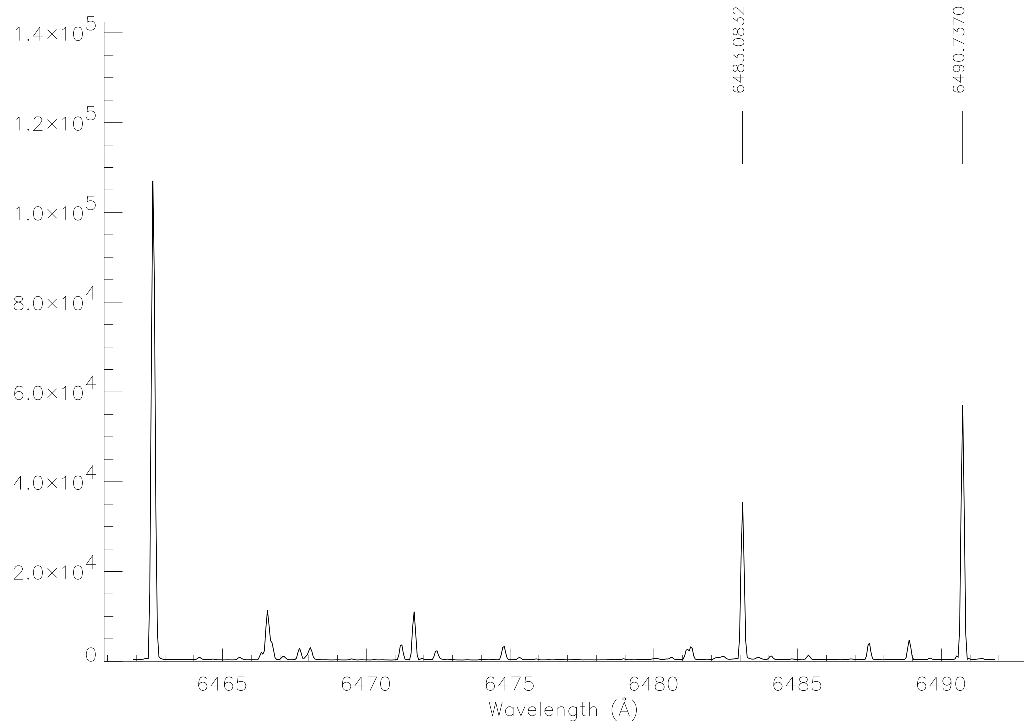
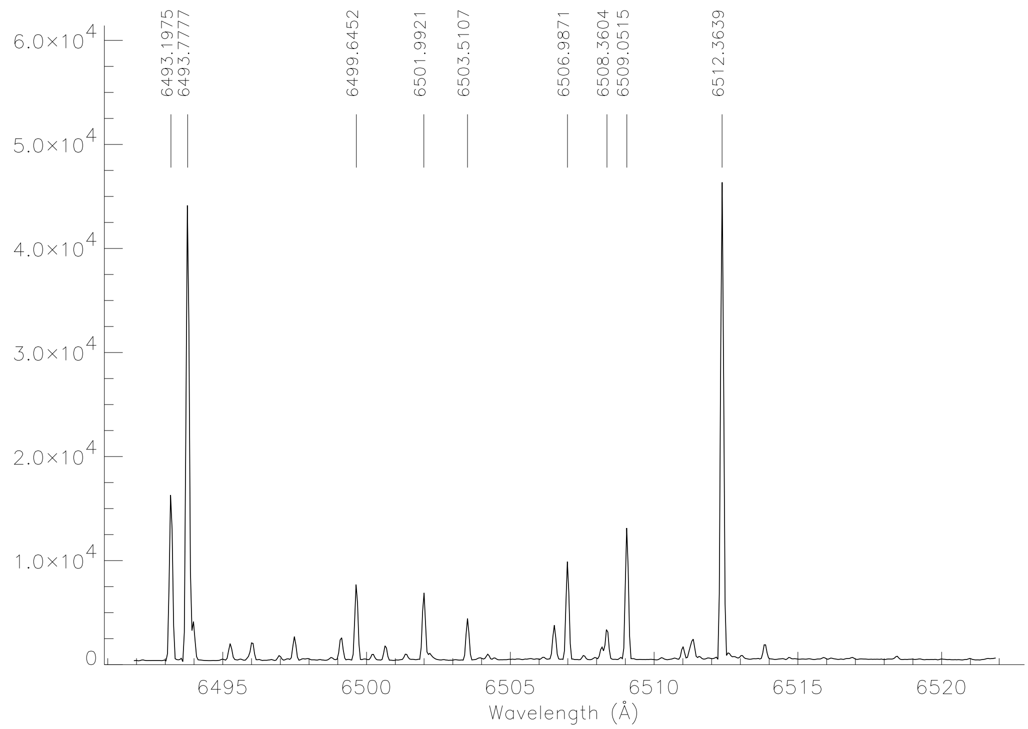
6405
6410
6415
6420
6425
6430
Wavelength (Å)

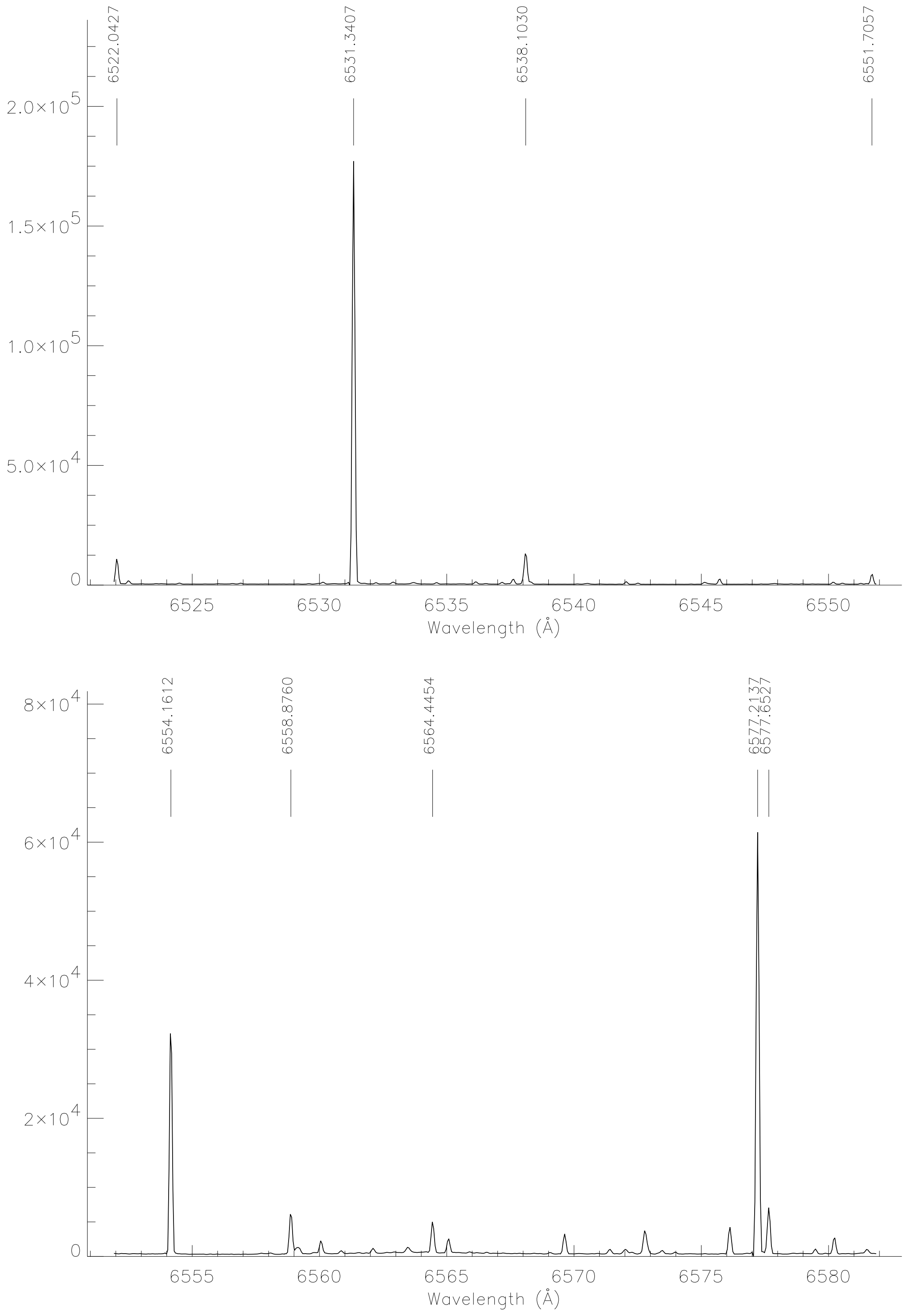

6437.7609
6439.0706
6446.7713
6457.2814
5.0×10^5
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
6435
6440
6445
6450
6455
6460
Wavelength (Å)

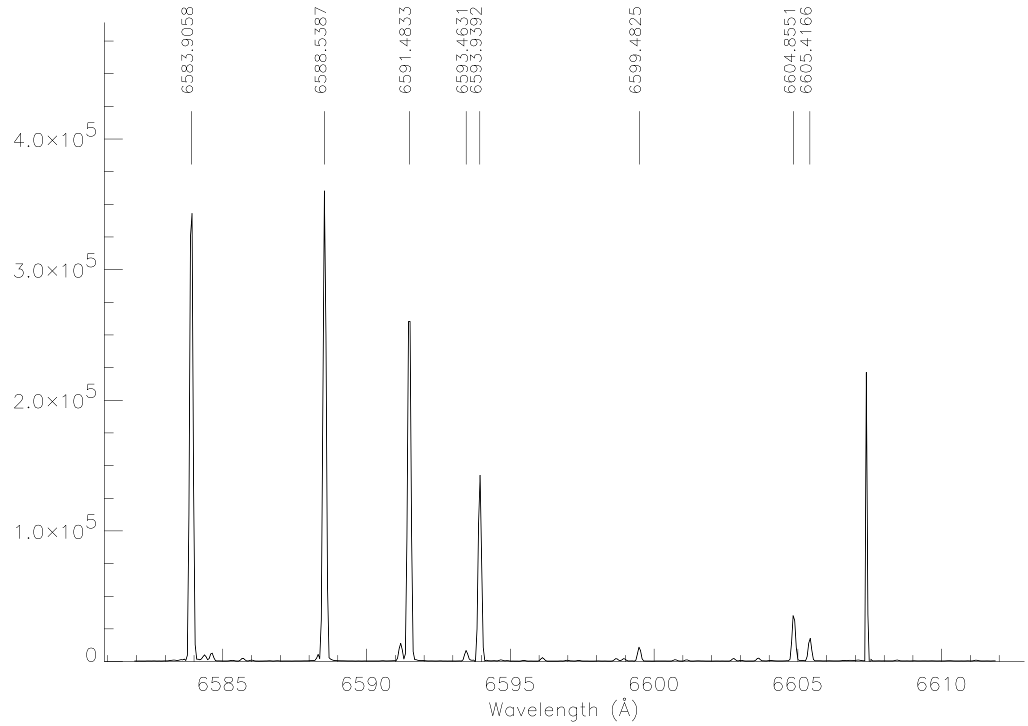


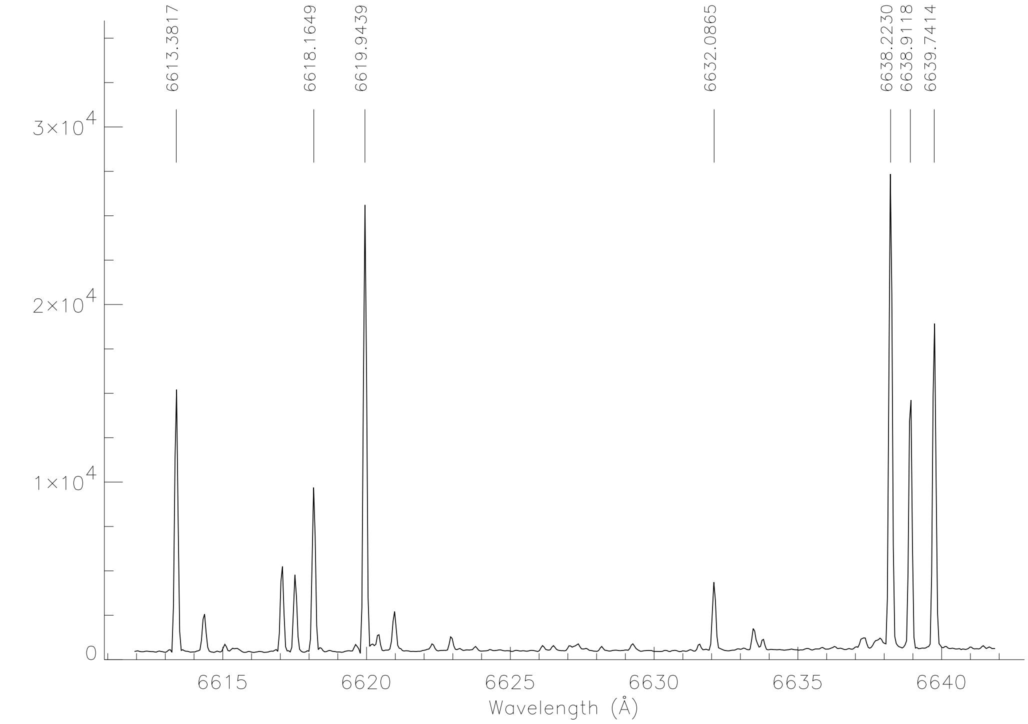
6483.0832
6490.7370
1.4×10^5
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
6465
6470
6475
6480
6485
6490
Wavelength (Å)

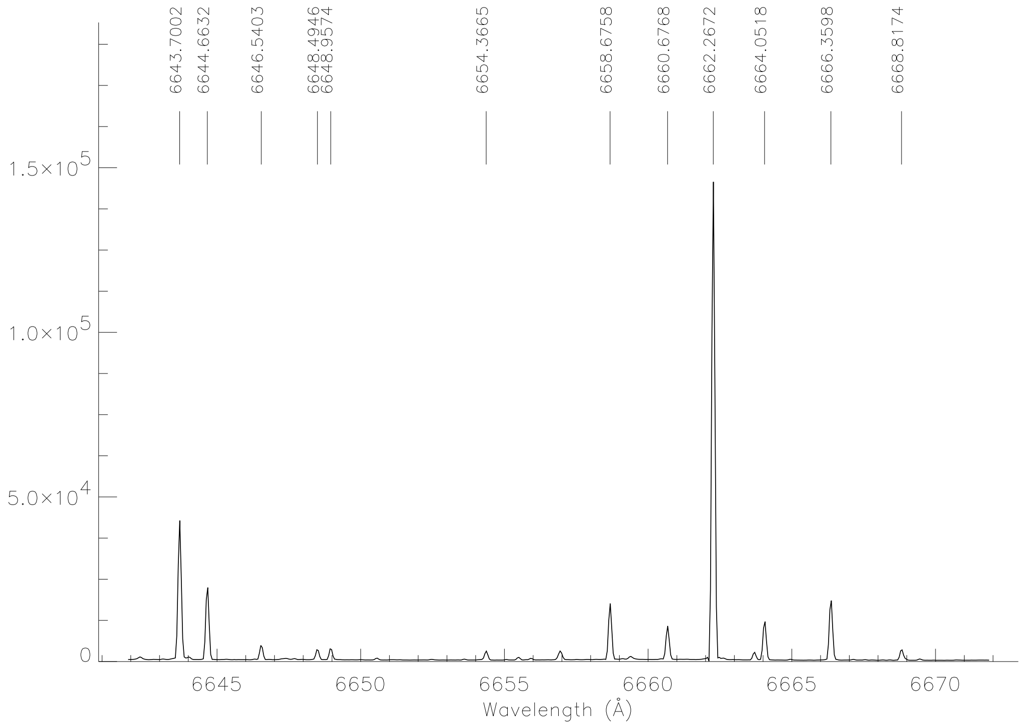


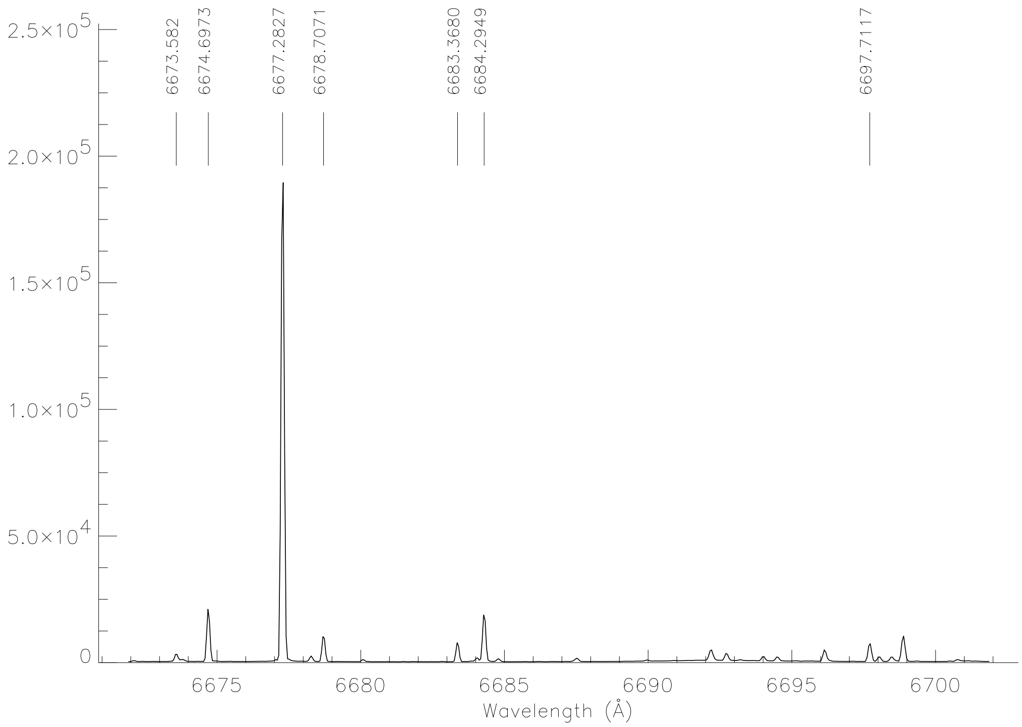
6493.1975
6493.7777
6499.6452
6501.9921
6503.5107
6506.9871
6508.3604
6509.0515
6512.3639
6.0×10^4
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
6495
6500
6505
6510
6515
6520
Wavelength (Å)

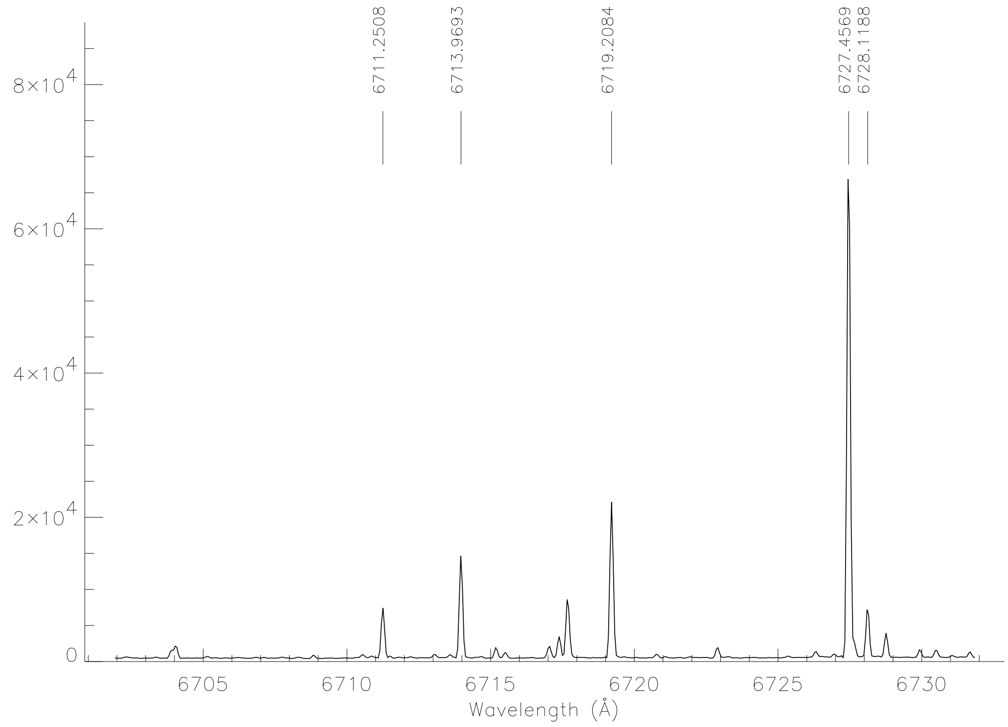

6522.0427
6531.3407
6538.1030
6551.7057
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
6525
6530
6535
6540
6545
6550
Wavelength (Å)
6554.1612
6558.8760
6564.4454
6577.2137
6577.6527
8×10^4
6×10^4
4×10^4
2×10^4
0
6555
6560
6565
6570
6575
6580
Wavelength (Å)

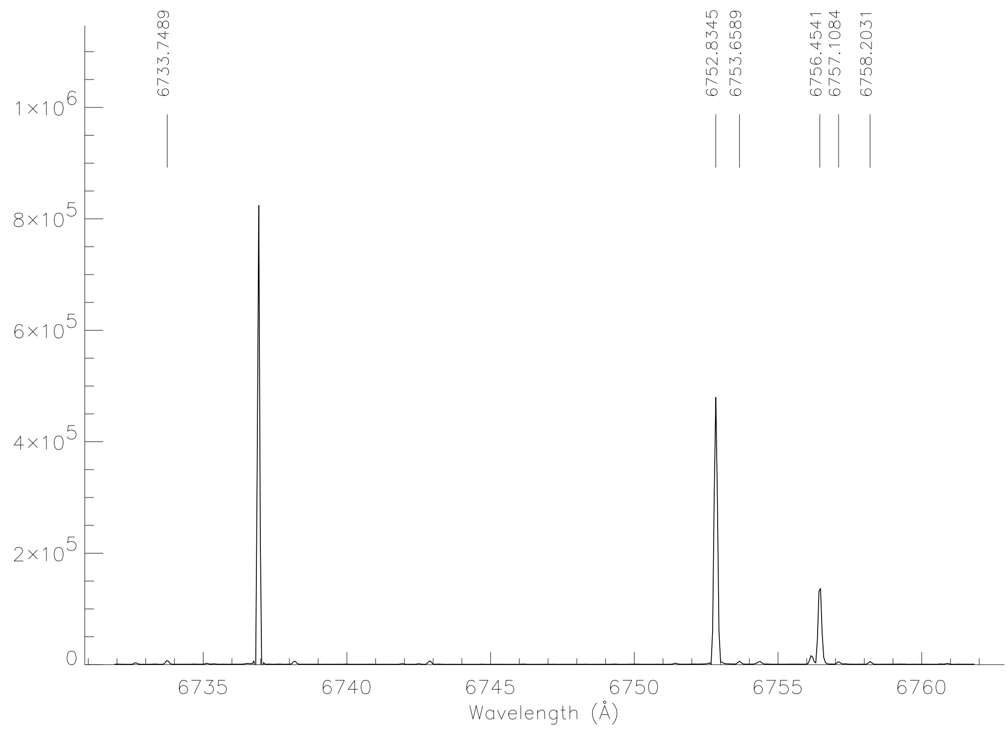

6583.9058
6588.5387
6591.4833
6593.4631
6593.9392
6599.4825
6604.8551
6605.4166
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
6585
6590
6595
6600
6605
6610
Wavelength (Å)


6613.3817
6618.1649
6619.9439
6632.0865
6638.2230
6638.9118
6639.7414
3×10^4
2×10^4
1×10^4
0
6615
6620
6625
6630
6635
6640
Wavelength (Å)


6643.7002
6644.6632
6646.5403
6648.4946
6648.9574
6654.3665
6658.6758
6660.6768
6662.2672
6664.0518
6666.3598
6668.8174
1.5×10^5
1.0×10^5
5.0×10^4
0
6645
6650
6655
6660
6665
6670
Wavelength (Å)


6673.582
6674.6973
6677.2827
6678.7071
6683.3680
6684.2949
6697.7117
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
6675
6680
6685
6690
6695
6700
Wavelength (Å)


6711.2508
6713.9693
6719.2084
6727.4569
6728.1188
8×10^4
6×10^4
4×10^4
2×10^4
0
6705
6710
6715
6720
6725
6730
Wavelength (Å)


6733.7489
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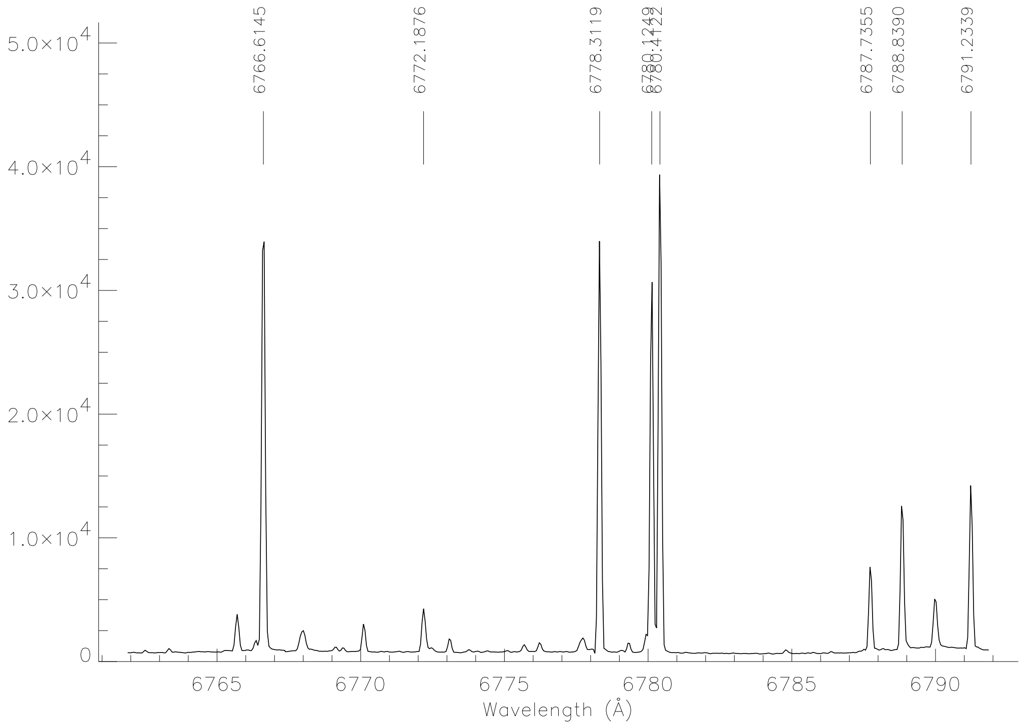
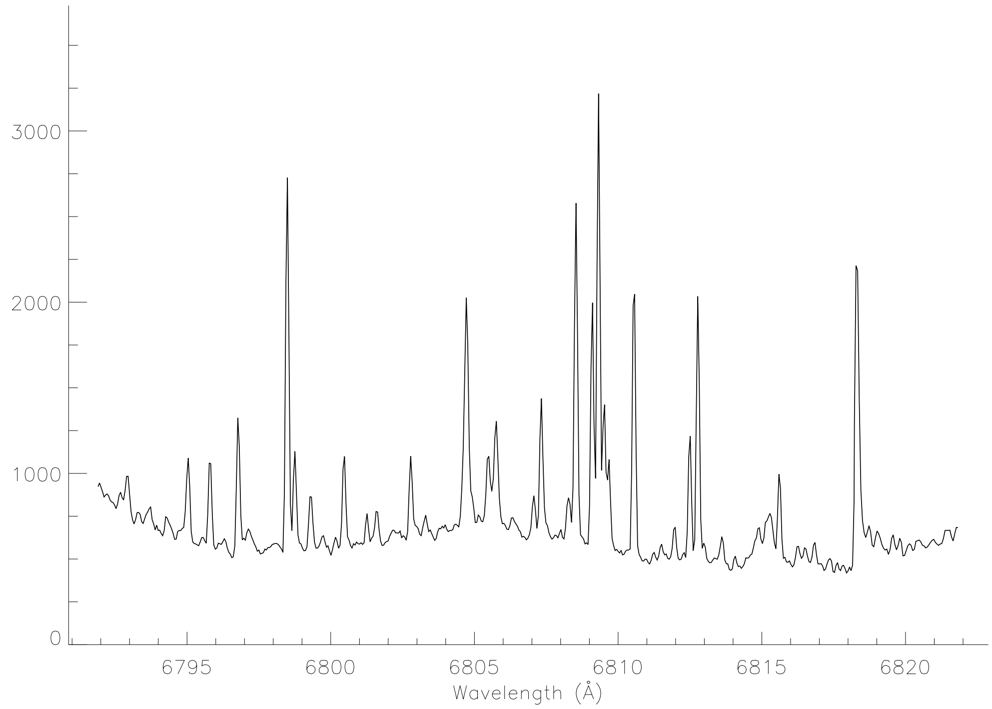
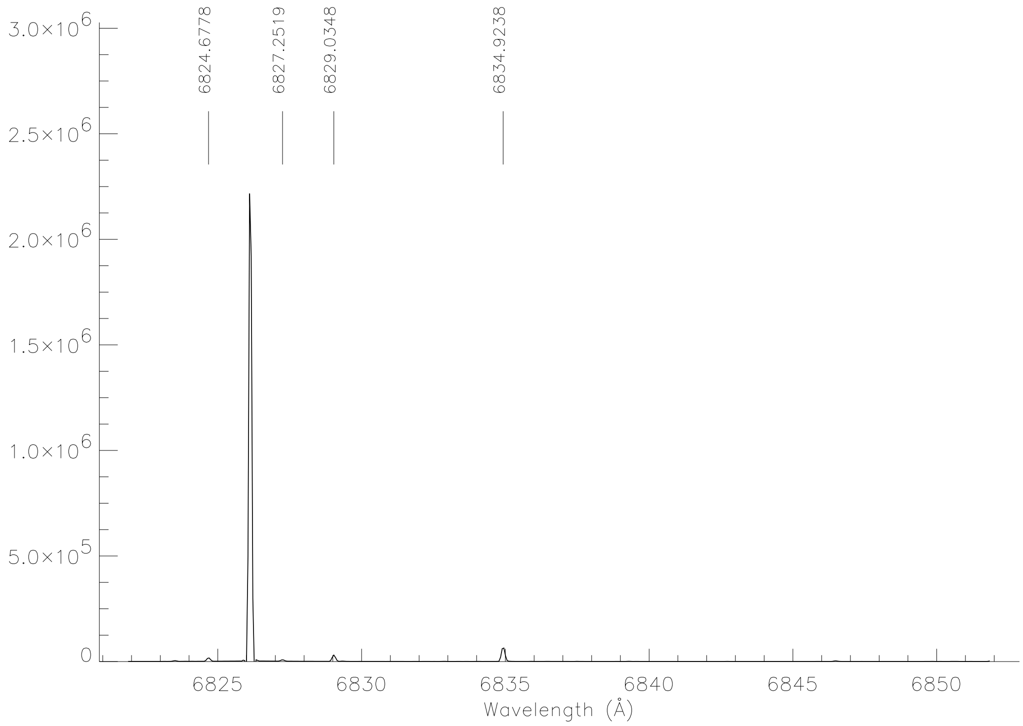
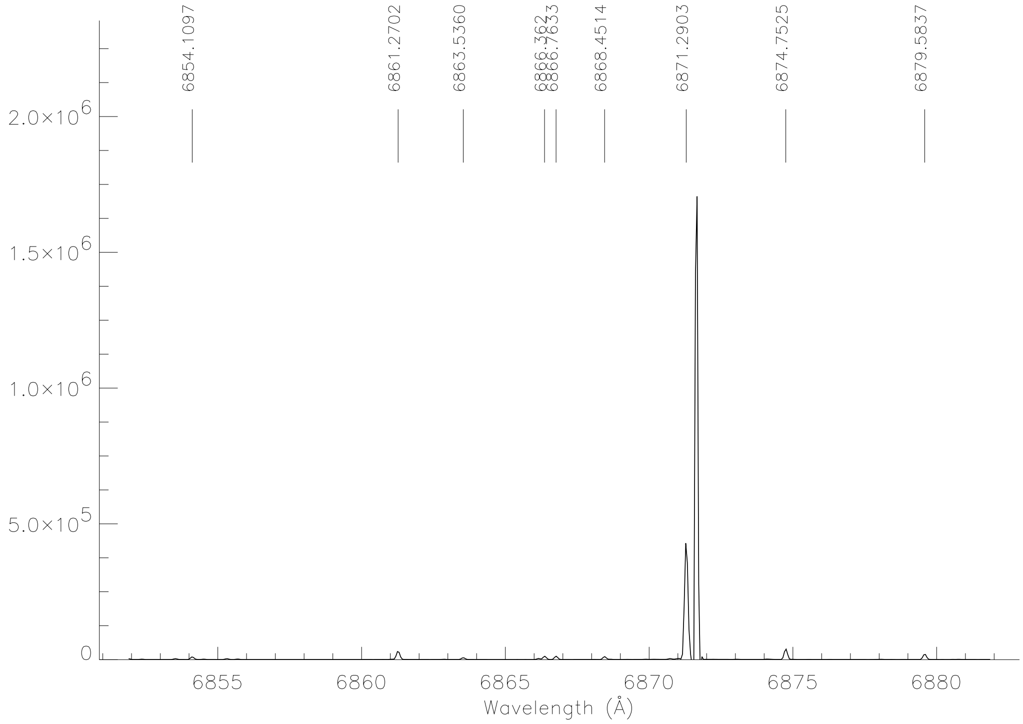
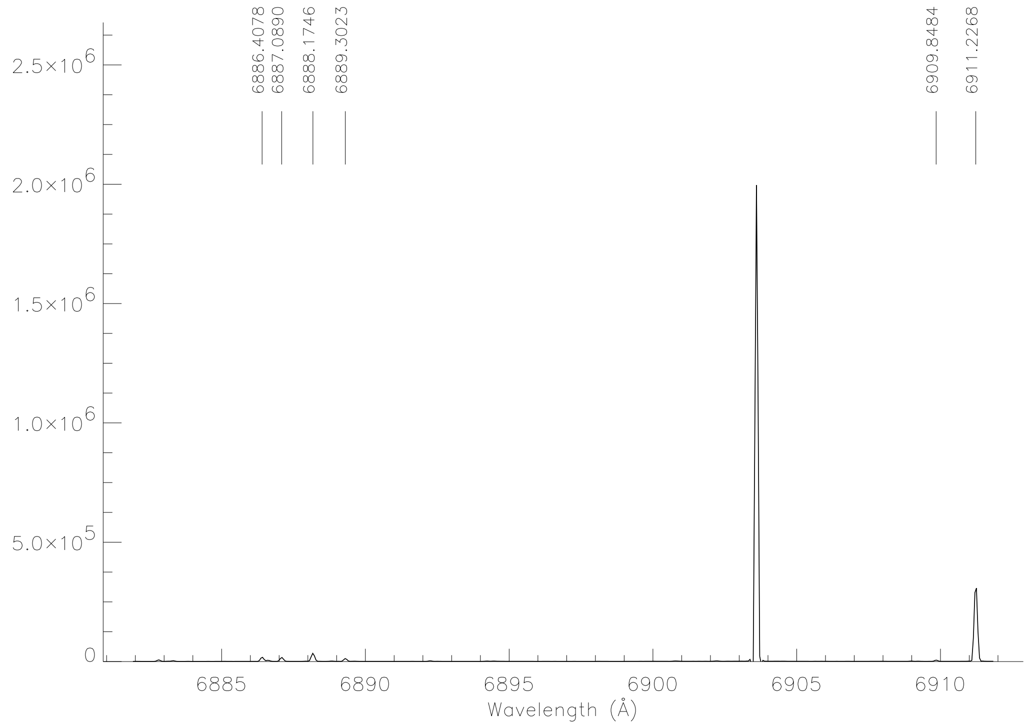
6753.6589
6756.4541
6757.1084
6758.2031
1×10^6
8×10^5
6×10^5
4×10^5
2×10^5
0
6735
6740
6745
6750
6755
6760
Wavelength (Å)


6766.6145
6772.1876
6778.3119
6780.1249
6780.4122
6787.7355
6788.8390
6791.2339
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
6765
6770
6775
6780
6785
6790
Wavelength (Å)


3000
2000
1000
0
6795
6800
6805
6810
6815
6820
Wavelength (Å)


6824.6778
6827.2519
6829.0348
6834.9238
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
6825
6830
6835
6840
6845
6850
Wavelength (Å)


6854.1097
6861.2702
6863.5360
6866.362
6866.7633
6868.4514
6871.2903
6874.7525
6879.5837
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
6855
6860
6865
6870
6875
6880
Wavelength (Å)


6886.4078
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6888.1746
6889.3023
6909.8484
6911.2268
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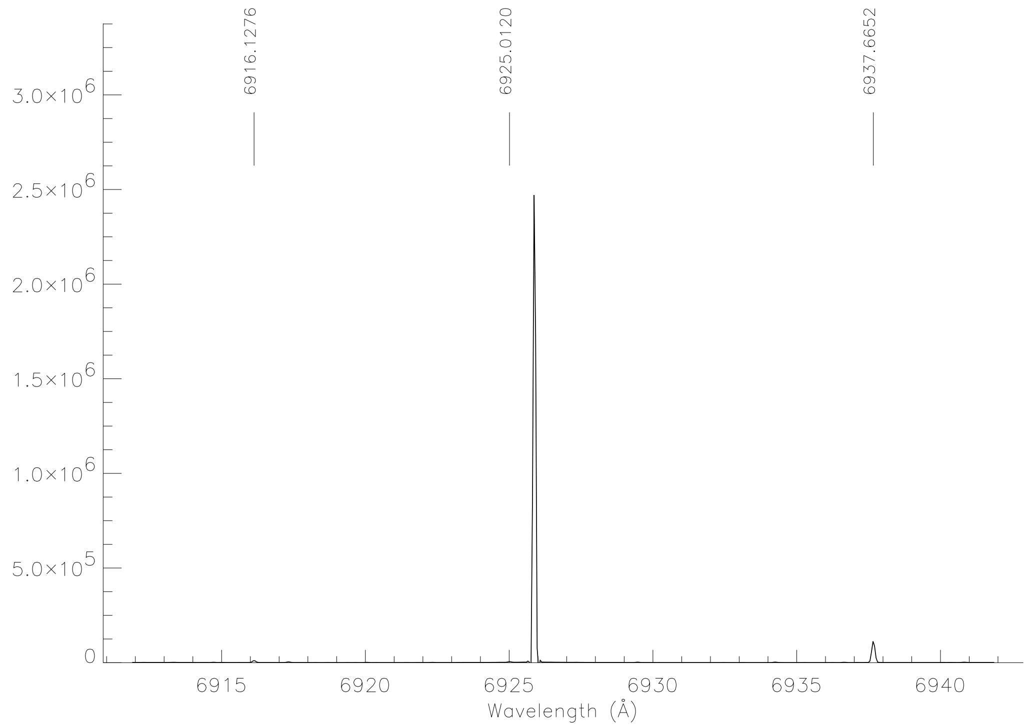
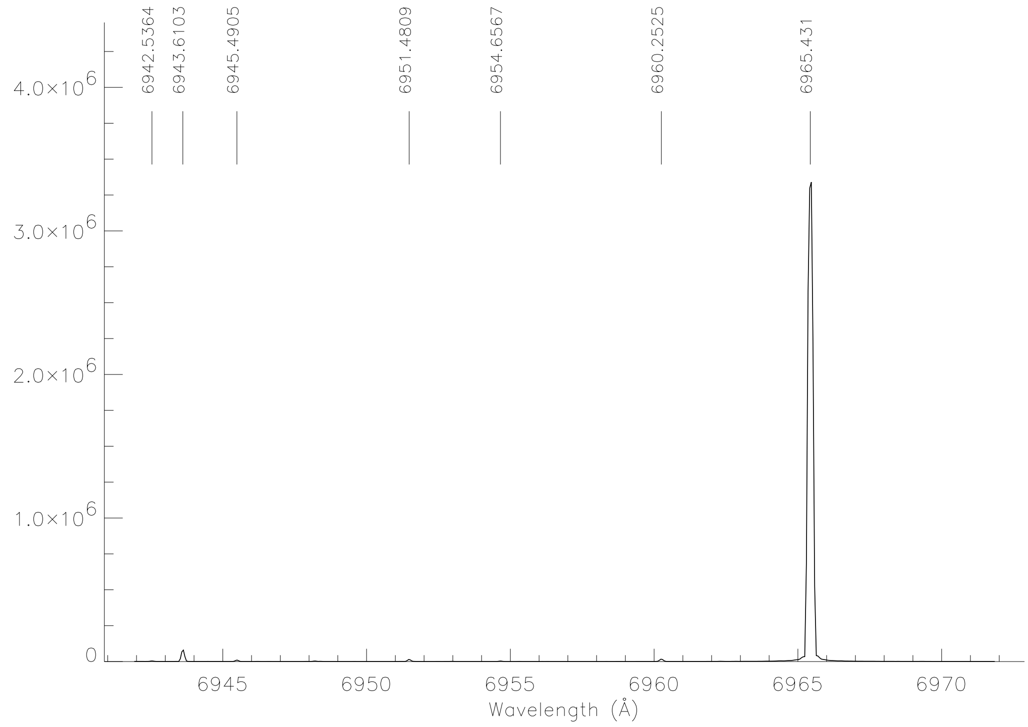
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
6885
6890
6895
6900
6905
6910
Wavelength (Å)


6916.1276
6925.0120
6937.6652
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
6915
6920
6925
6930
6935
6940
Wavelength (Å)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6943.6103
6945.4905
6951.4809
6954.6567
6960.2525
6965.431
4.0×10^6
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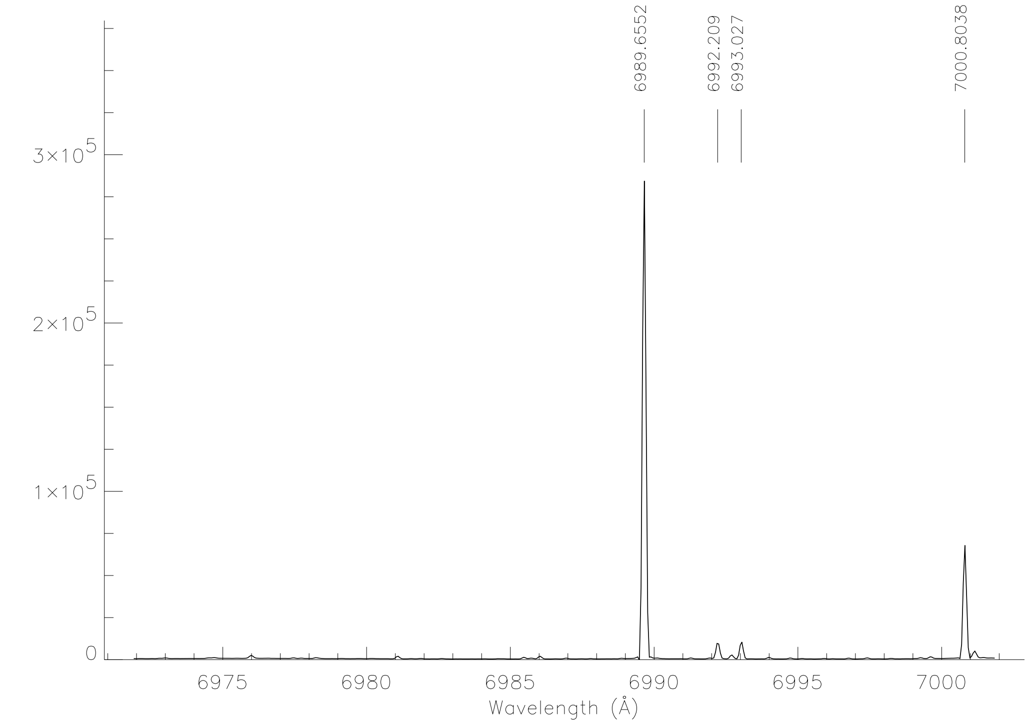
2.0×10^6
1.0×10^6
0
6945
6950
6955
6960
6965
6970
Wavelength (Å)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6993.027
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1×10^5
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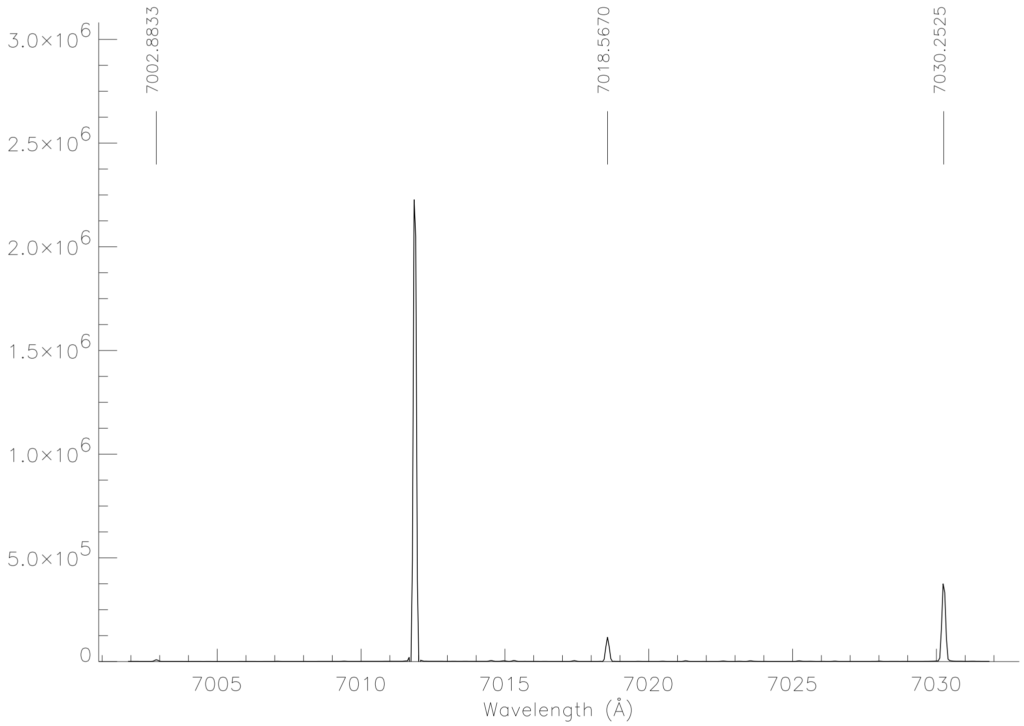
6975
6980
6985
6990
6995
7000
Wavelength (Å)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7030.2525
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2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
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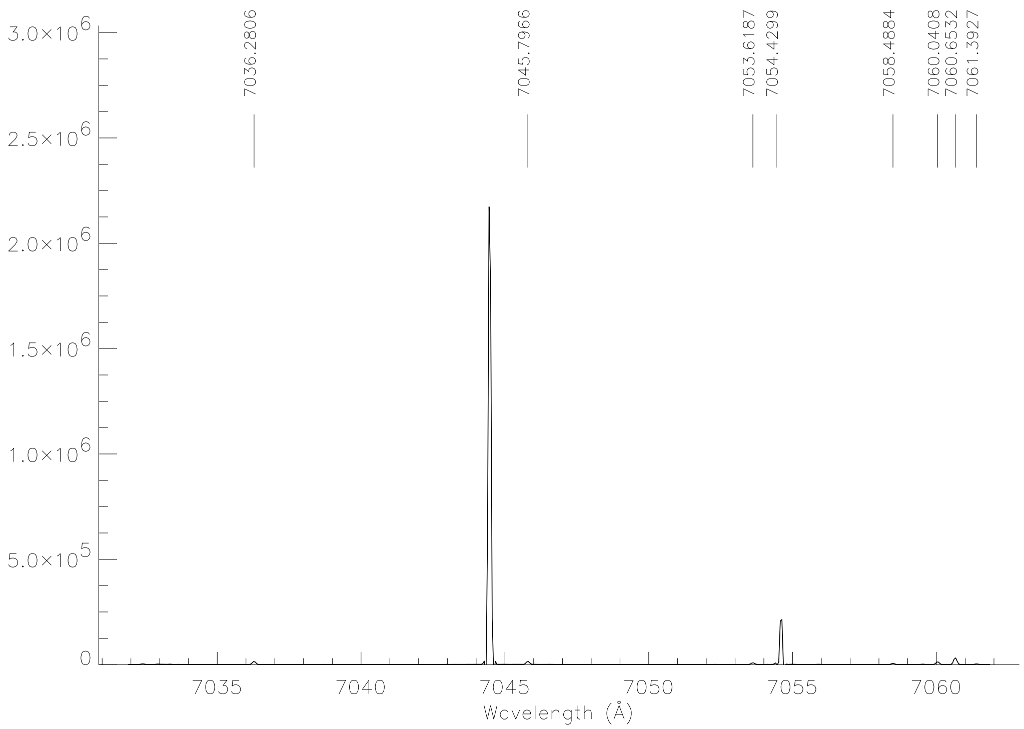
7010
7015
7020
7025
7030
Wavelength (Å)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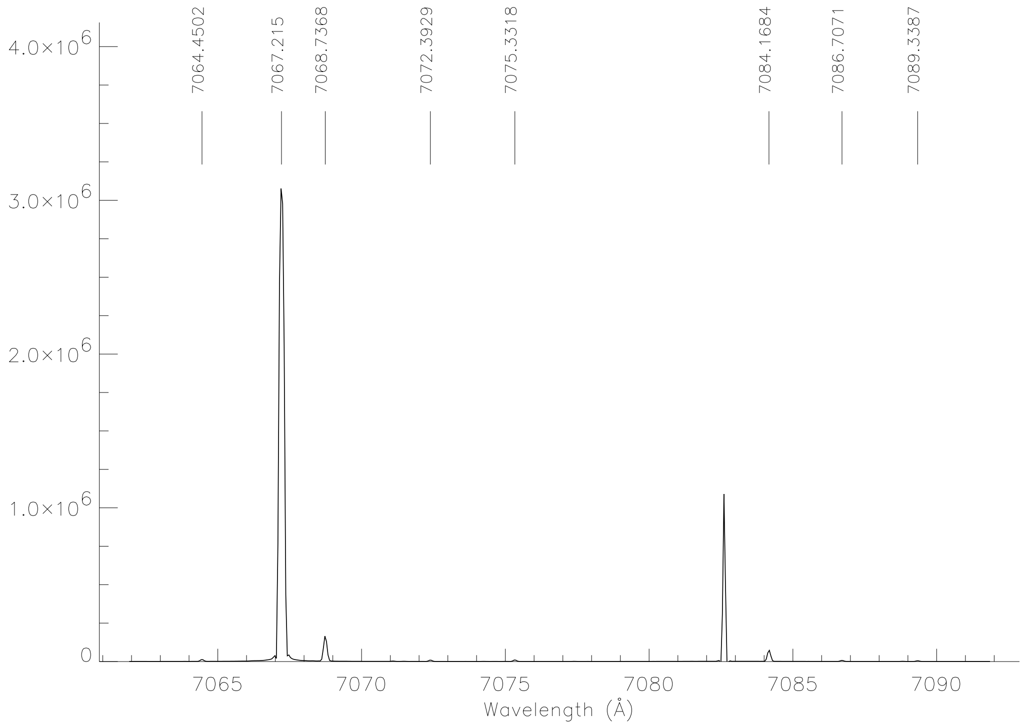
7058.4884
7060.0408
7060.6532
7061.3927
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
7035
7040
7045
7050
7055
7060
Wavelength (Å)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7072.3929
7075.3318
7084.1684
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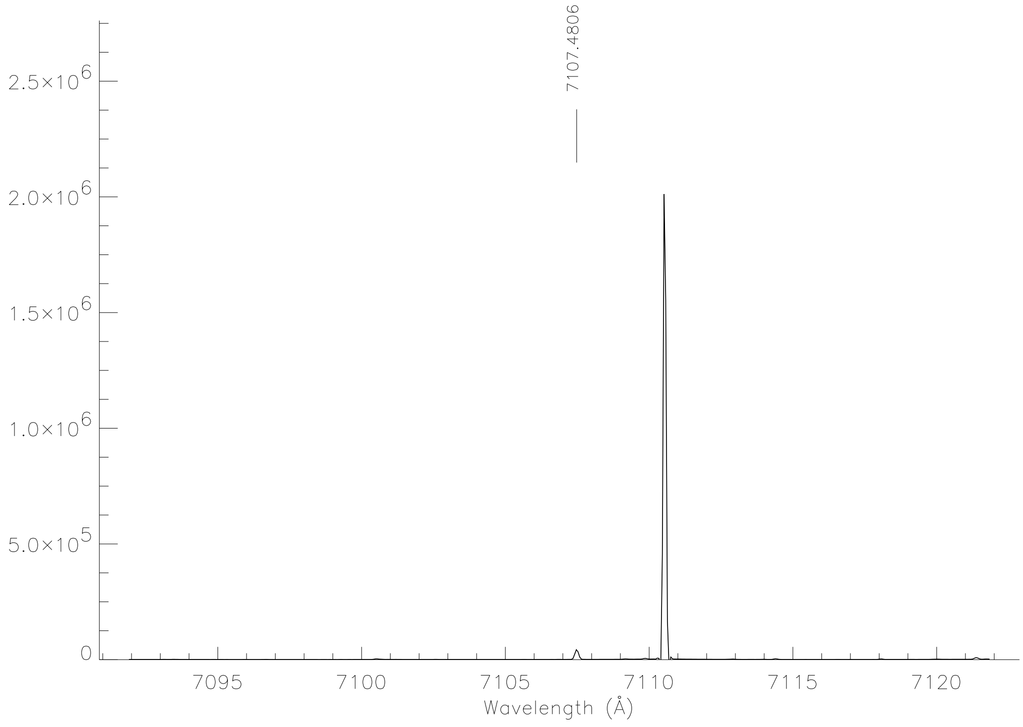
7089.3387
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7065
7070
7075
7080
7085
7090
Wavelength (Å)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5.0×10^5
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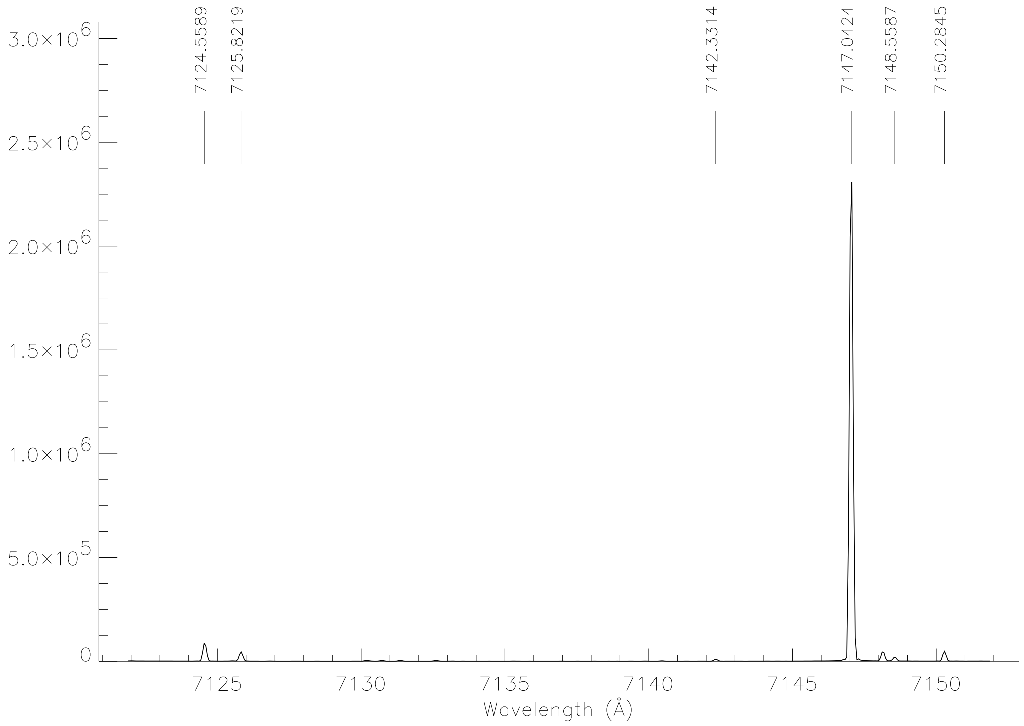
7100
7105
7110
7115
7120
Wavelength (Å)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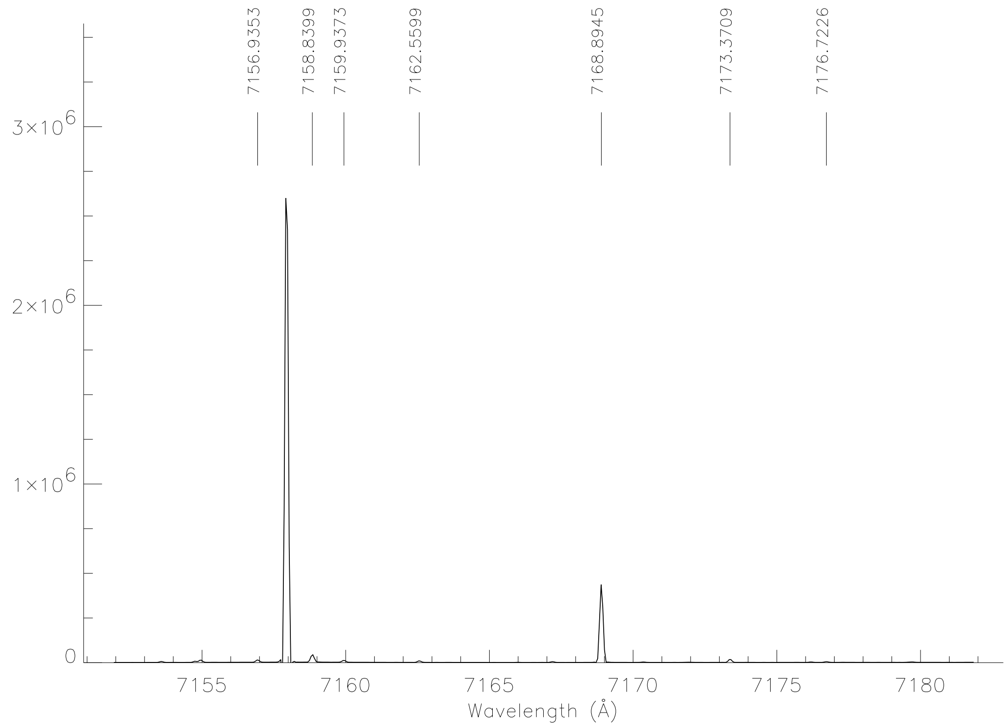
7125.8219
7142.3314
7147.0424
7148.5587
7150.2845
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
7125
7130
7135
7140
7145
7150
Wavelength (Å)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7159.9373
7162.5599
7168.8945
7173.3709
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2×10^6
1×10^6
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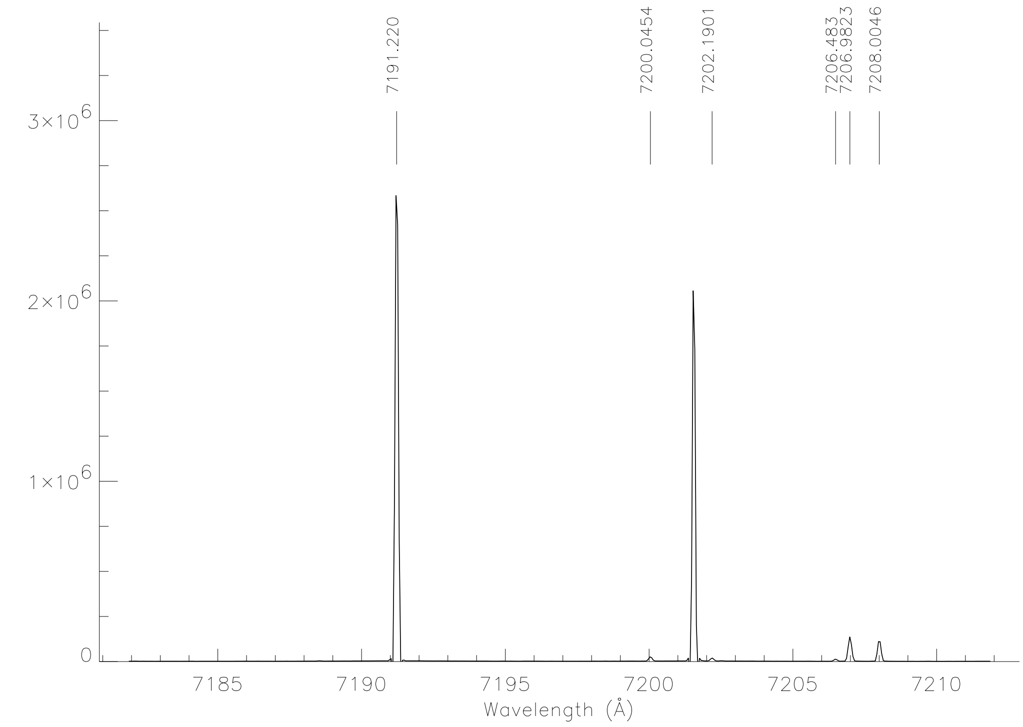
7160
7165
7170
7175
7180
Wavelength (Å)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7200.0454
7202.1901
7206.483
7206.9823
7208.0046
3×10^6
2×10^6
1×10^6
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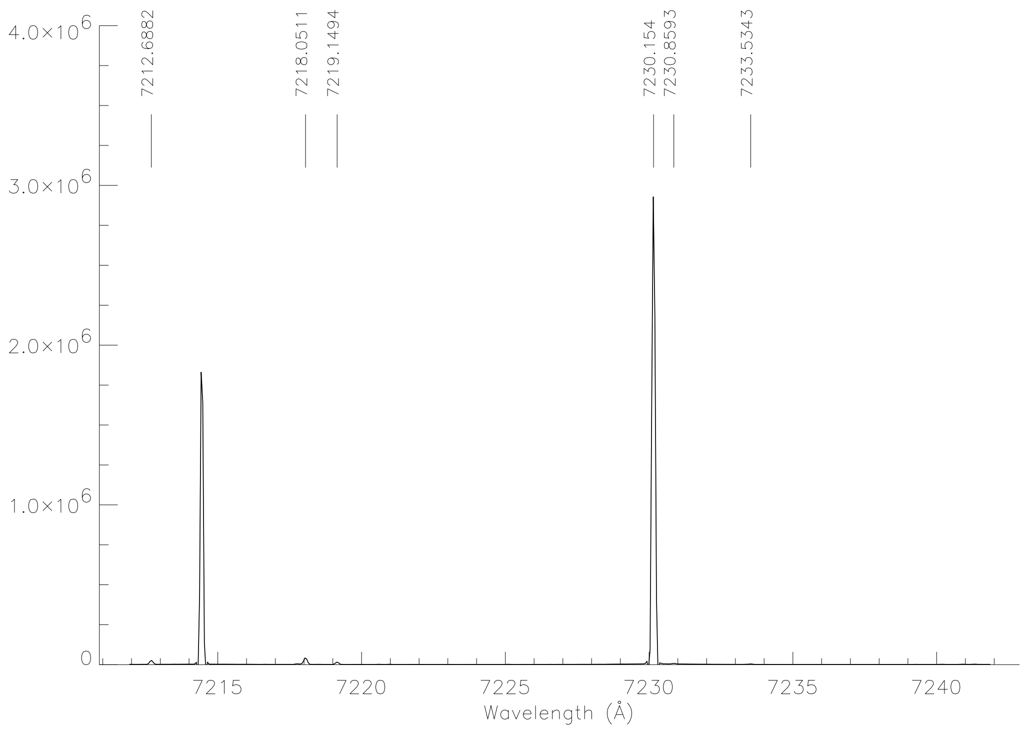
7190
7195
7200
7205
7210
Wavelength (Å)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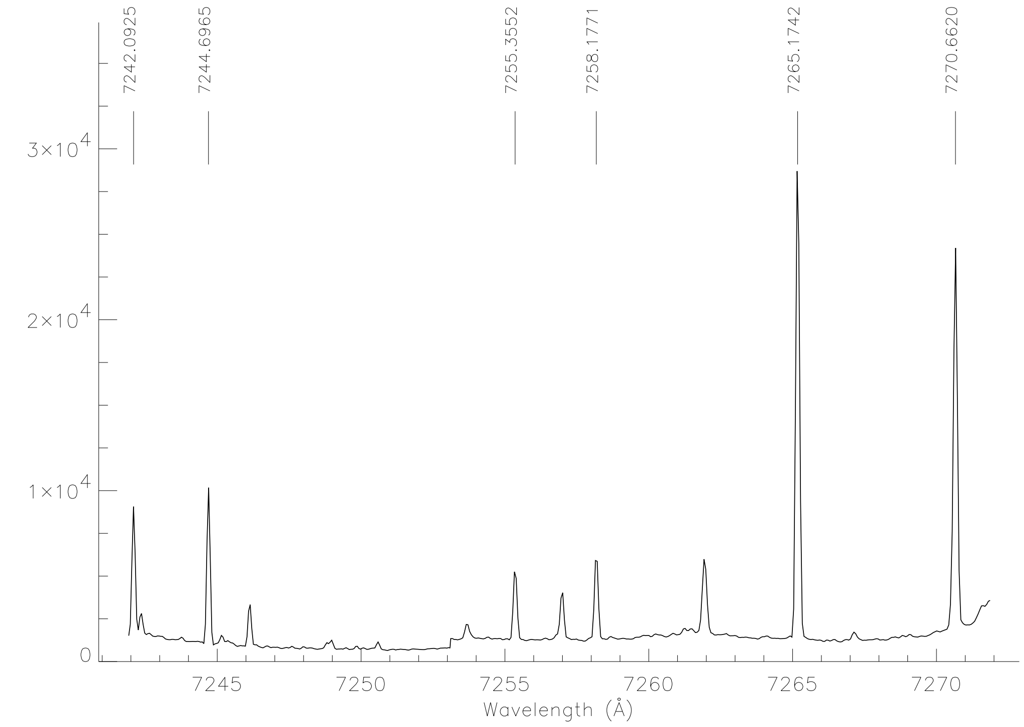
7218.0511
7219.1494
7230.154
7230.8593
7233.5343
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7215
7220
7225
7230
7235
7240
Wavelength (Å)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7244.6965
7255.3552
7258.1771
7265.1742
7270.6620
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2×10^4
1×10^4
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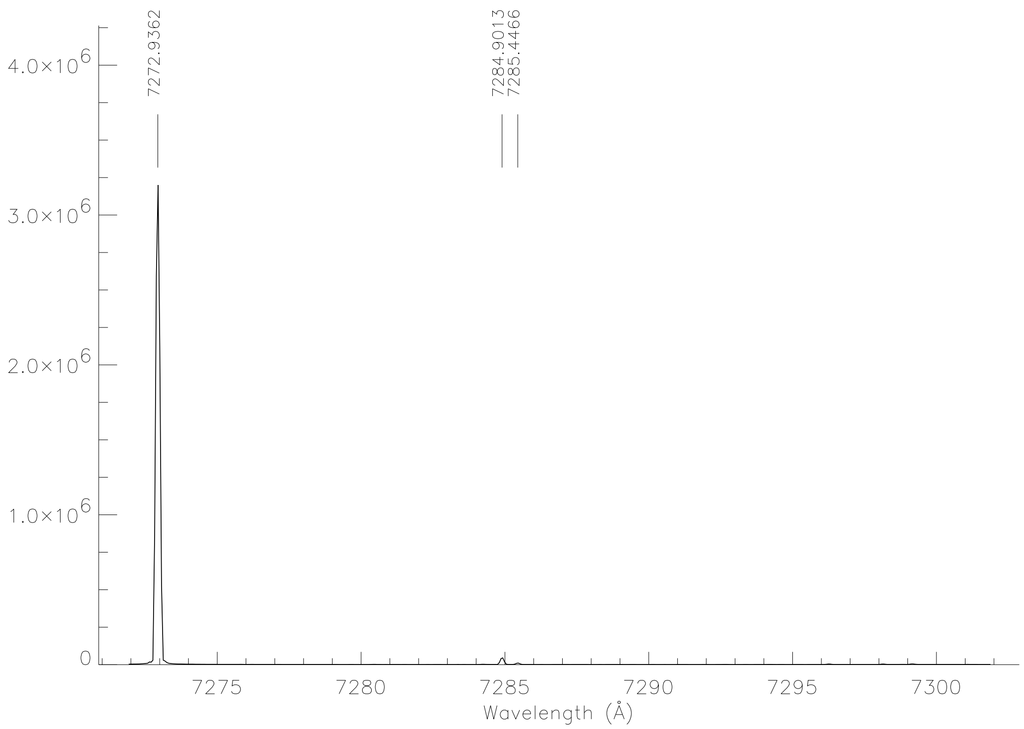
7250
7255
7260
7265
7270
Wavelength (Å)


7272.9362
7284.9013
7285.4466
4.0×10^6
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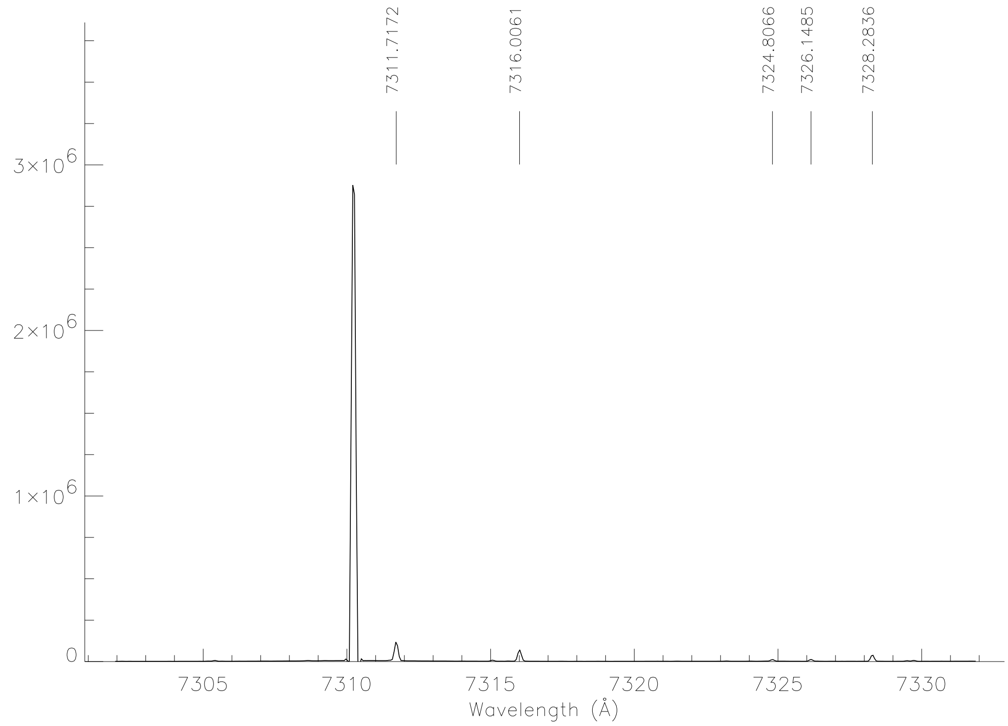
2.0×10^6
1.0×10^6
0
7275
7280
7285
7290
7295
7300
Wavelength (Å)


7311.7172
7316.0061
7324.8066
7326.1485
7328.2836
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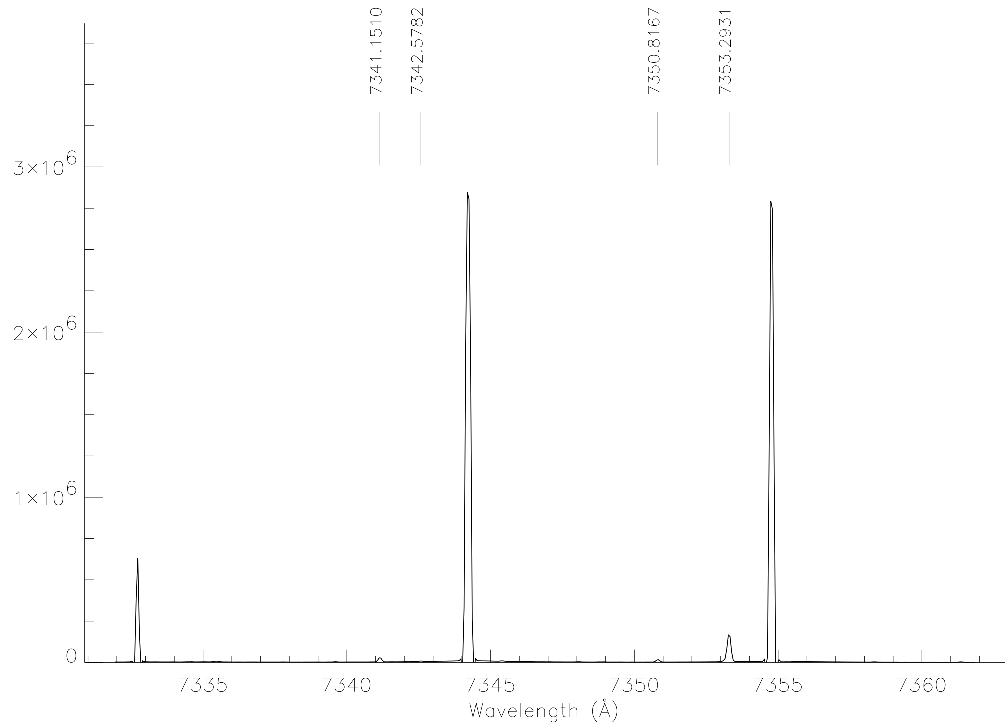
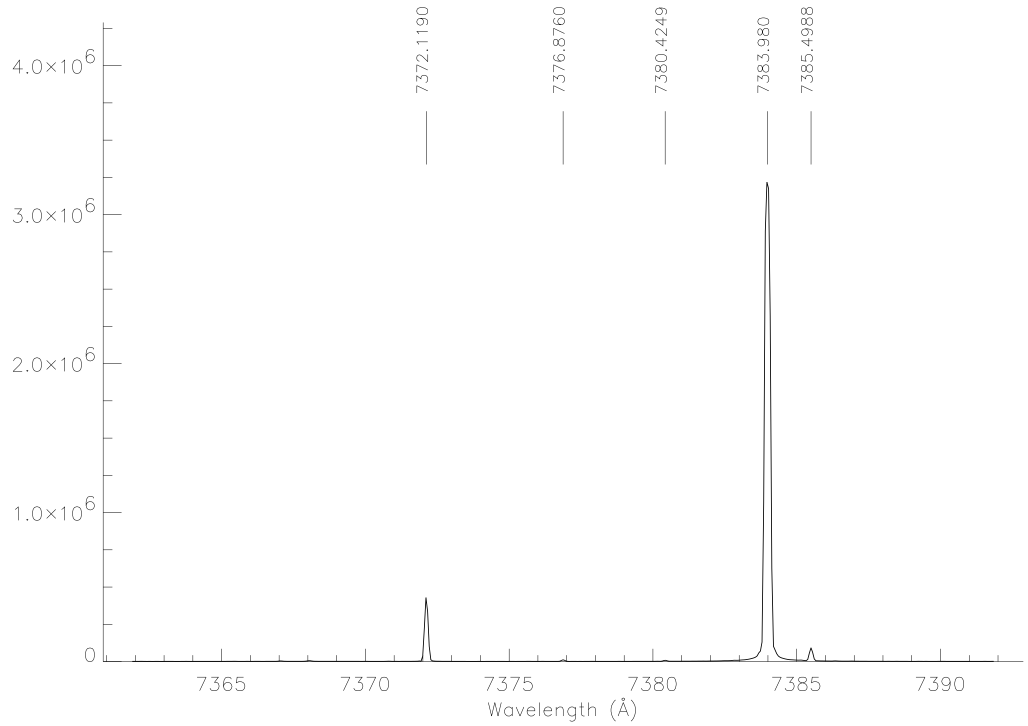
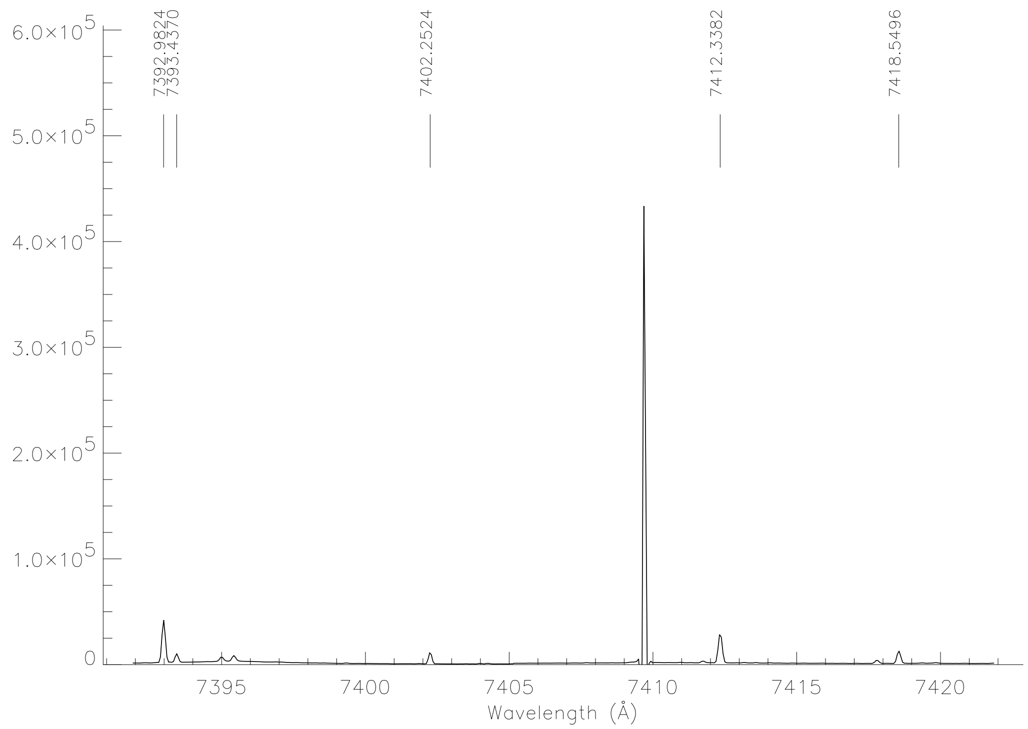
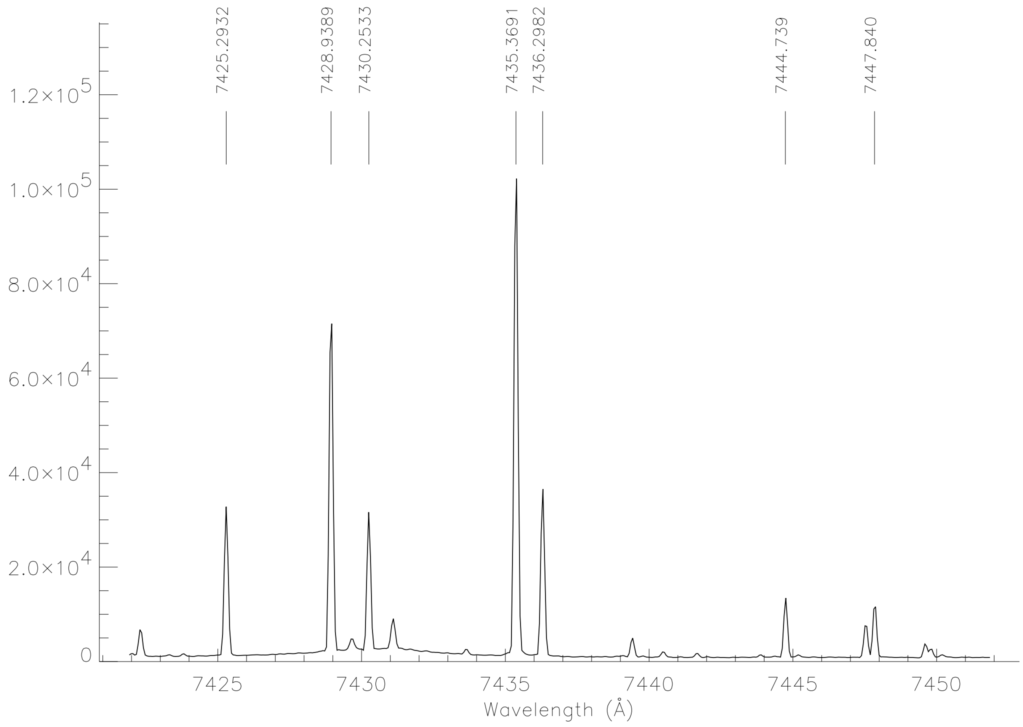
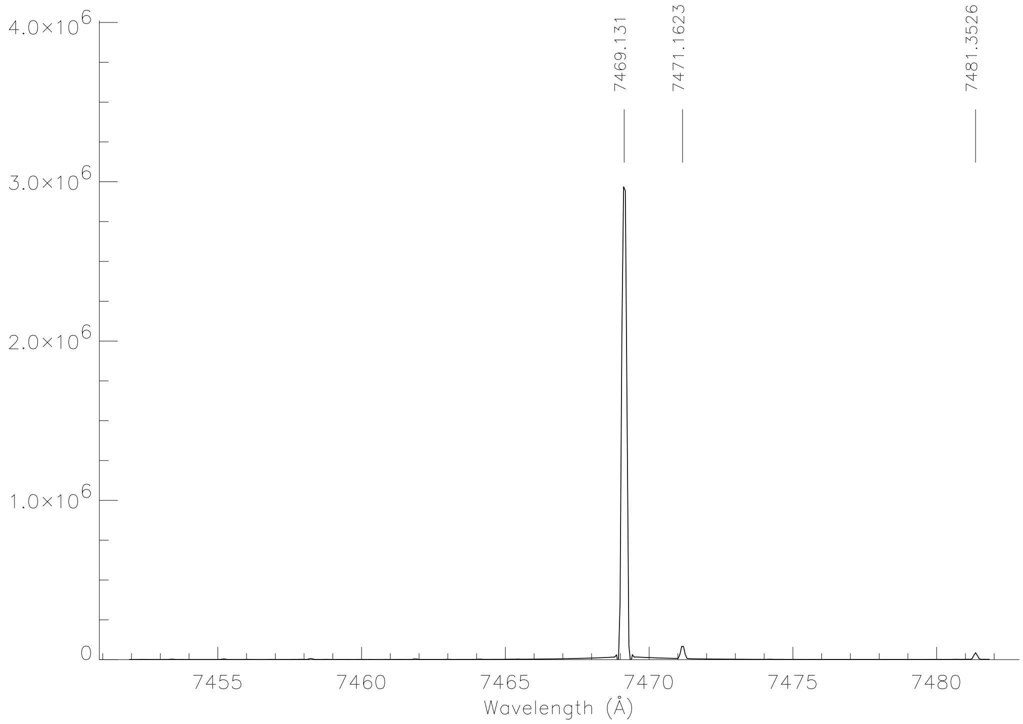
2×10^6
1×10^6
0
7305
7310
7315
7320
7325
7330
Wavelength (Å)

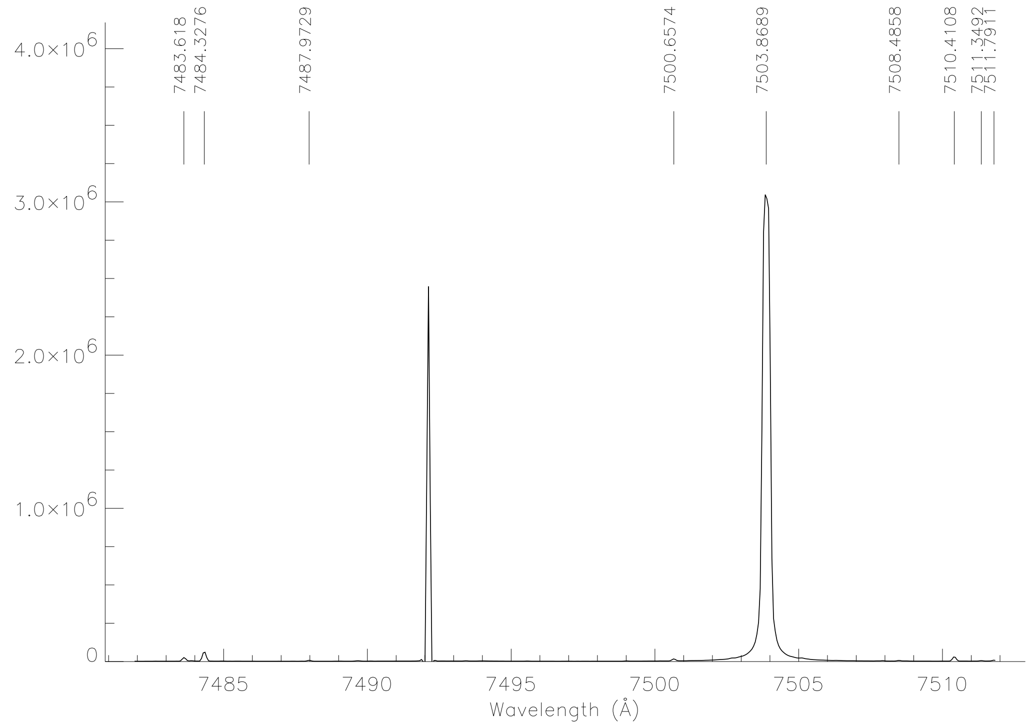

7341.1510
7342.5782
7350.8167
7353.2931
3×10^6
2×10^6
1×10^6
0
7335
7340
7345
7350
7355
7360
Wavelength (Å)


7372.1190
7376.8760
7380.4249
7383.980
7385.4988
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7365
7370
7375
7380
7385
7390
Wavelength (Å)

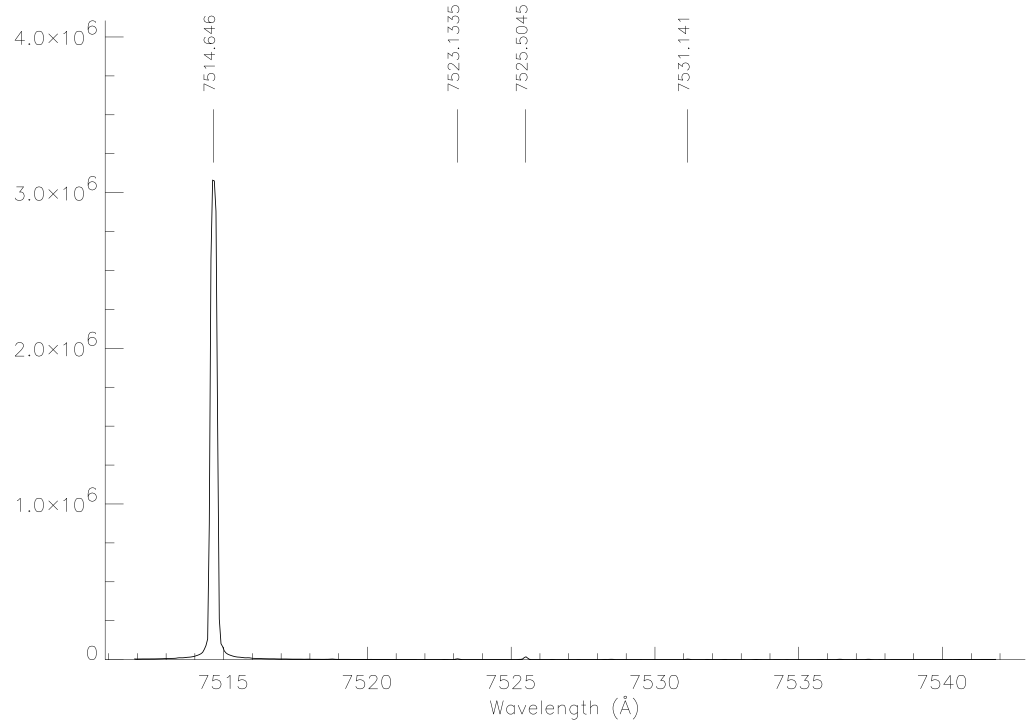

7392.9824
7393.4370
7402.2524
7412.3382
7418.5496
6.0×10^5
5.0×10^5
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
7395
7400
7405
7410
7415
7420
Wavelength (Å)


7425.2932
7428.9389
7430.2533
7435.3691
7436.2982
7444.739
7447.840
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
7425
7430
7435
7440
7445
7450
Wavelength (Å)

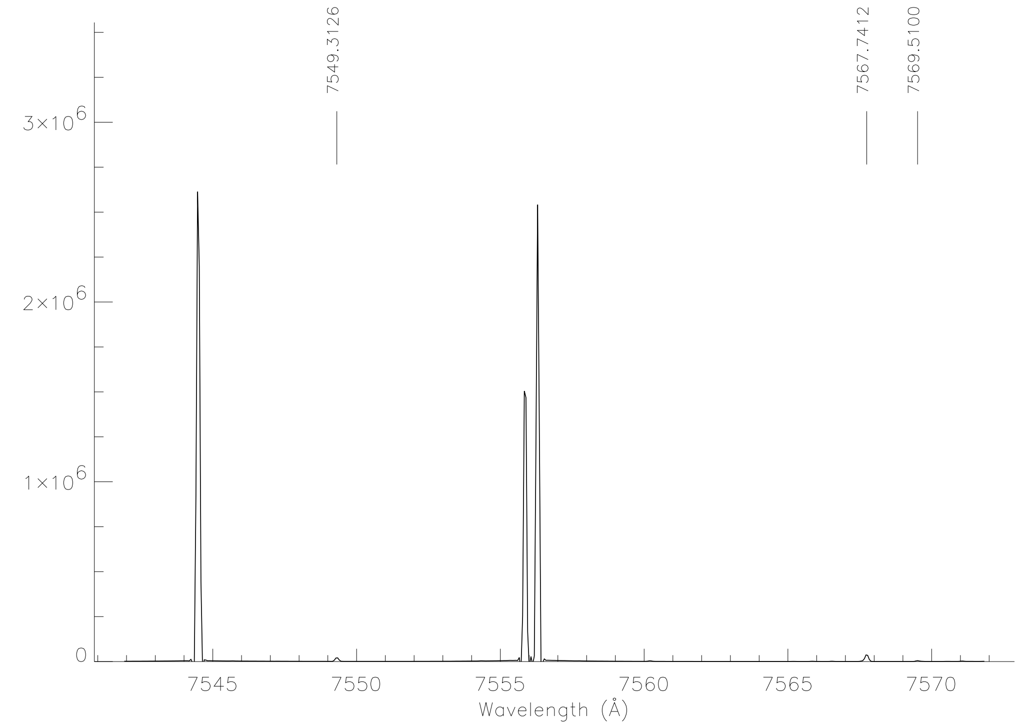

7469.131
7471.1623
7481.3526
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7455
7460
7465
7470
7475
7480
Wavelength (Å)



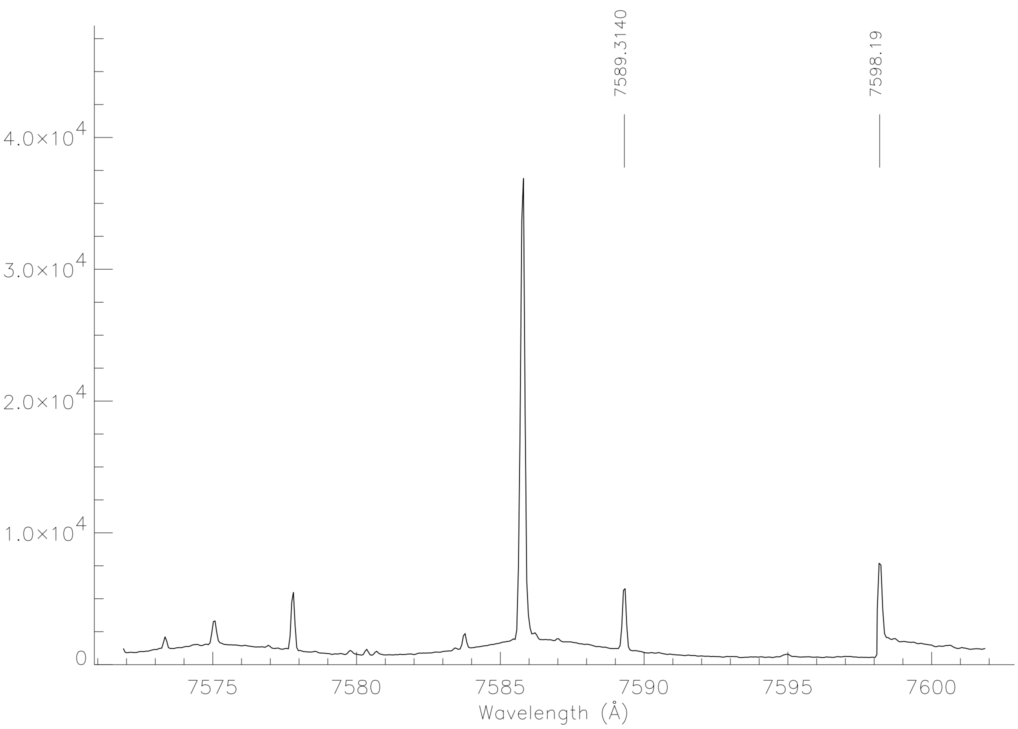
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7483.618
7484.3276
7487.9729
7500.6574
7503.8689
7508.4858
7510.4108
7511.3492
7511.7911
7485
7490
7495
7500
7505
7510
Wavelength (Å)



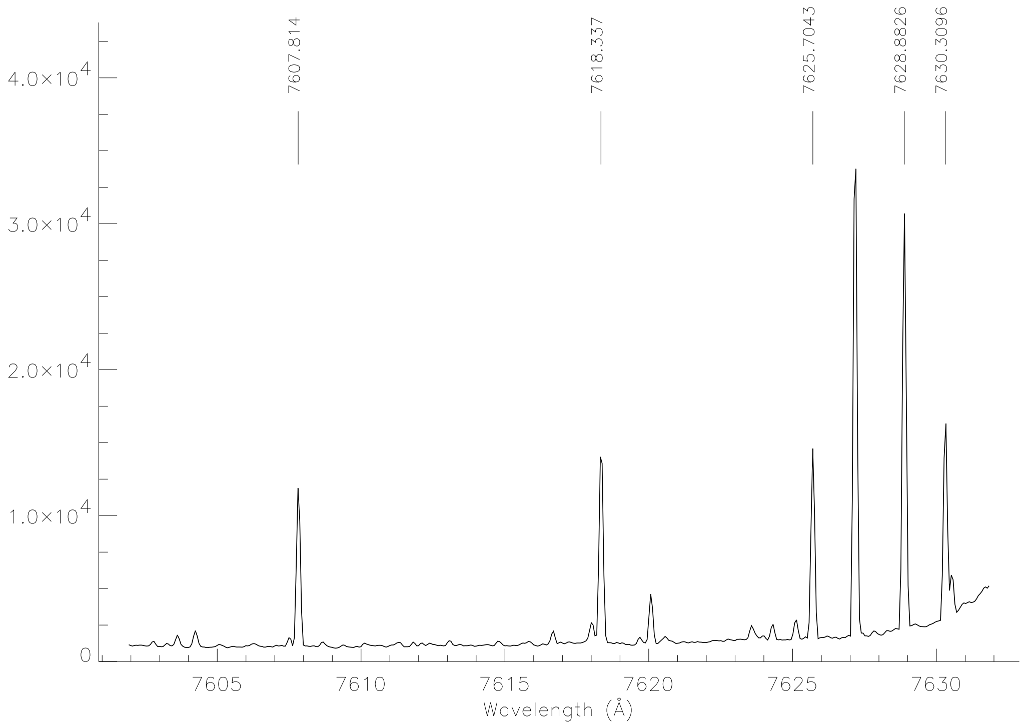
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7514.646
7523.1335
7525.5045
7531.141
7515
7520
7525
7530
7535
7540
Wavelength (Å)

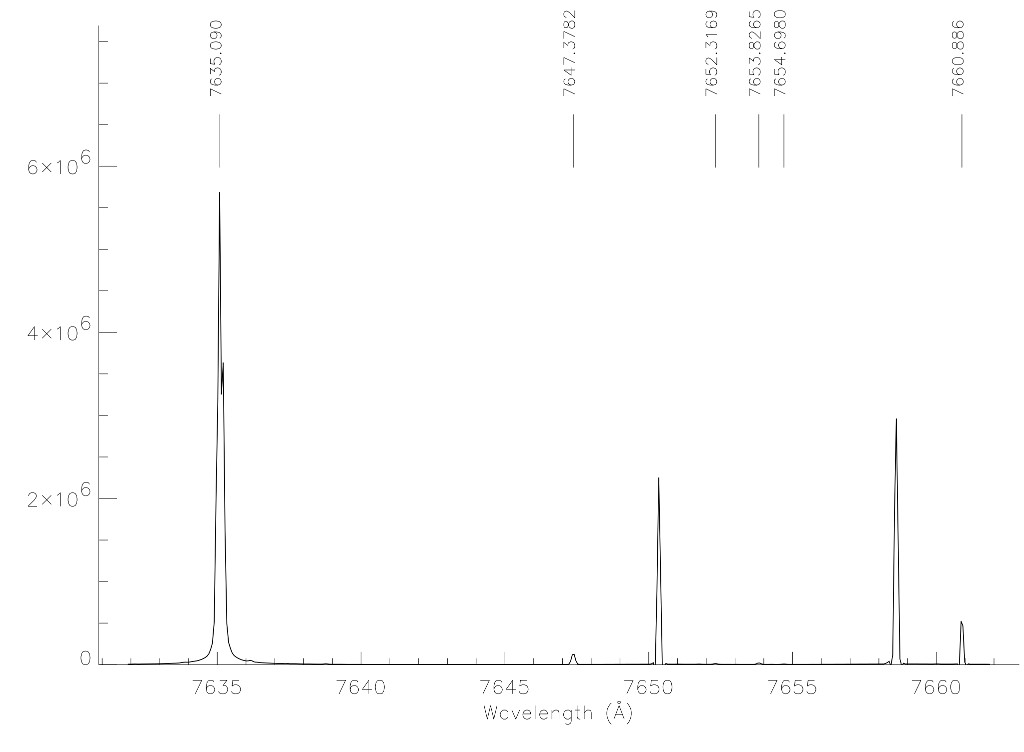


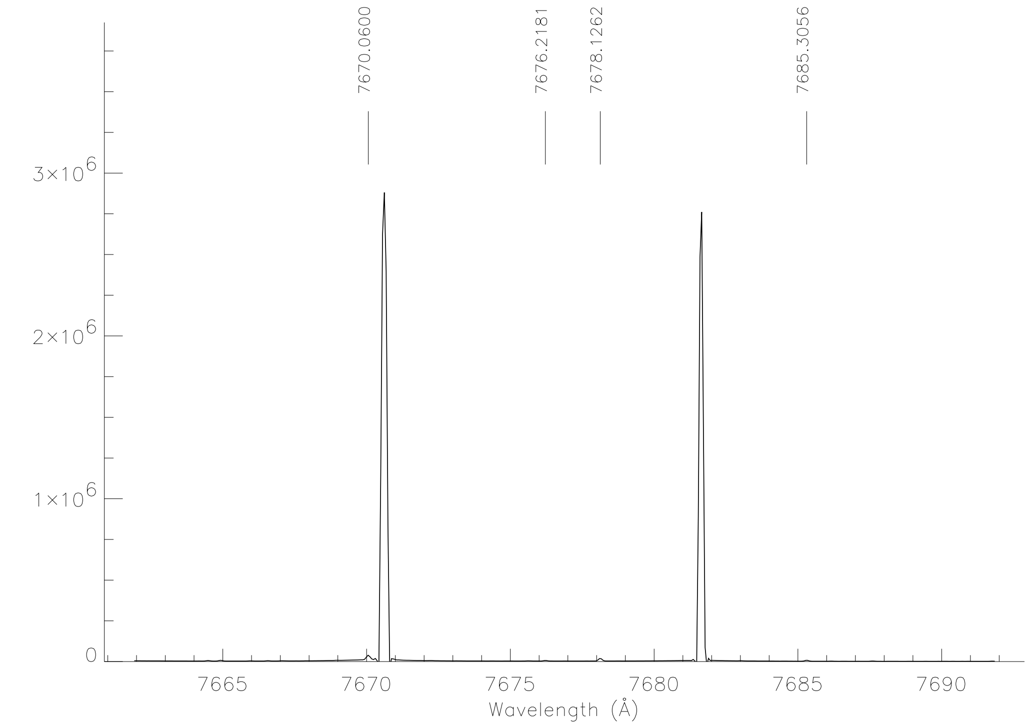
7549.3126
7567.7412
7569.5100
3×10^6
2×10^6
1×10^6
0
7545
7550
7555
7560
7565
7570
Wavelength (Å)



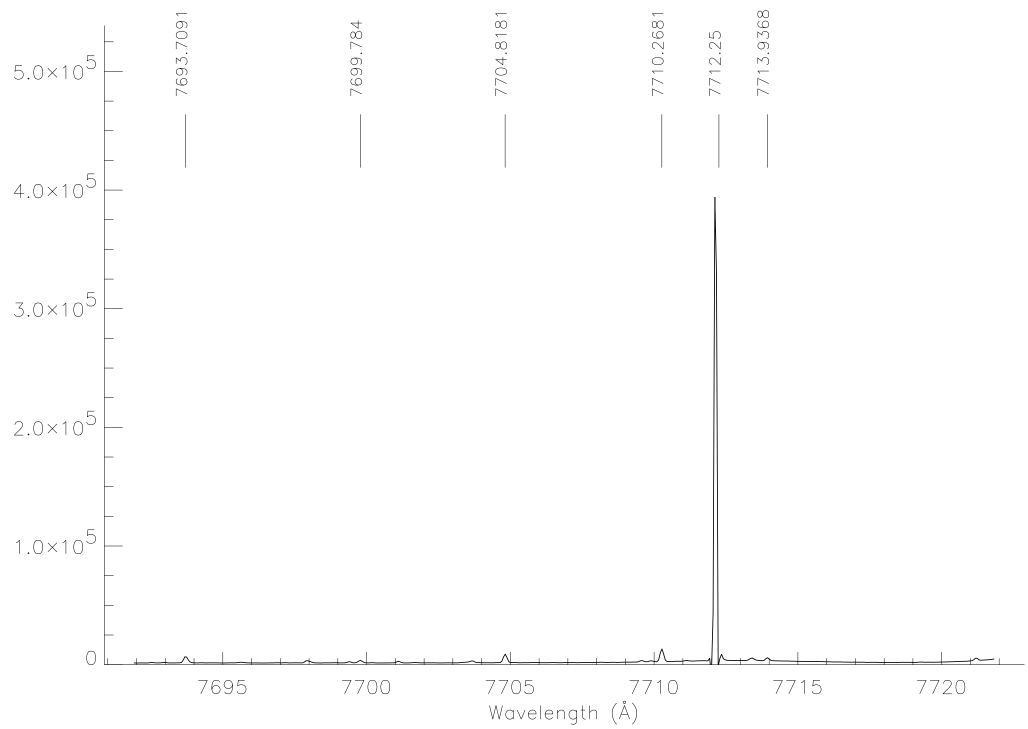
7589.3140
7598.19
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
7575
7580
7585
7590
7595
7600
Wavelength (Å)


7607.814
7618.337
7625.7043
7628.8826
7630.3096
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
7605
7610
7615
7620
7625
7630
Wavelength (Å)

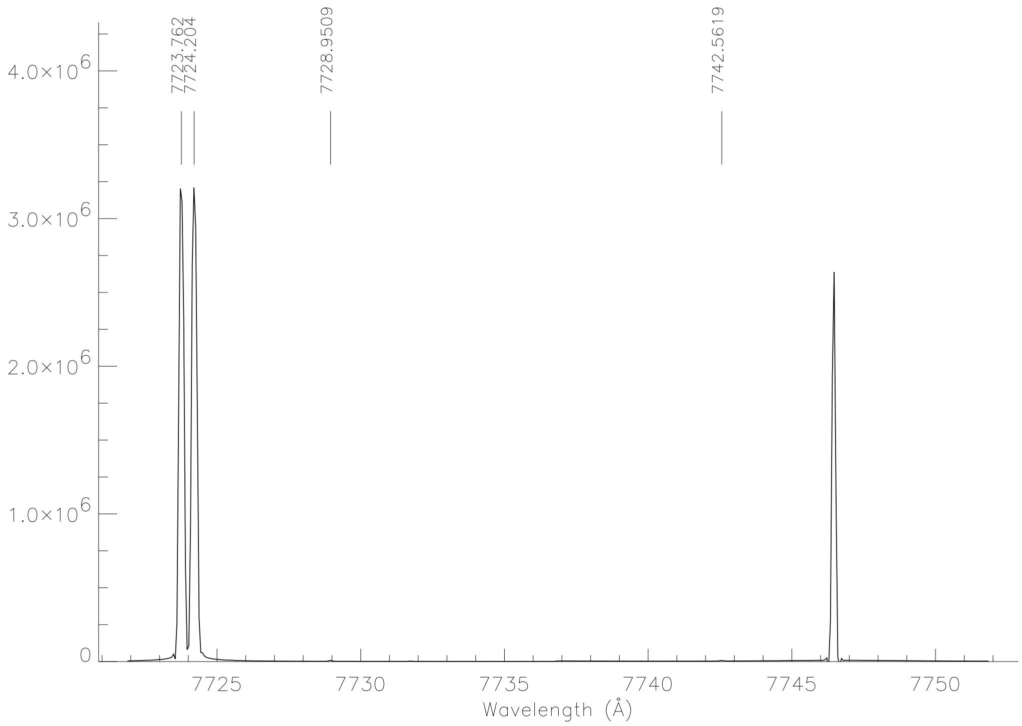

7635.090
7647.3782
7652.3169
7653.8265
7654.6980
7660.886
6×10^6
4×10^6
2×10^6
0
7635
7640
7645
7650
7655
7660
Wavelength (Å)

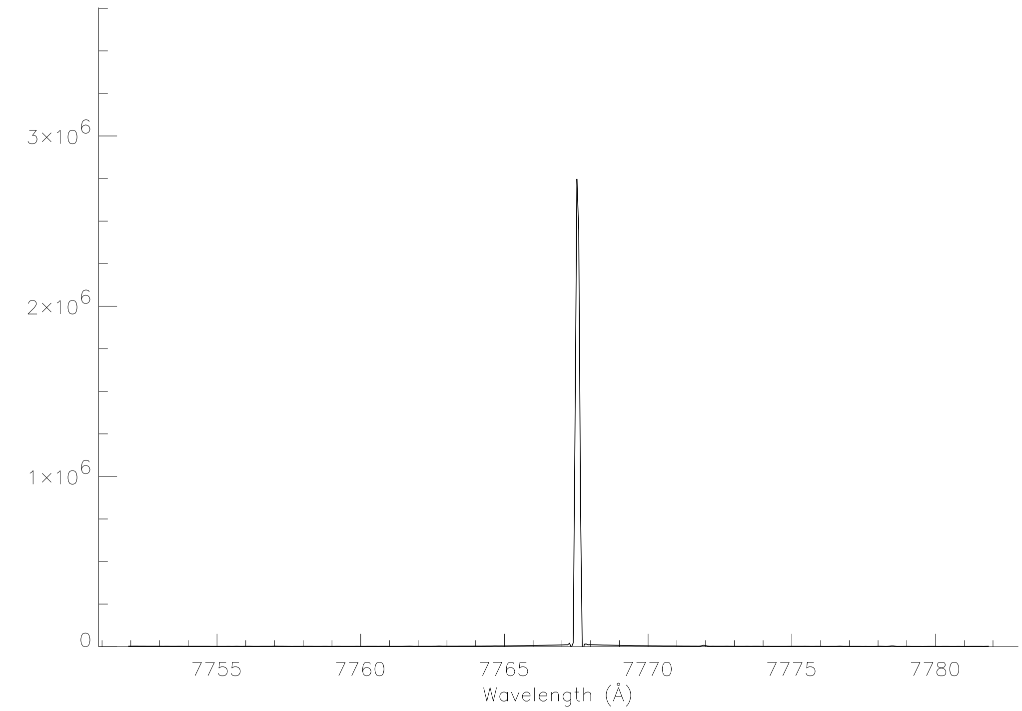


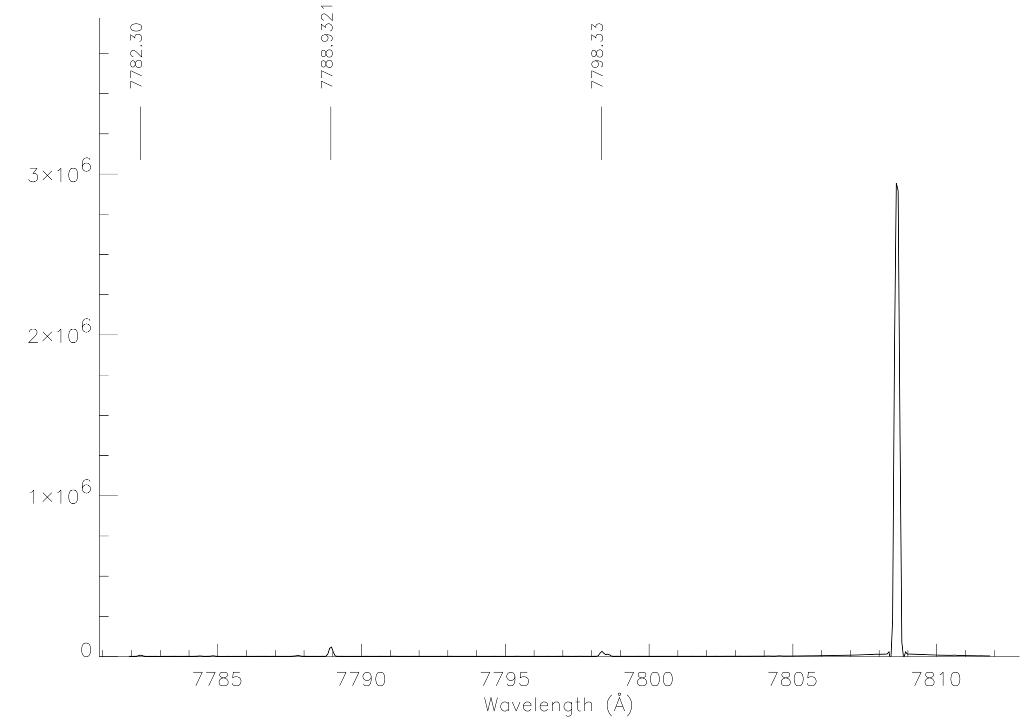
7670.0600
7676.2181
7678.1262
7685.3056
3×10^6
2×10^6
1×10^6
0
7665
7670
7675
7680
7685
7690
Wavelength (Å)

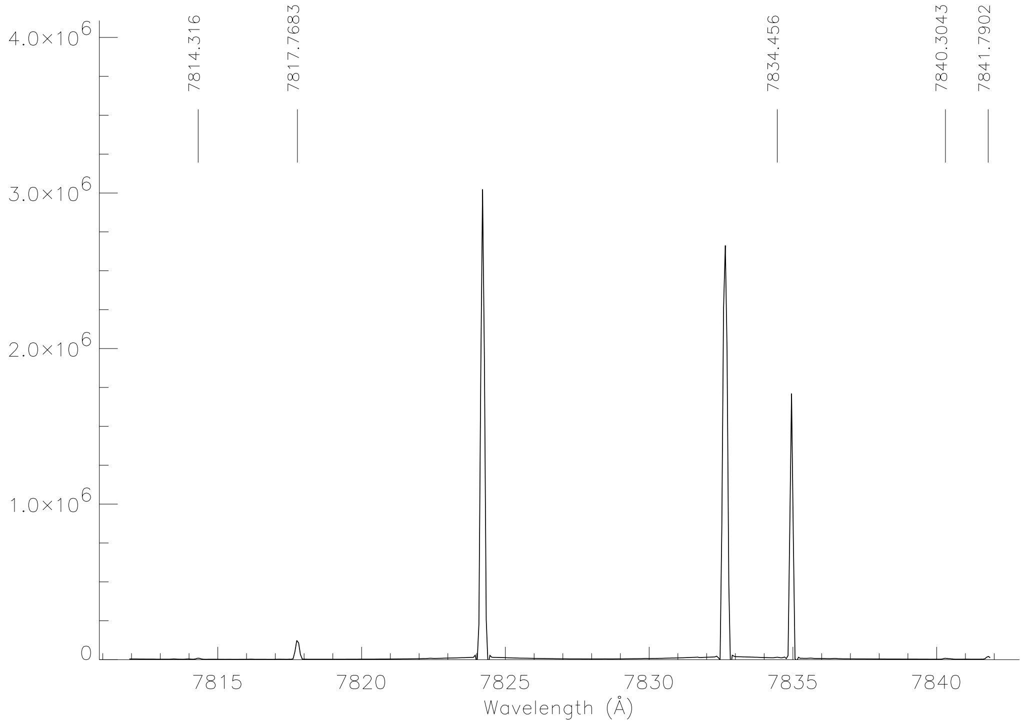


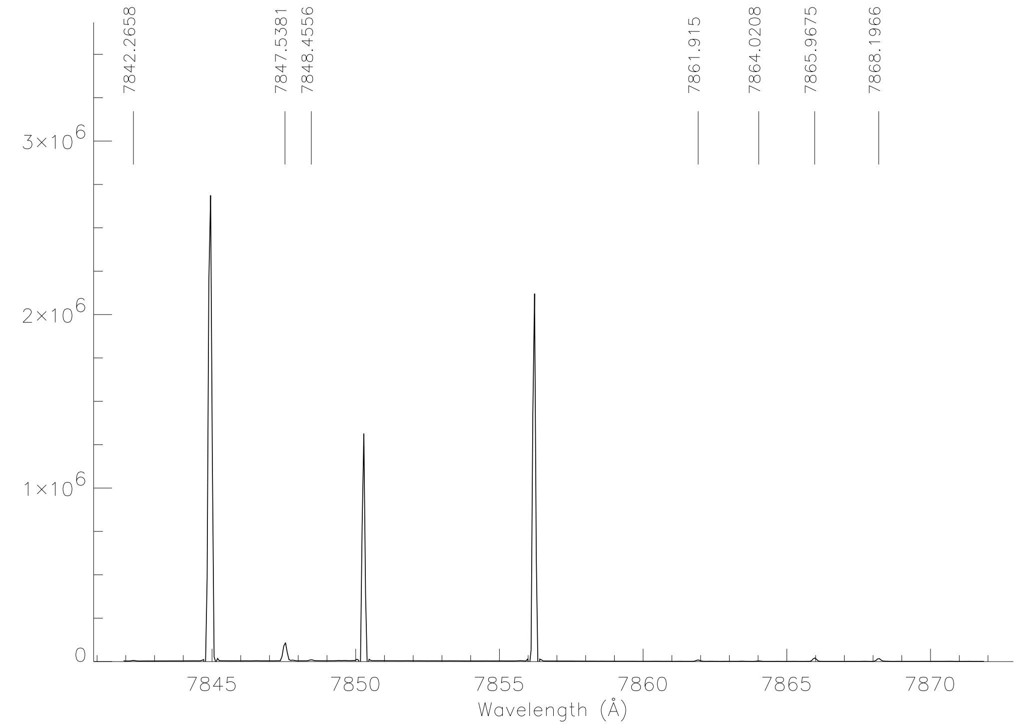
7693.7091
7699.784
7704.8181
7710.2681
7712.25
7713.9368
5.0×10^5
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
7695
7700
7705
7710
7715
7720
Wavelength (Å)

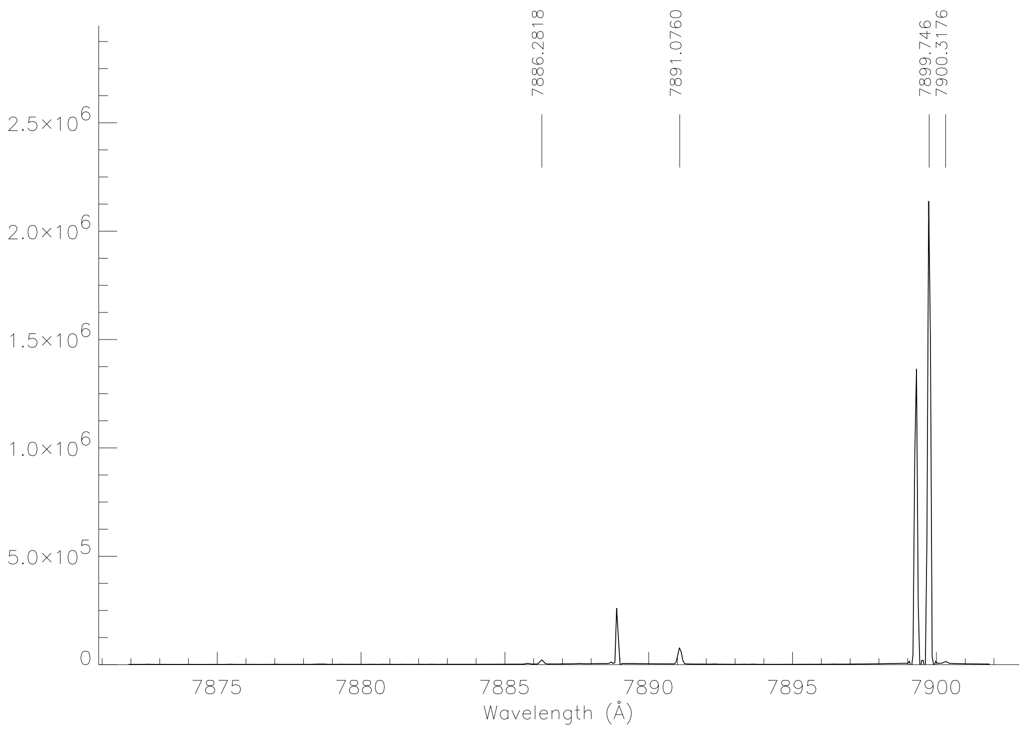

7723.762
7724.204
7728.9509
7742.5619
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7725
7730
7735
7740
7745
7750
Wavelength (Å)

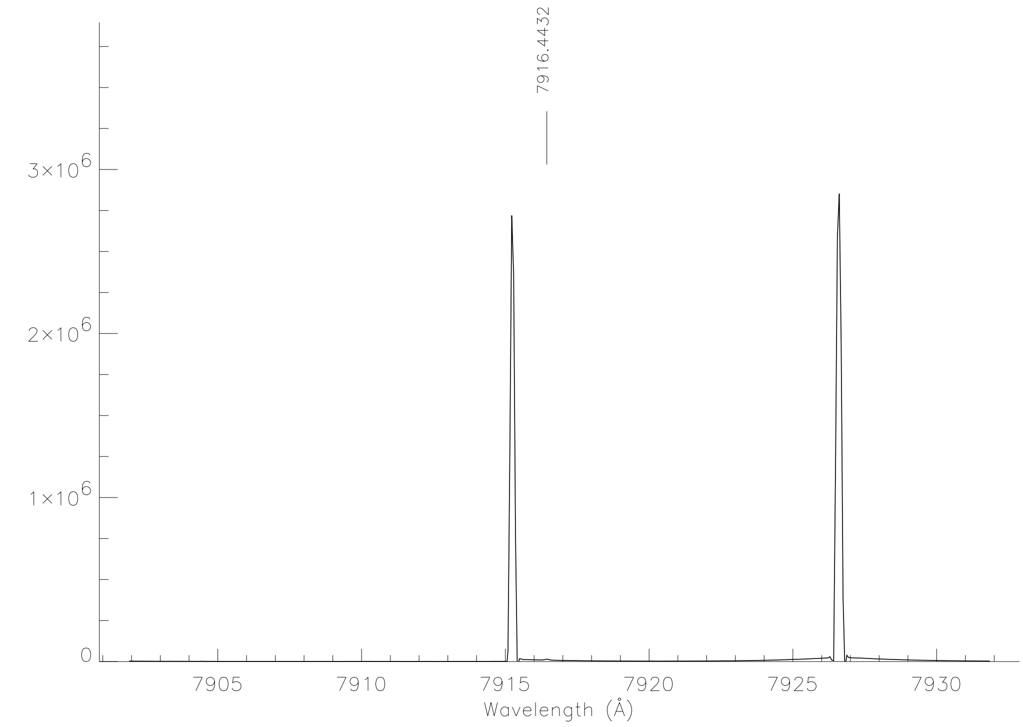

3×10^6
2×10^6
1×10^6
0
7755
7760
7765
7770
7775
7780
Wavelength (Å)

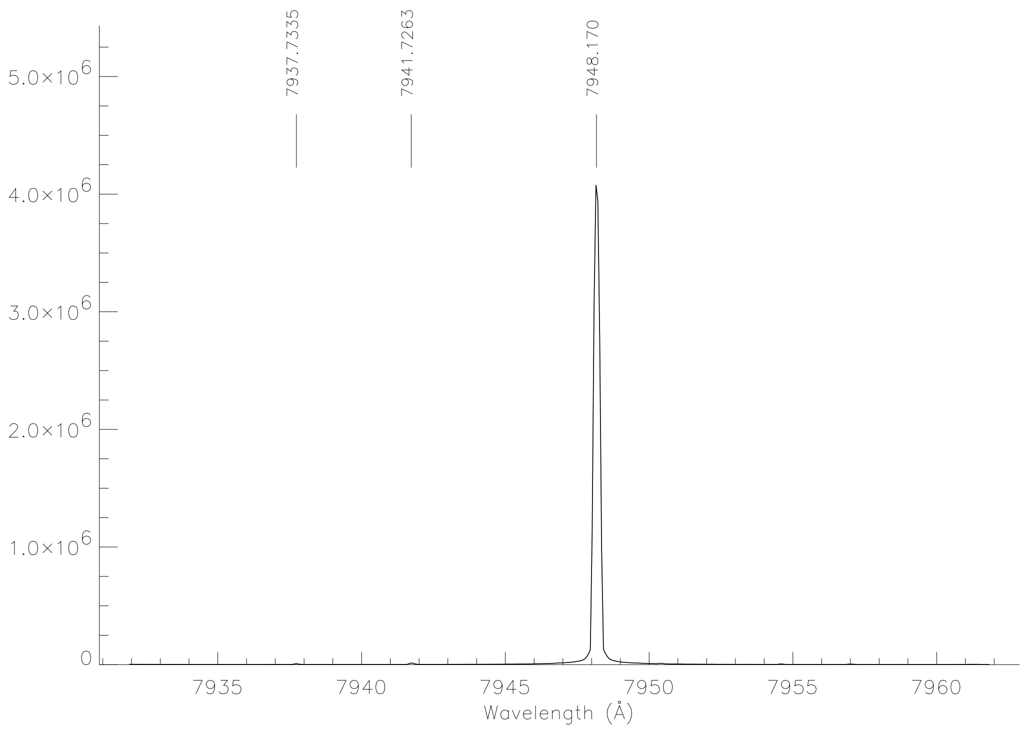

7782.30
7788.9321
7798.33
3×10^6
2×10^6
1×10^6
0
7785
7790
7795
7800
7805
7810
Wavelength (Å)


7814.316
7817.7683
7834.456
7840.3043
7841.7902
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7815
7820
7825
7830
7835
7840
Wavelength (Å)


7842.2658
7847.5381
7848.4556
7861.915
7864.0208
7865.9675
7868.1966
3×10^6
2×10^6
1×10^6
0
7845
7850
7855
7860
7865
7870
Wavelength (Å)


7886.2818
7891.0760
7899.746
7900.3176
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
7875
7880
7885
7890
7895
7900
Wavelength (Å)


7916.4432
3×10^6
2×10^6
1×10^6
0
7905
7910
7915
7920
7925
7930
Wavelength (Å)


7937.7335
7941.7263
7948.170
5.0×10^6
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
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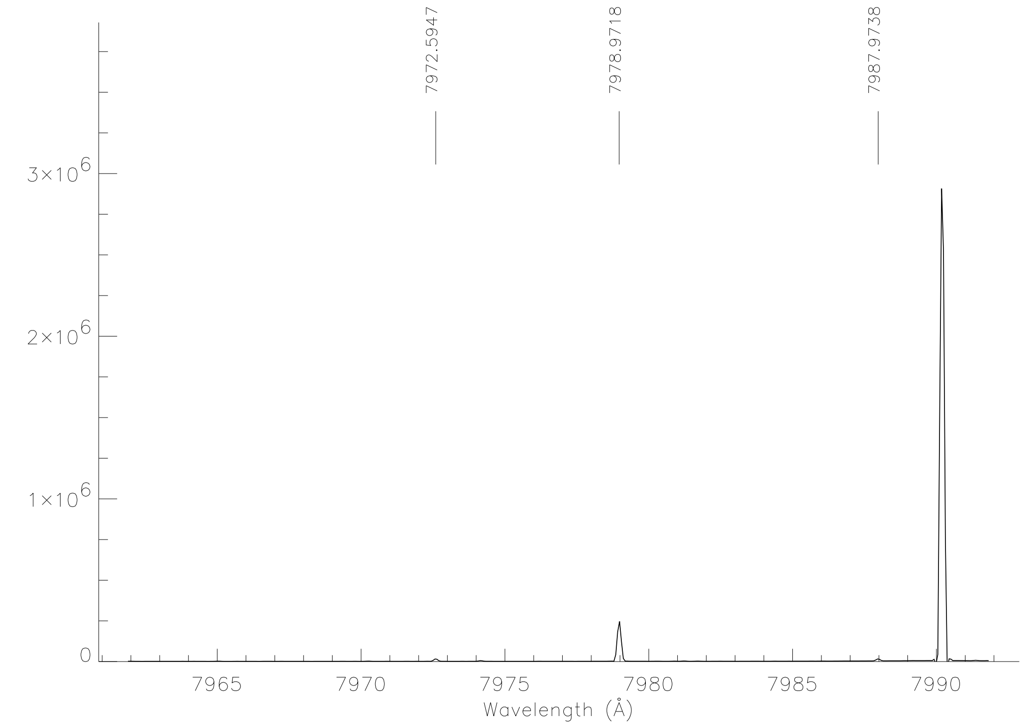
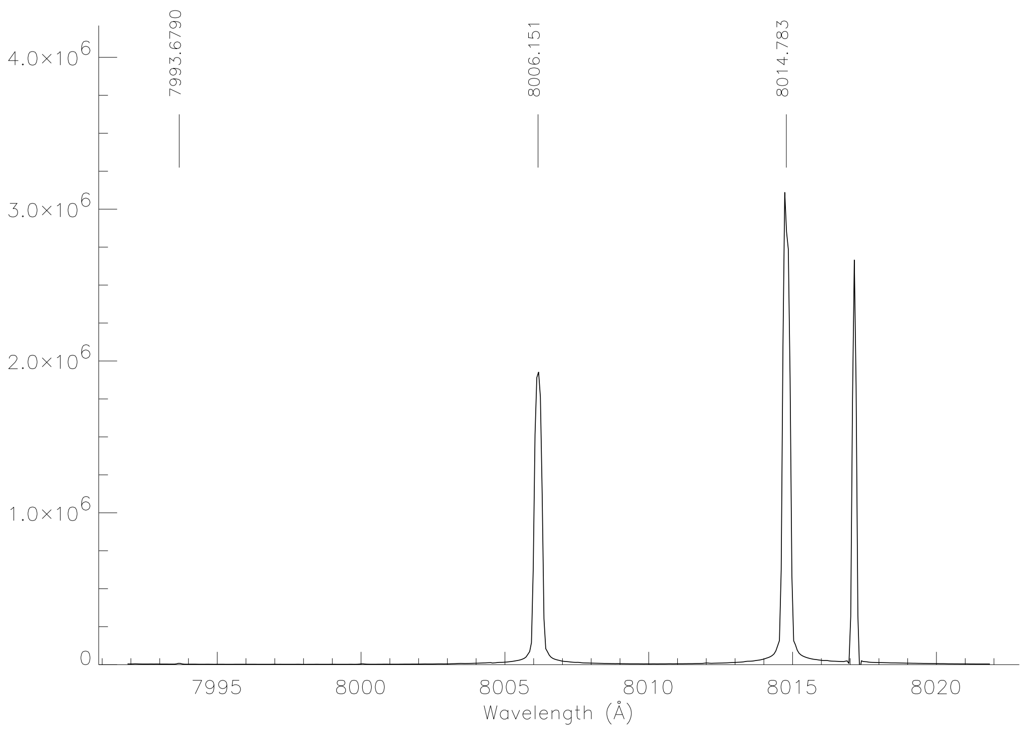
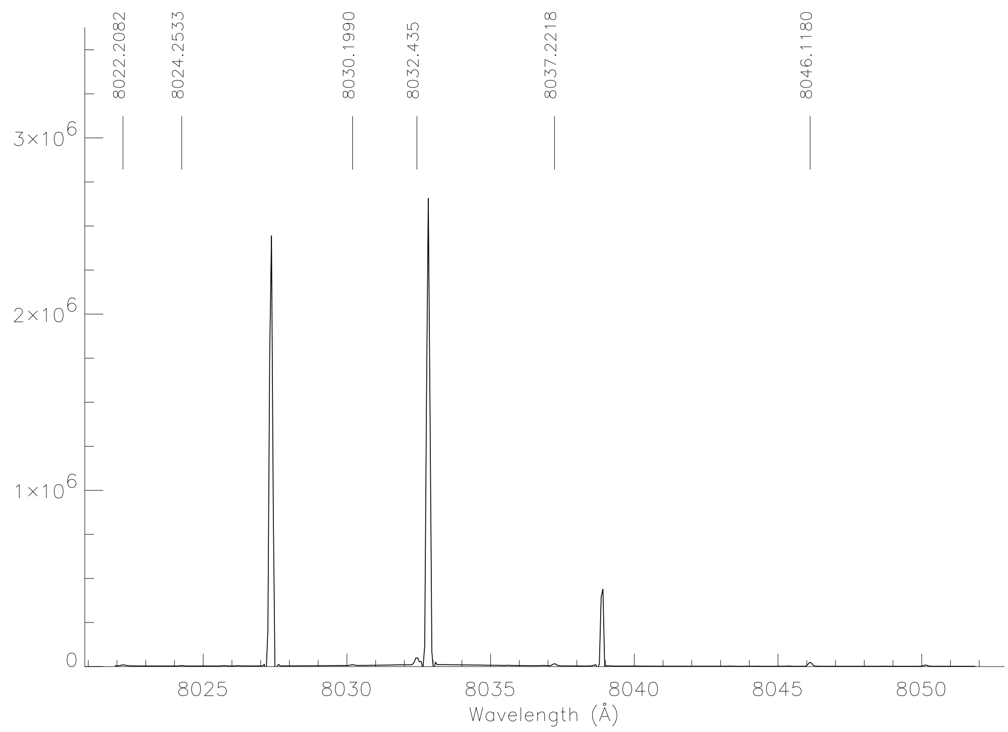
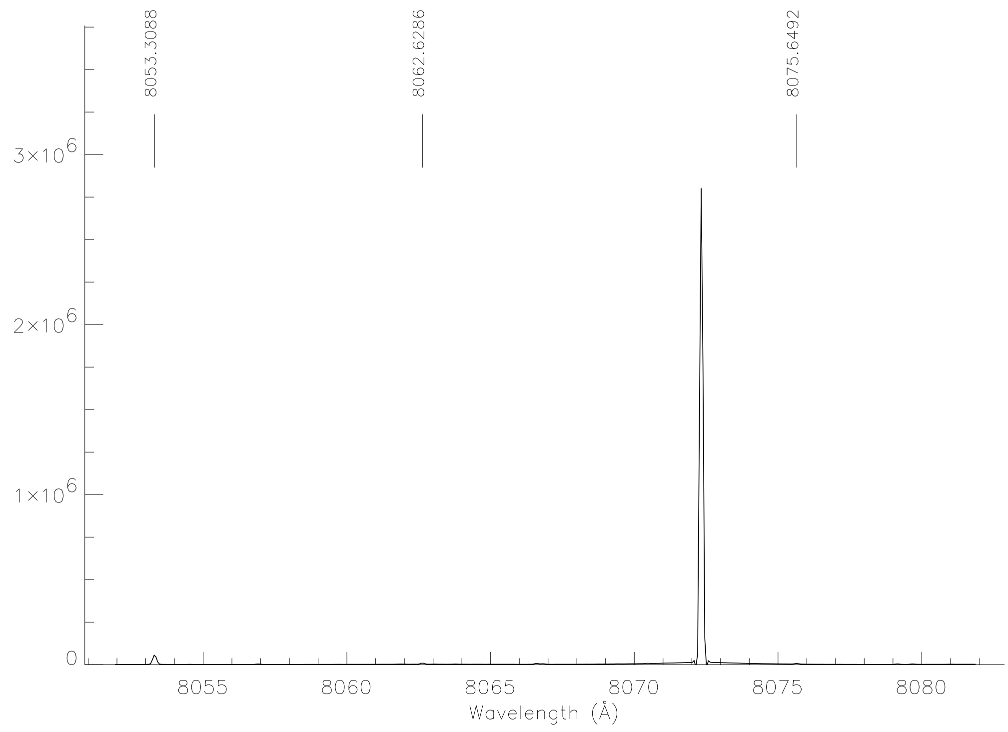
7935
7940
7945
7950
7955
7960
Wavelength (Å)


7972.5947
7978.9718
7987.9738
3×10^6
2×10^6
1×10^6
0
7965
7970
7975
7980
7985
7990
Wavelength (Å)


7993.6790
8006.151
8014.783
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
7995
8000
8005
8010
8015
8020
Wavelength (Å)



8022.2082
8024.2533
8030.1990
8032.435
8037.2218
8046.1180
3×10^6
2×10^6
1×10^6
0
8025
8030
8035
8040
8045
8050
Wavelength (Å)



8053.3088
8062.6286
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2×10^6
1×10^6
0
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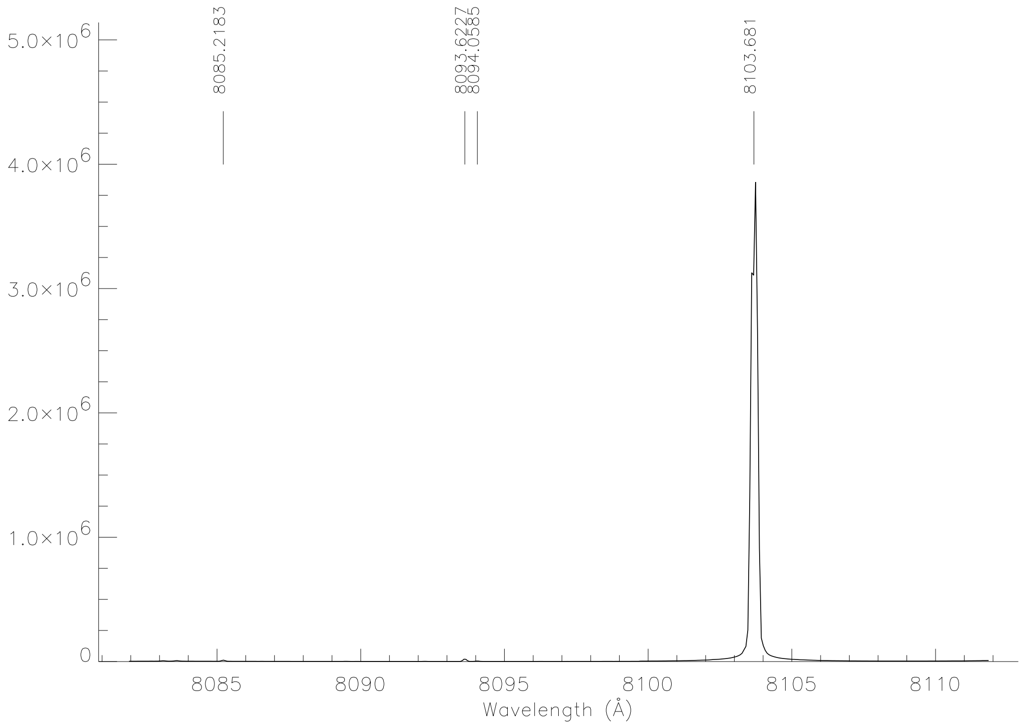
8060
8065
8070
8075
8080
Wavelength (Å)


8085.2183
8093.6227
8094.0585
8103.681
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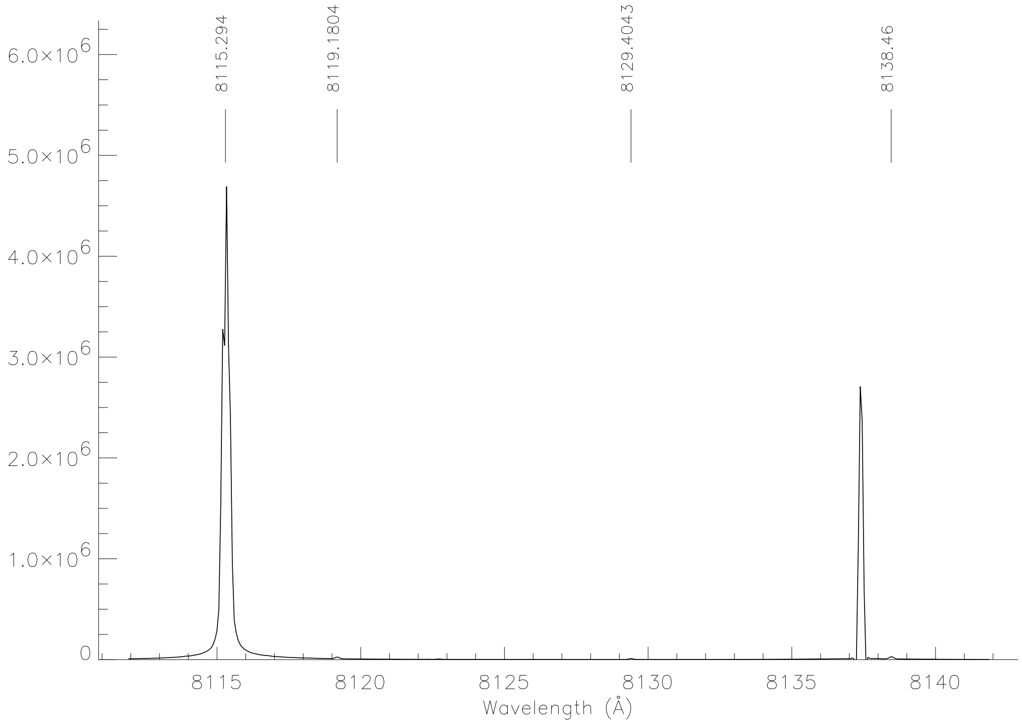
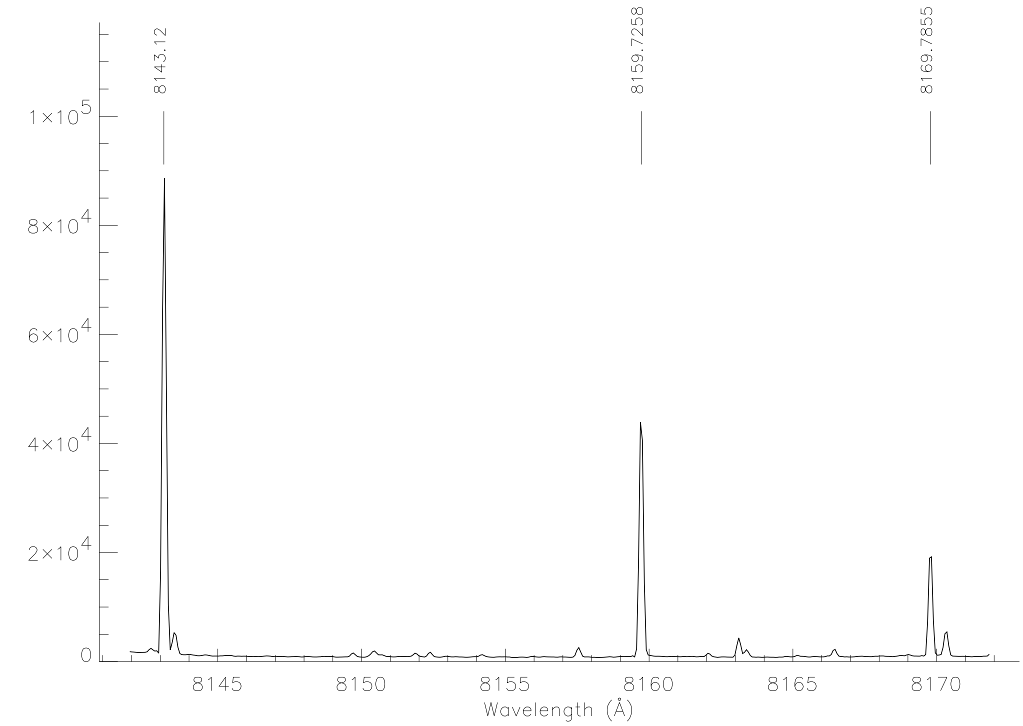
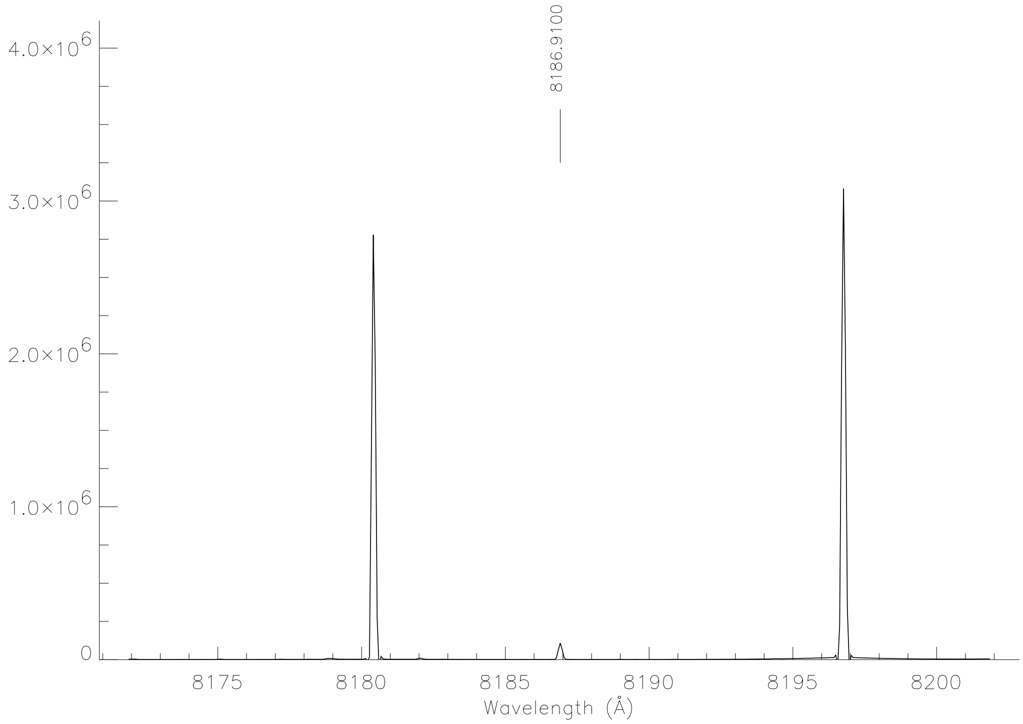
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
8085
8090
8095
8100
8105
8110
Wavelength (Å)


8115.294
8119.1804
8129.4043
8138.46
6.0×10^6
5.0×10^6
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
8115
8120
8125
8130
8135
8140
Wavelength (Å)


8143.12
8159.7258
8169.7855
1×10^5
8×10^4
6×10^4
4×10^4
2×10^4
0
8145
8150
8155
8160
8165
8170
Wavelength (Å)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1.0×10^6
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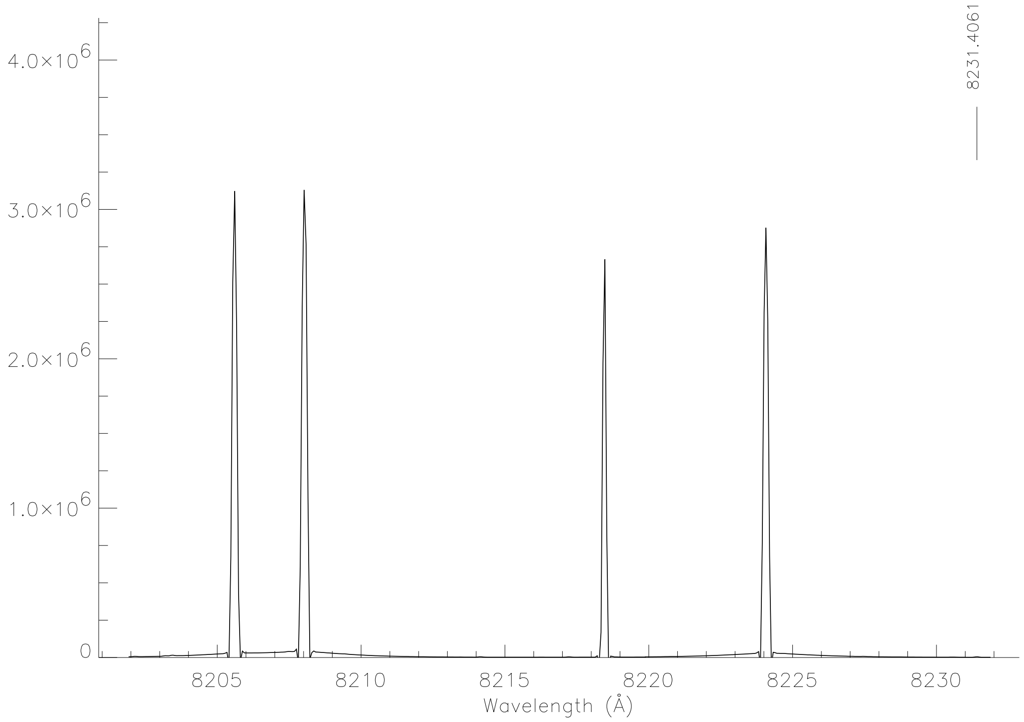
8180
8185
8190
8195
8200
Wavelength (Å)


8231.4061
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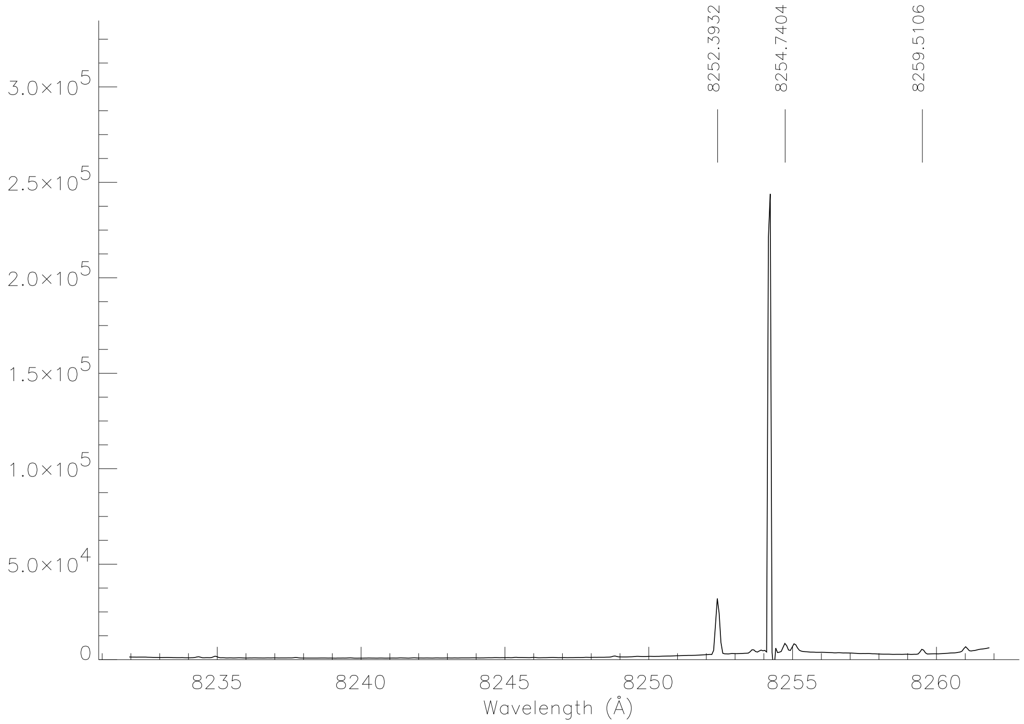
1.0×10^6
0
8205
8210
8215
8220
8225
8230
Wavelength (Å)


8252.3932
8254.7404
8259.5106
3.0×10^5
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
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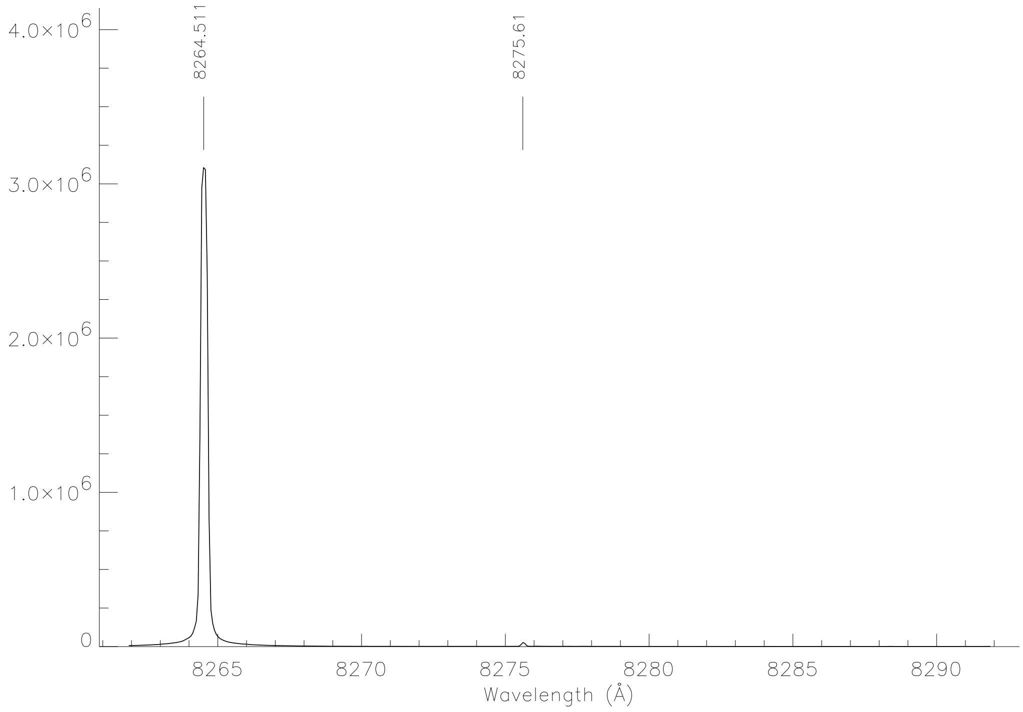
8235
8240
8245
8250
8255
8260
Wavelength (Å)



8264.511
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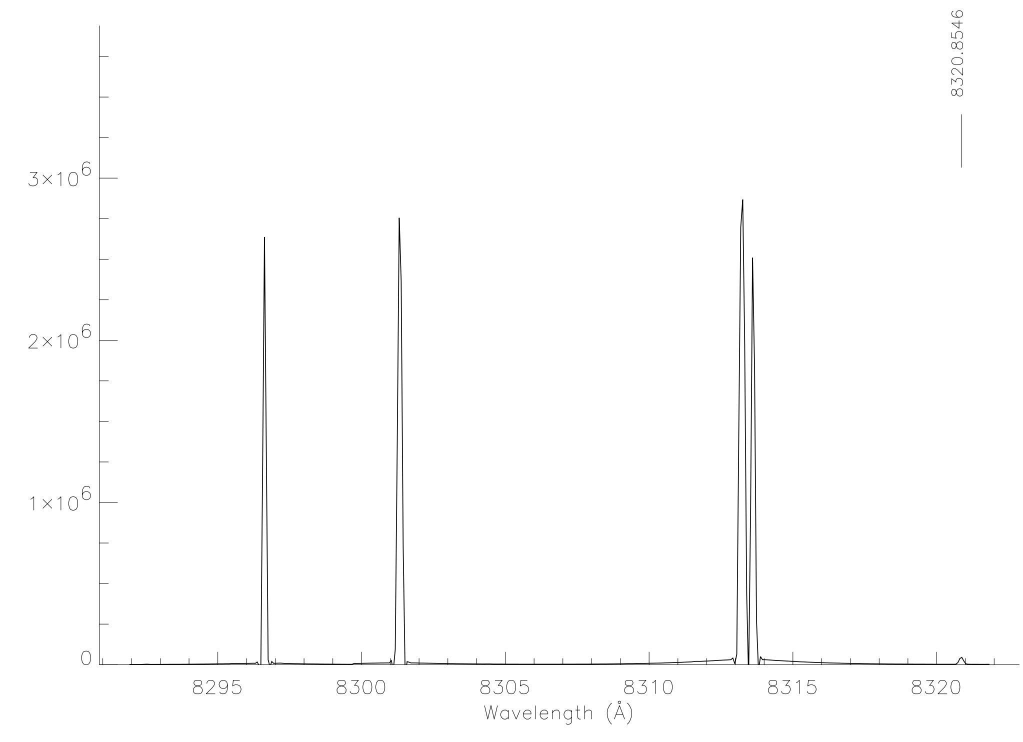
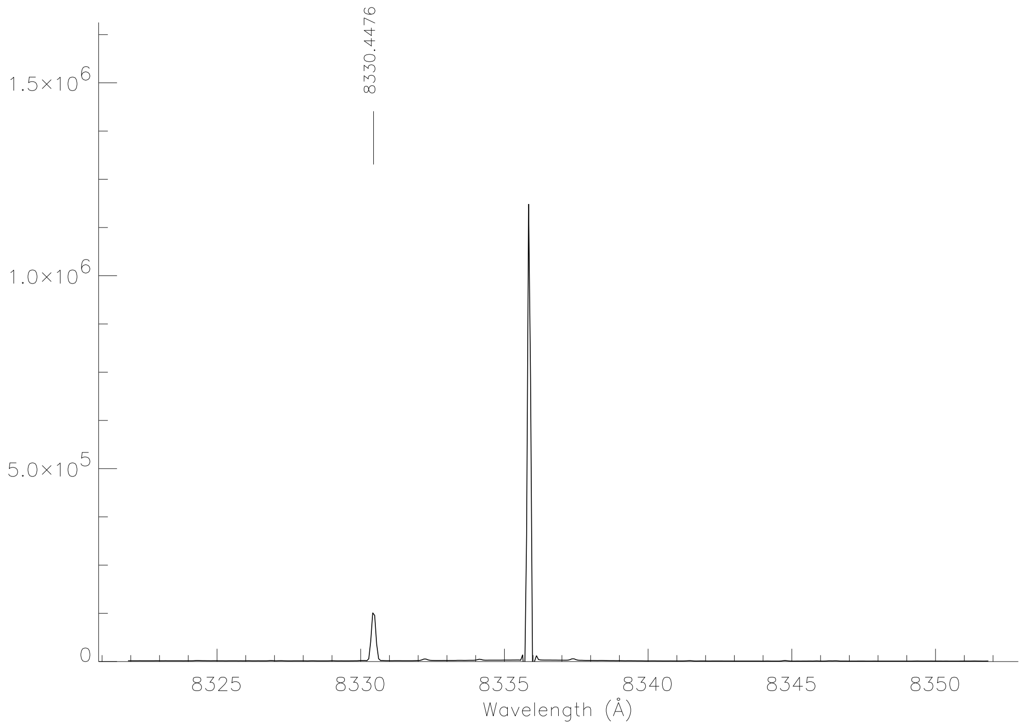
8275
8280
8285
8290
Wavelength (Å)



8320.8546
3×10^6
2×10^6
1×10^6
0
8295
8300
8305
8310
8315
8320
Wavelength (Å)


8330.4476
1.5×10^6
1.0×10^6
5.0×10^5
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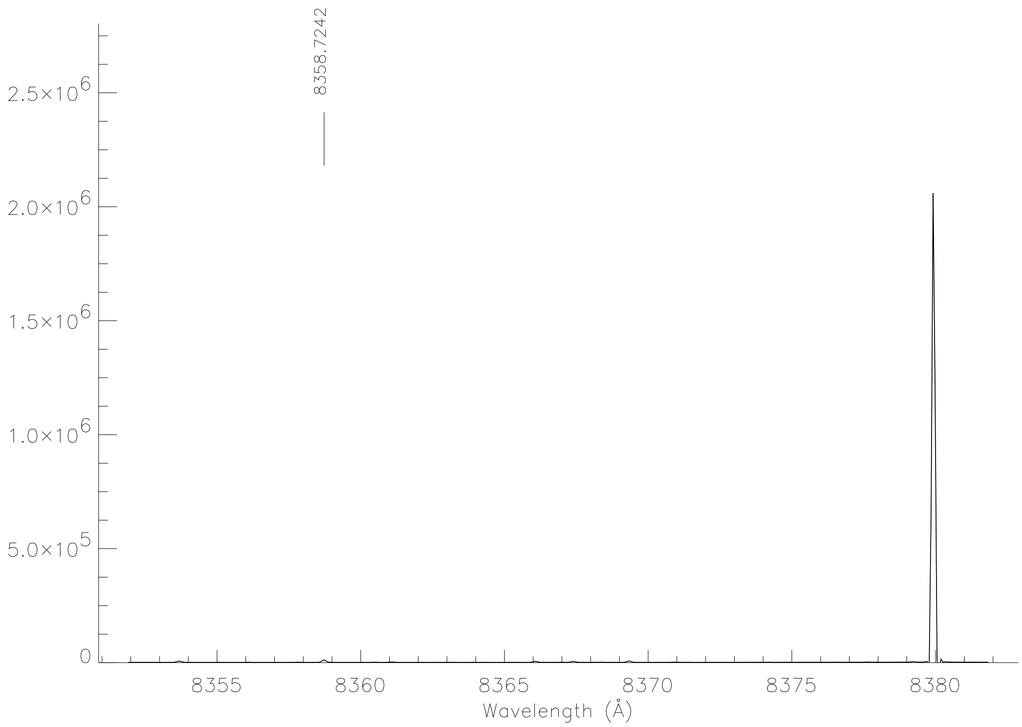
8325
8330
8335
8340
8345
8350
Wavelength (Å)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5.0×10^5
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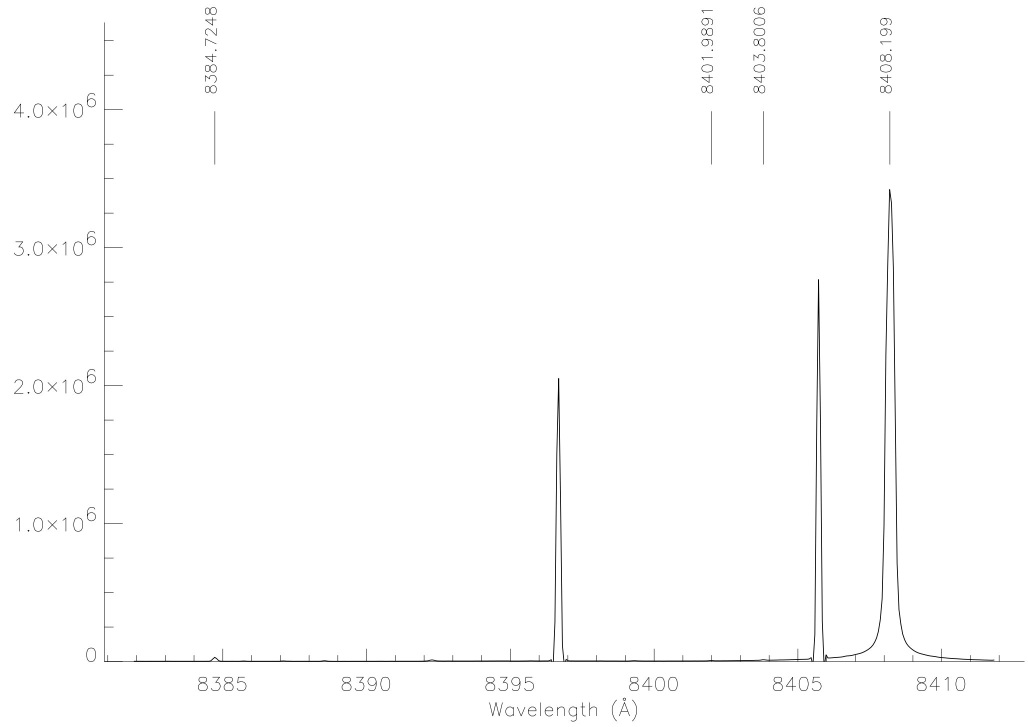
8365
8370
8375
8380
Wavelength (Å)


8384.7248
8401.9891
8403.8006
8408.199
4.0×10^6
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2.0×10^6
1.0×10^6
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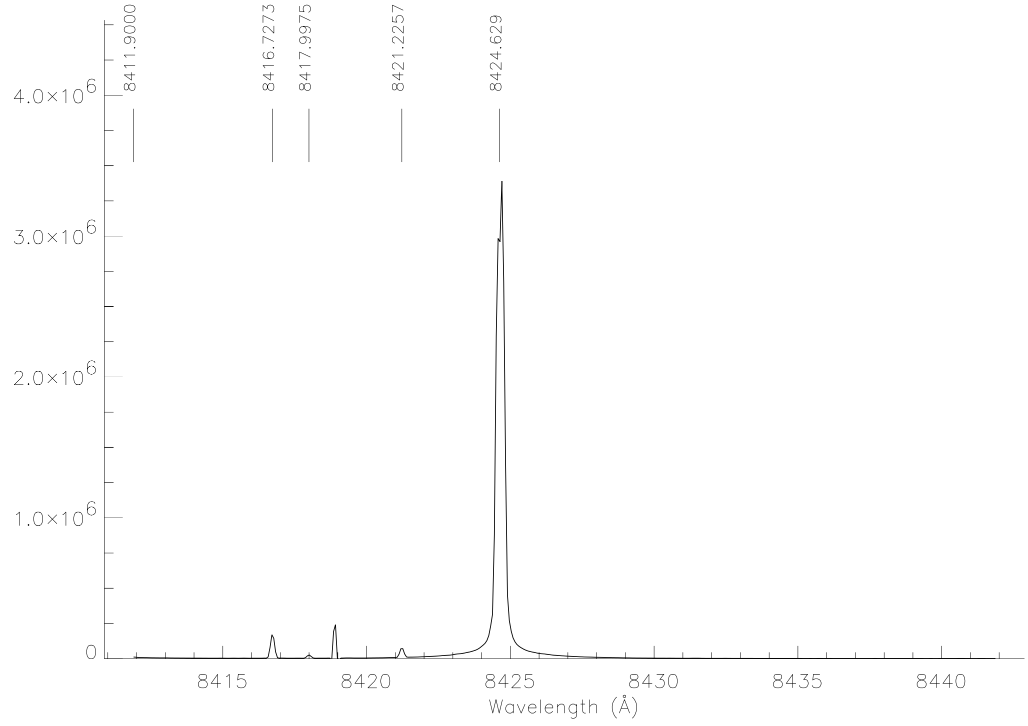
8385
8390
8395
8400
8405
8410
Wavelength (Å)


8411.9000
8416.7273
8417.9975
8421.2257
8424.629
4.0×10^6
3.0×10^6
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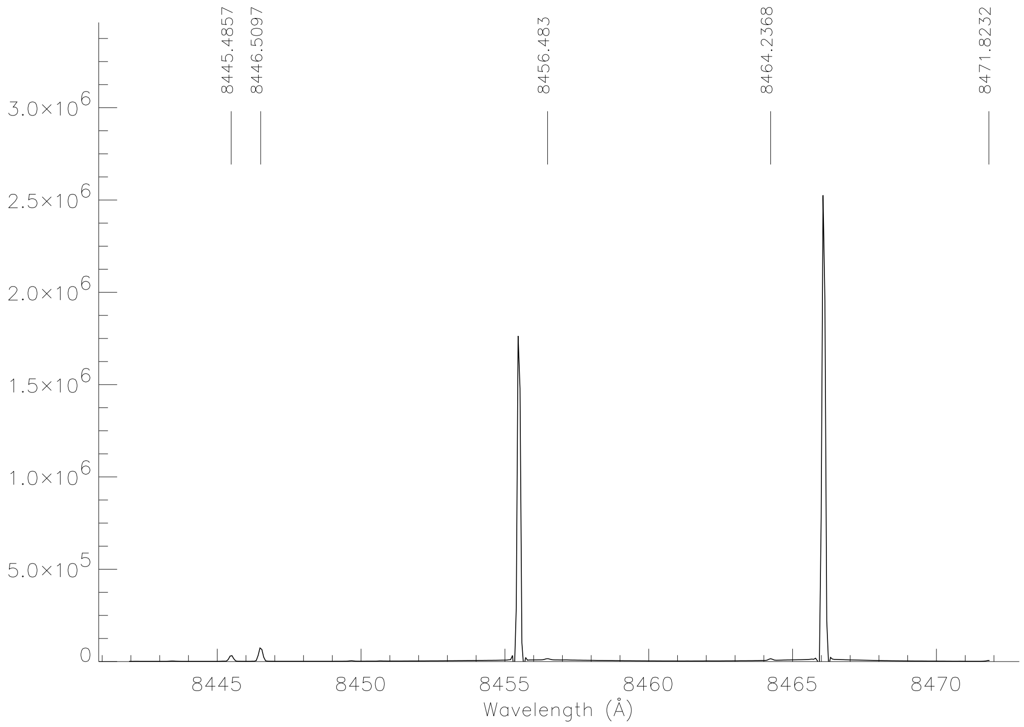
1.0×10^6
0
8415
8420
8425
8430
8435
8440
Wavelength (Å)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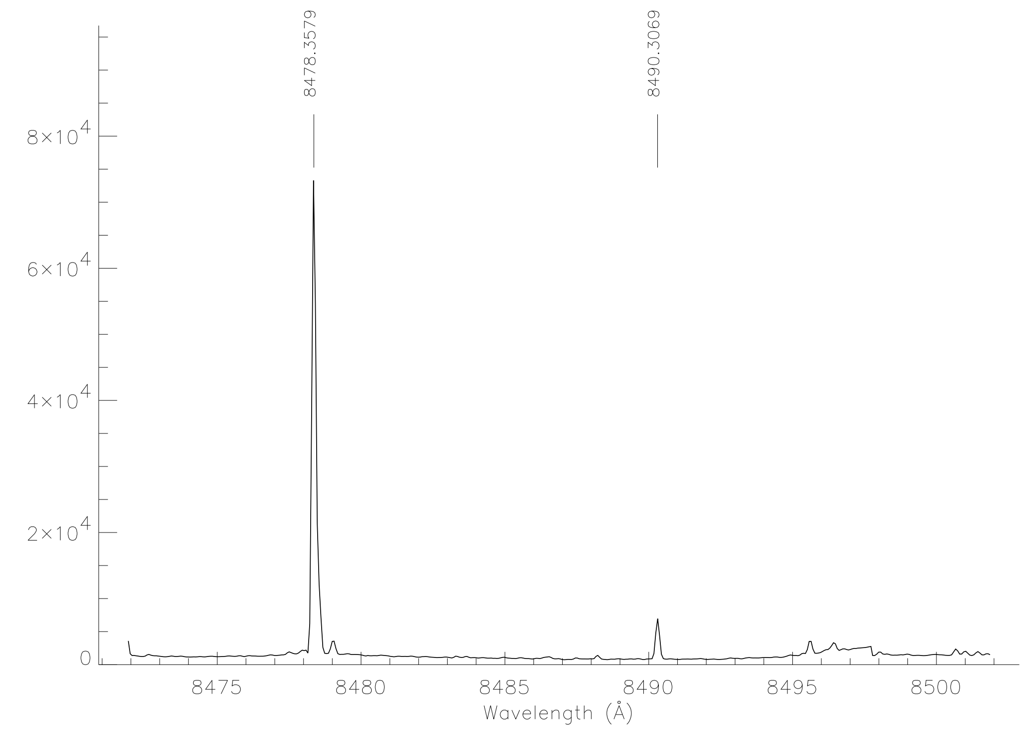
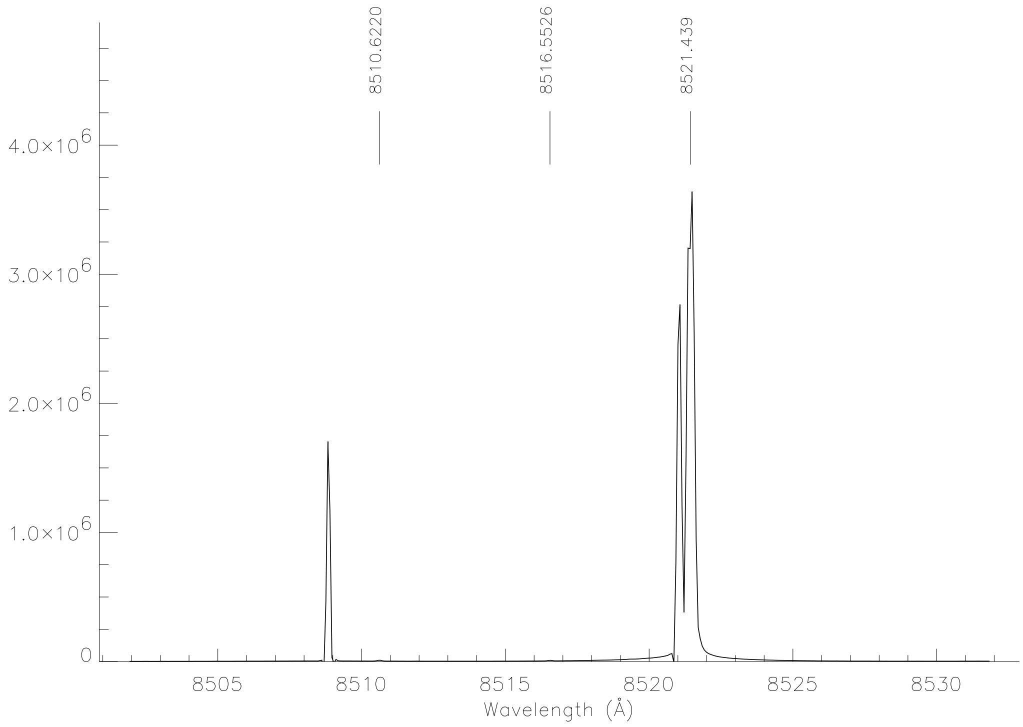
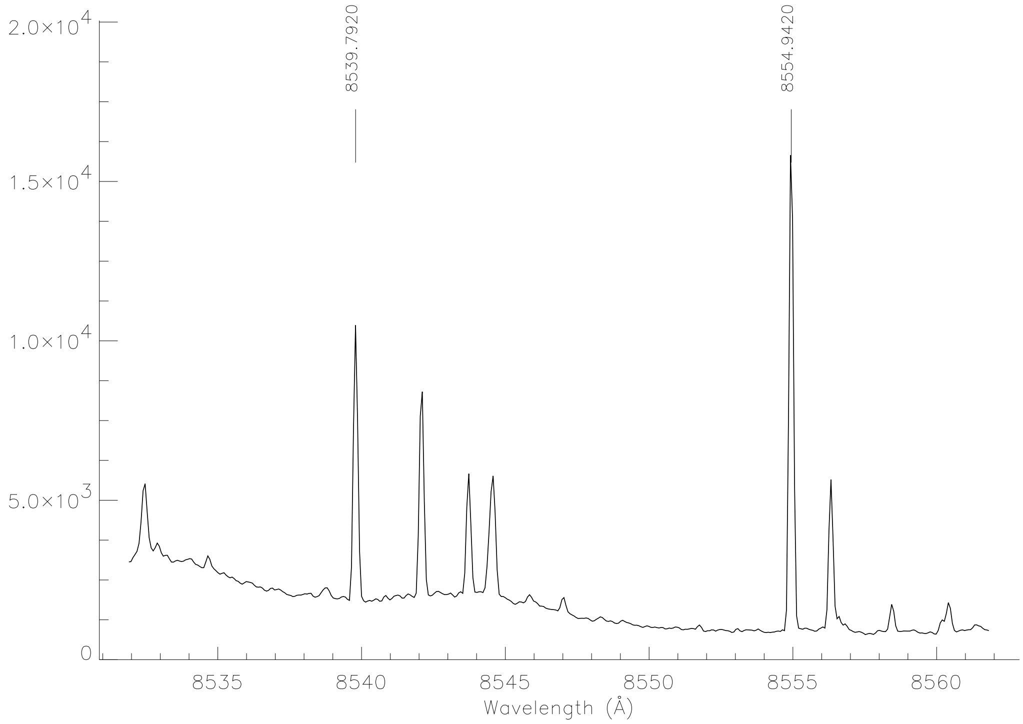
8446.5097
8456.483
8464.2368
8471.8232
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
8445
8450
8455
8460
8465
8470
Wavelength (Å)


8478.3579
8490.3069
8×10^4
6×10^4
4×10^4
2×10^4
0
8475
8480
8485
8490
8495
8500
Wavelength (Å)


8510.6220
8516.5526
8521.439
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
8505
8510
8515
8520
8525
8530
Wavelength (Å)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8554.9420
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
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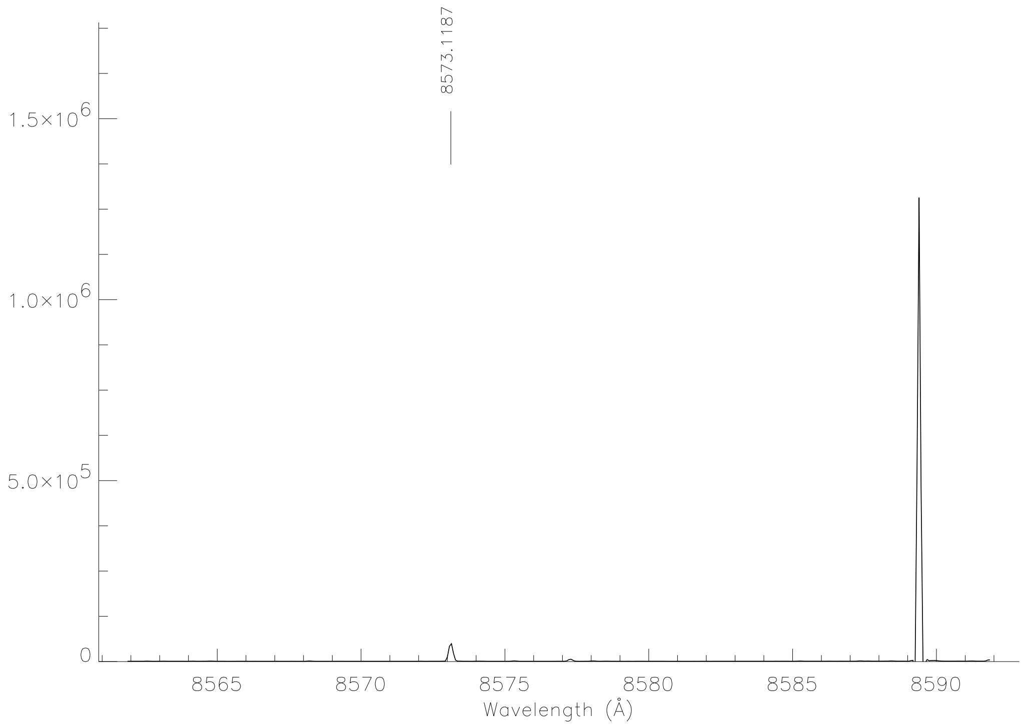
8540
8545
8550
8555
8560
Wavelength (Å)



8573.1187
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5.0×10^5
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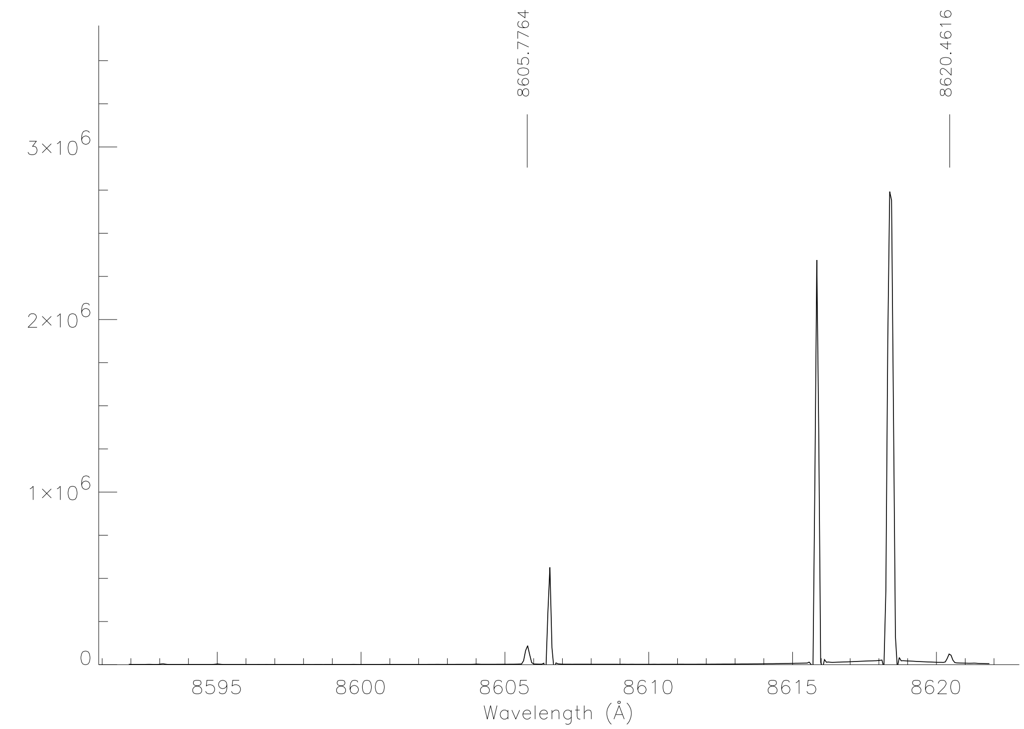
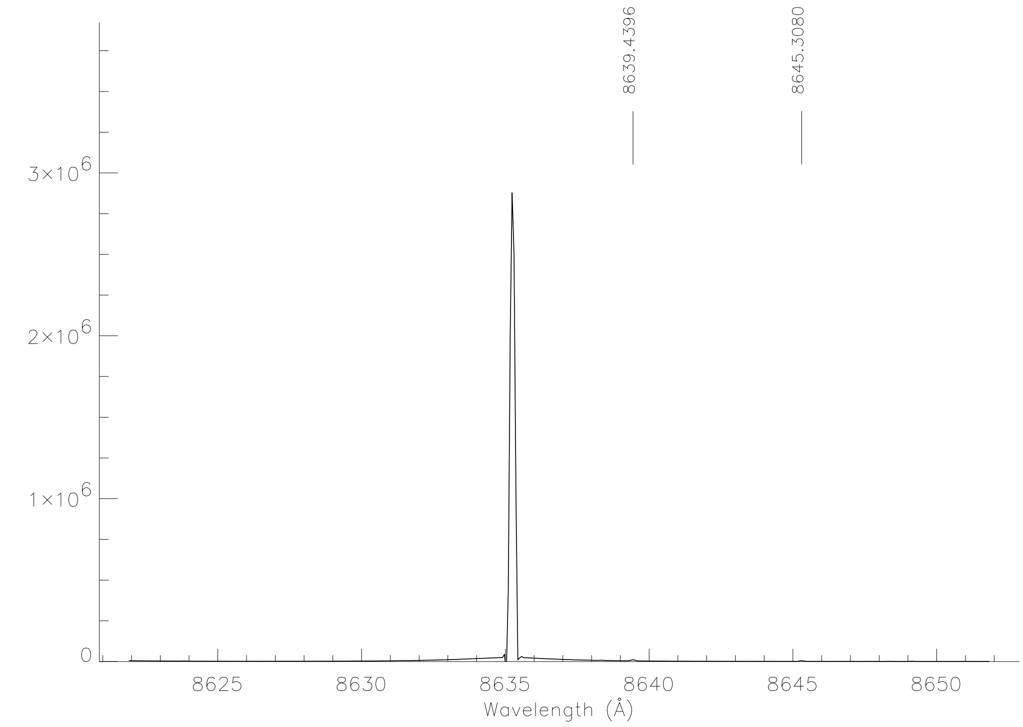
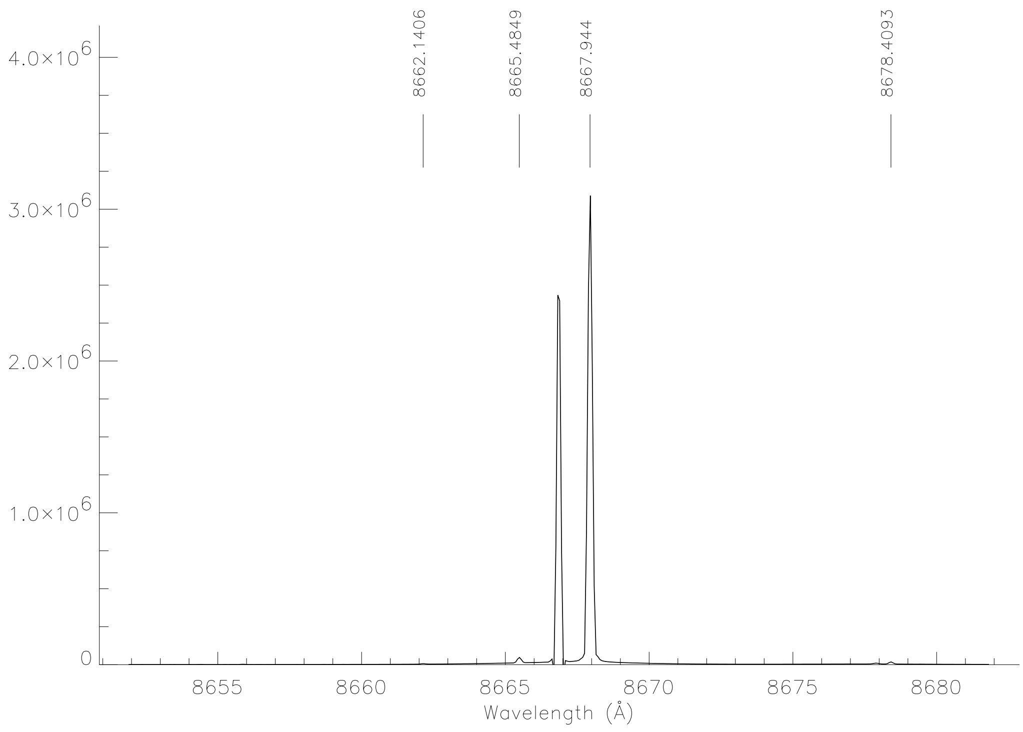
8570
8575
8580
8585
8590
Wavelength (Å)



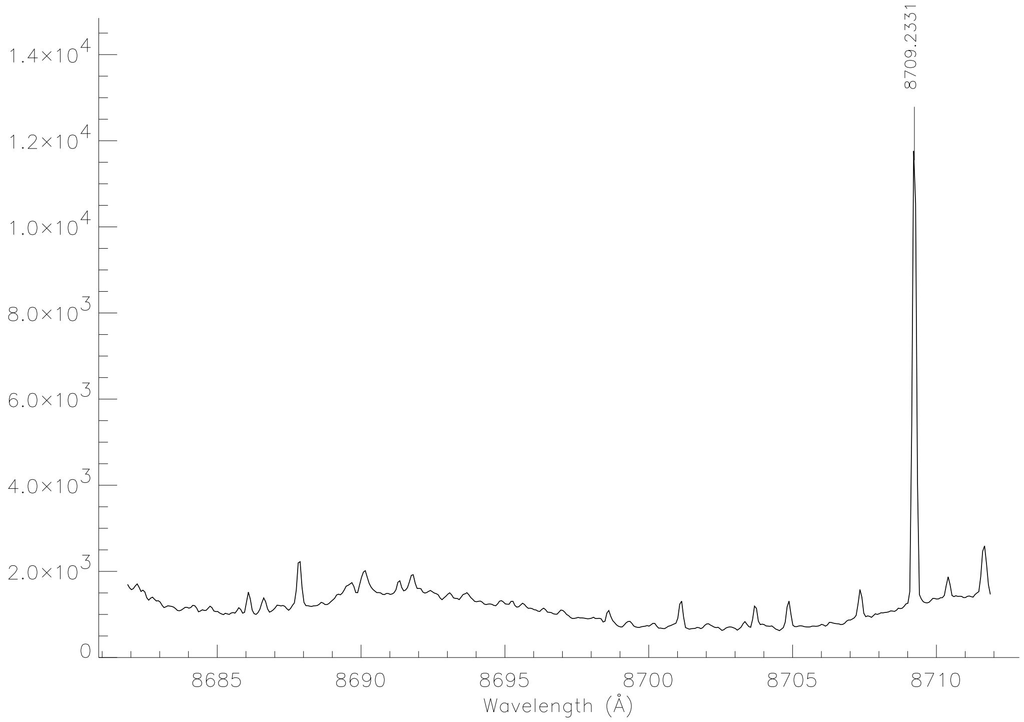
8605.7764
8620.4616
3×10^6
2×10^6
1×10^6
0
8595
8600
8605
8610
8615
8620
Wavelength (Å)

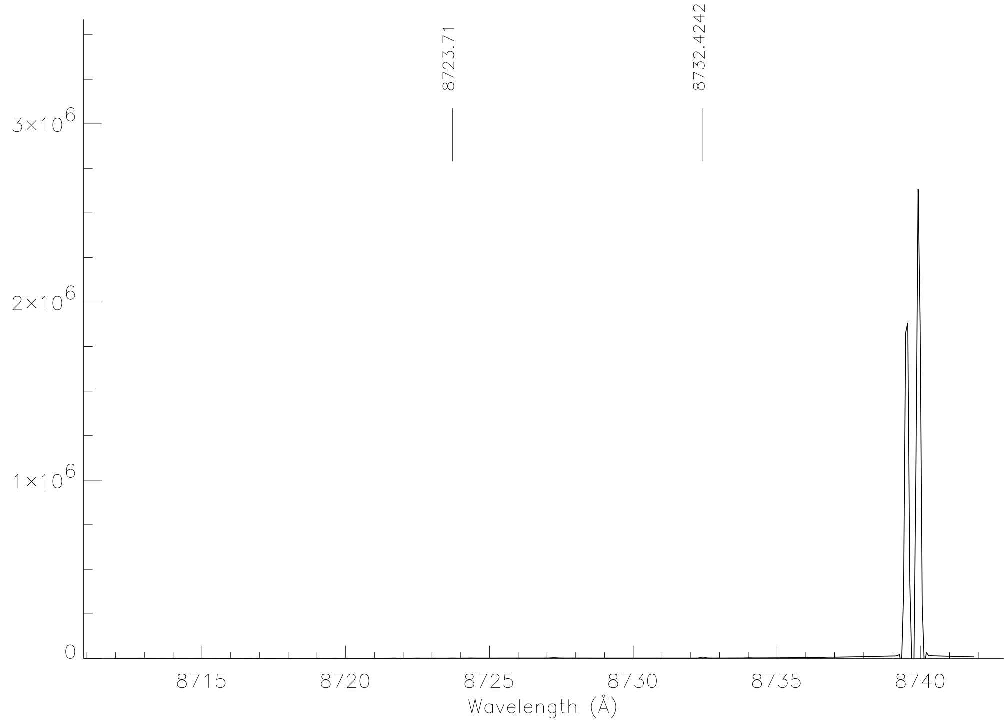


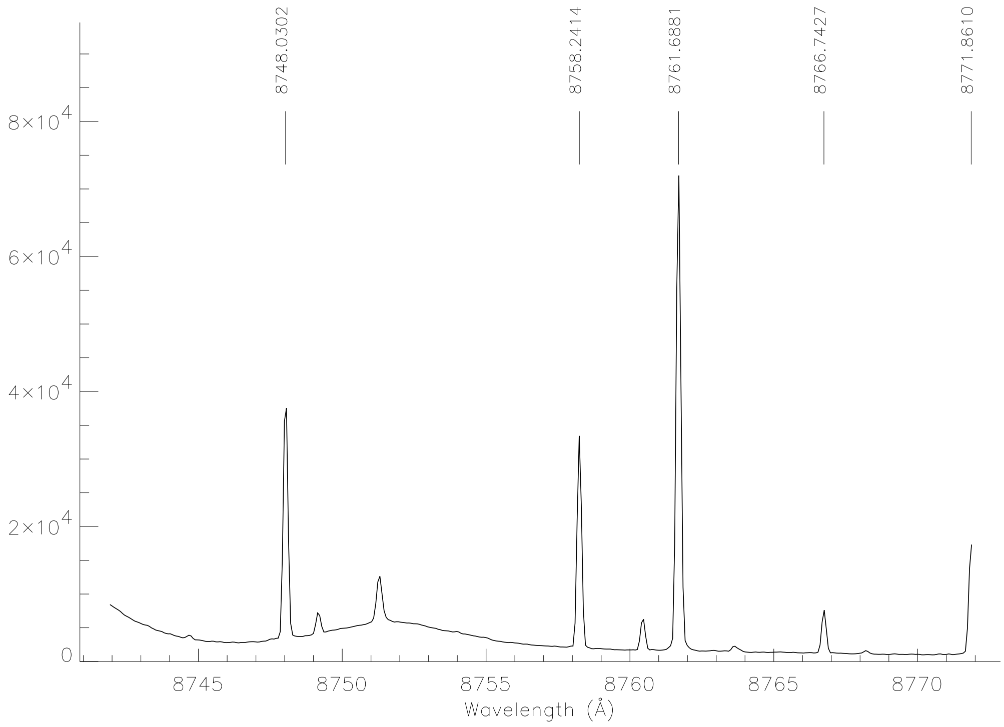
8639.4396
8645.3080
3×10^6
2×10^6
1×10^6
0
8625
8630
8635
8640
8645
8650
Wavelength (Å)

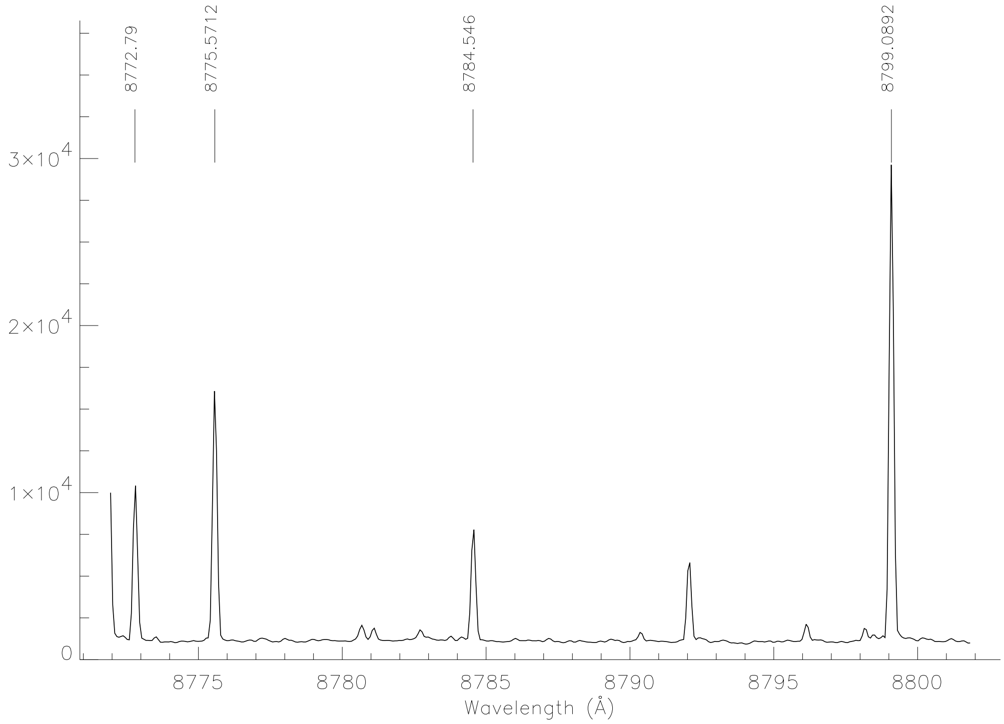


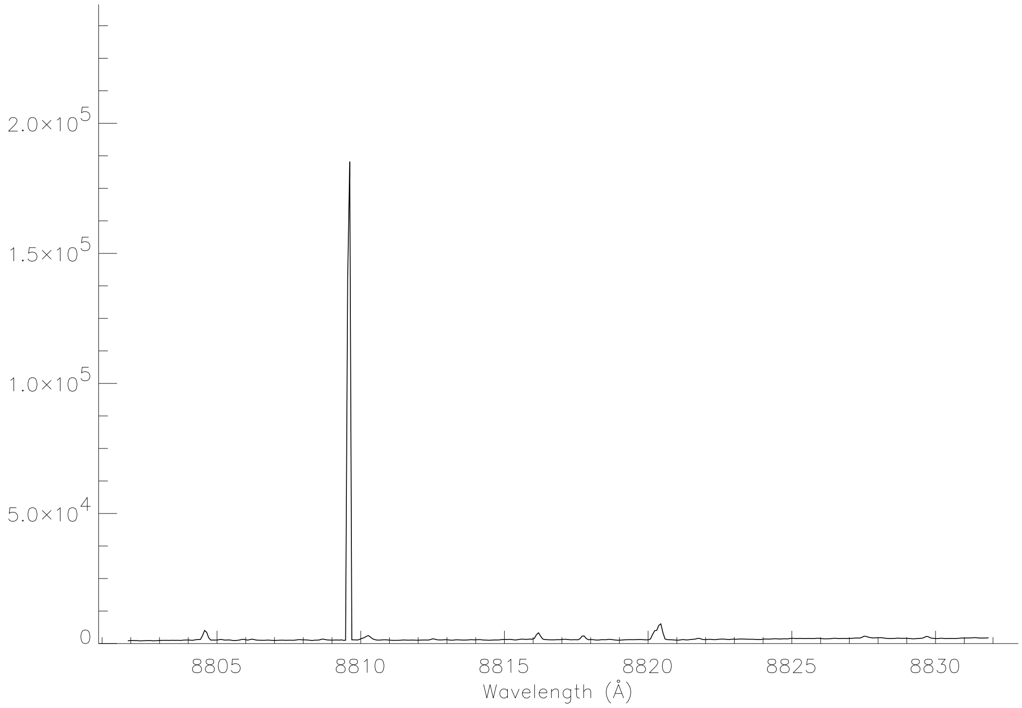
8662.1406
8665.4849
8667.944
8678.4093
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
8655
8660
8665
8670
8675
8680
Wavelength (Å)

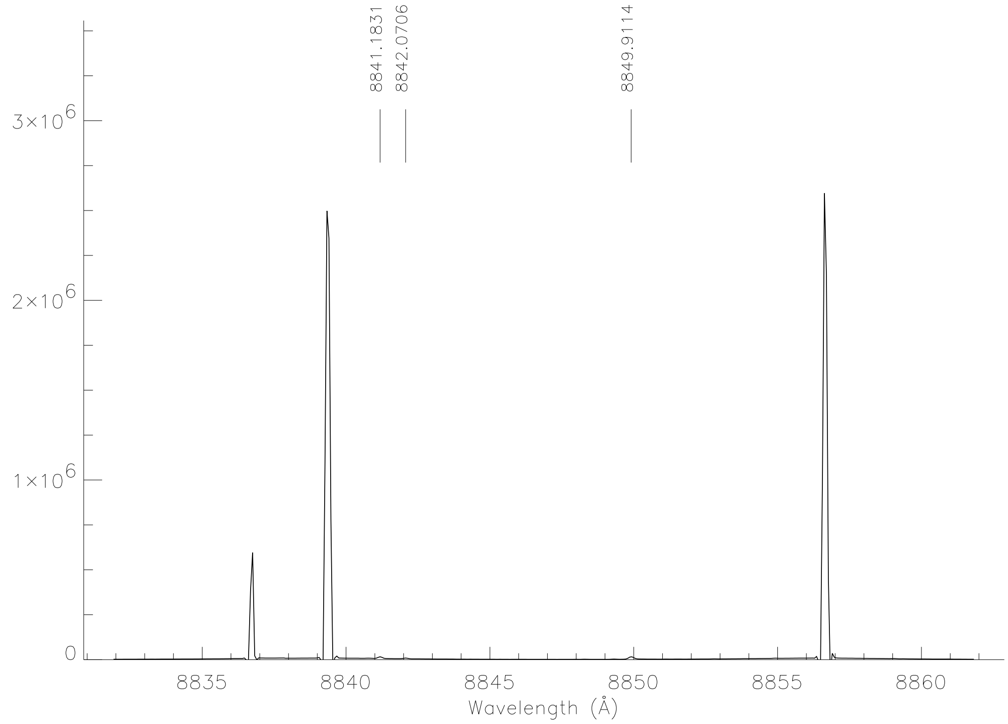

8709.2331
1.4×10^4
1.2×10^4
1.0×10^4
8.0×10^3
6.0×10^3
4.0×10^3
2.0×10^3
0
8685
8690
8695
8700
8705
8710
Wavelength (Å)

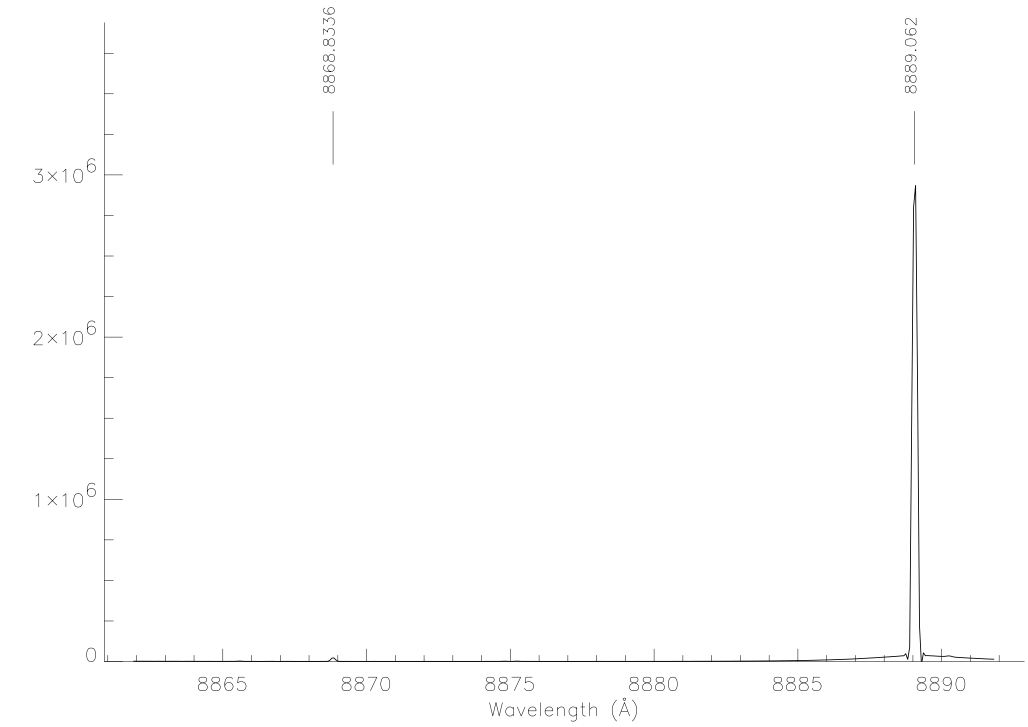

8723.71
8732.4242
3×10^6
2×10^6
1×10^6
0
8715
8720
8725
8730
8735
8740
Wavelength (Å)

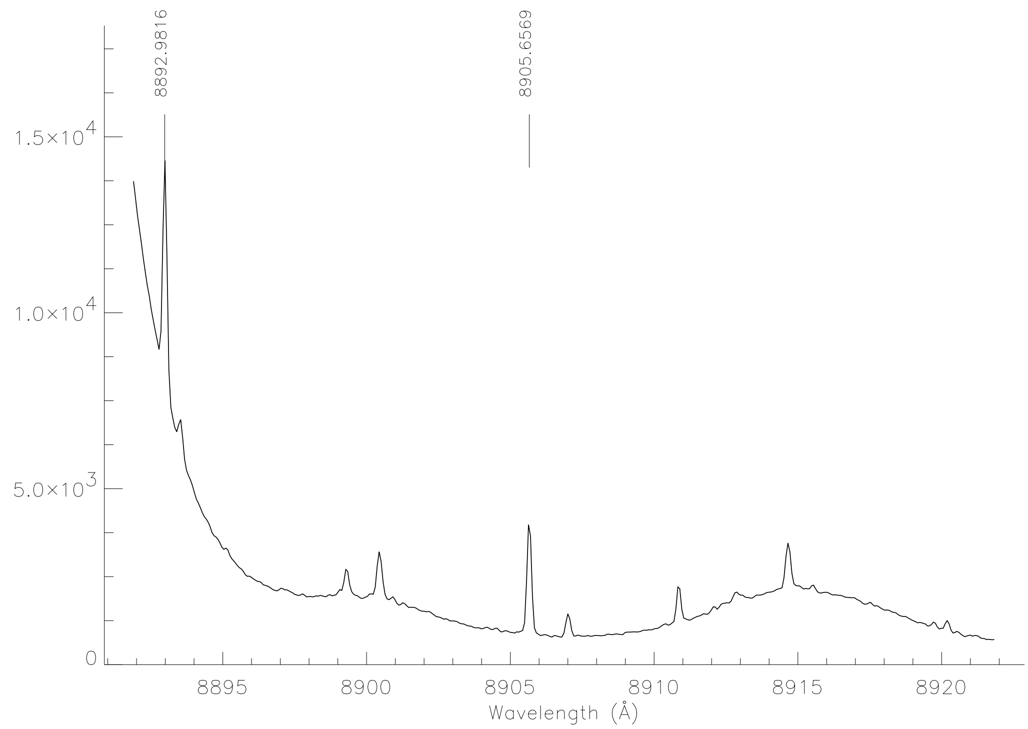

8748.0302
8758.2414
8761.6881
8766.7427
8771.8610
8×10^4
6×10^4
4×10^4
2×10^4
0
8745
8750
8755
8760
8765
8770
Wavelength (Å)

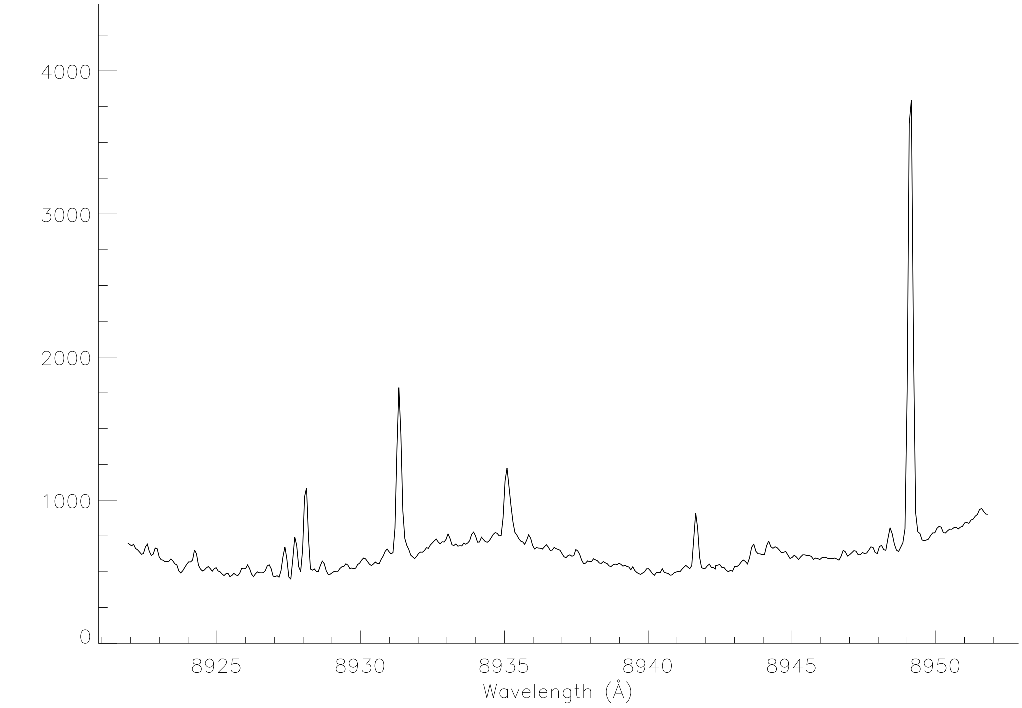

8772.79
8775.5712
8784.546
8799.0892
3×10^4
2×10^4
1×10^4
0
8775
8780
8785
8790
8795
8800
Wavelength (Å)


2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
8805
8810
8815
8820
8825
8830
Wavelength (Å)

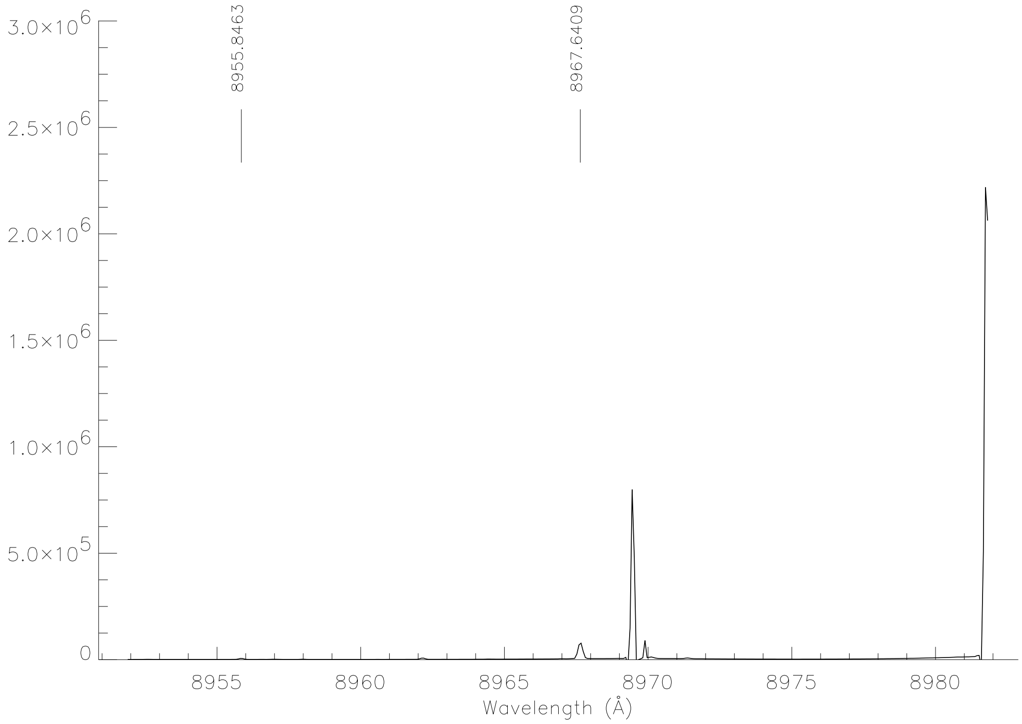

8841.1831
8842.0706
8849.9114
3×10^6
2×10^6
1×10^6
0
8835
8840
8845
8850
8855
8860
Wavelength (Å)


8868.8336
8889.062
3×10^6
2×10^6
1×10^6
0
8865
8870
8875
8880
8885
8890
Wavelength (Å)

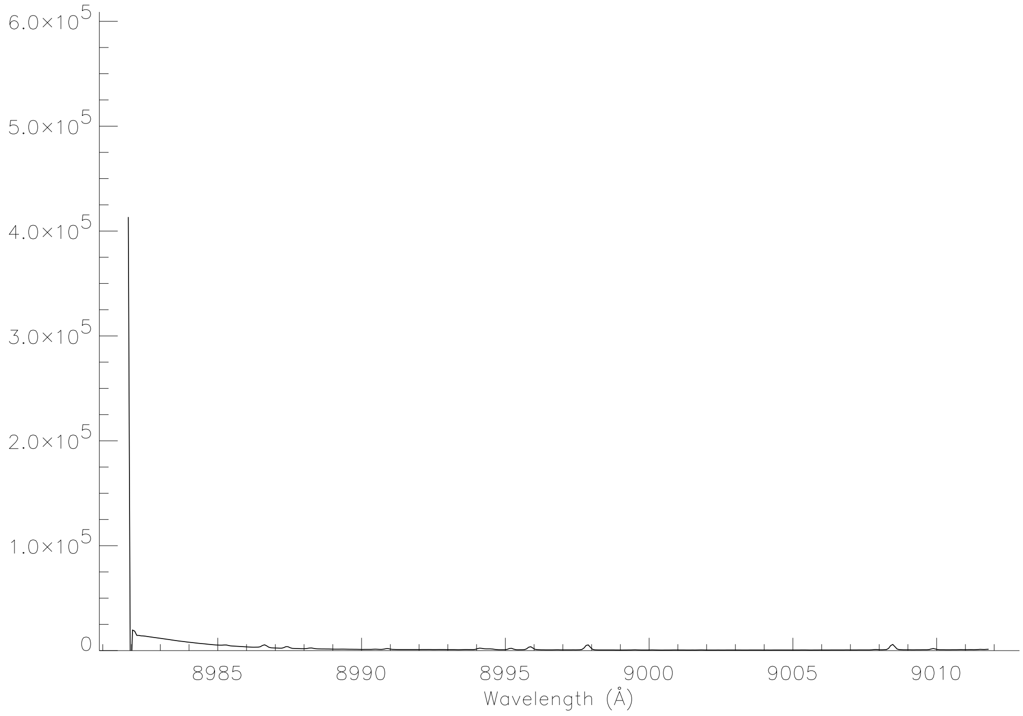

8892.9816
8905.6569
1.5×10^4
1.0×10^4
5.0×10^3
0
8895
8900
8905
8910
8915
8920
Wavelength (Å)

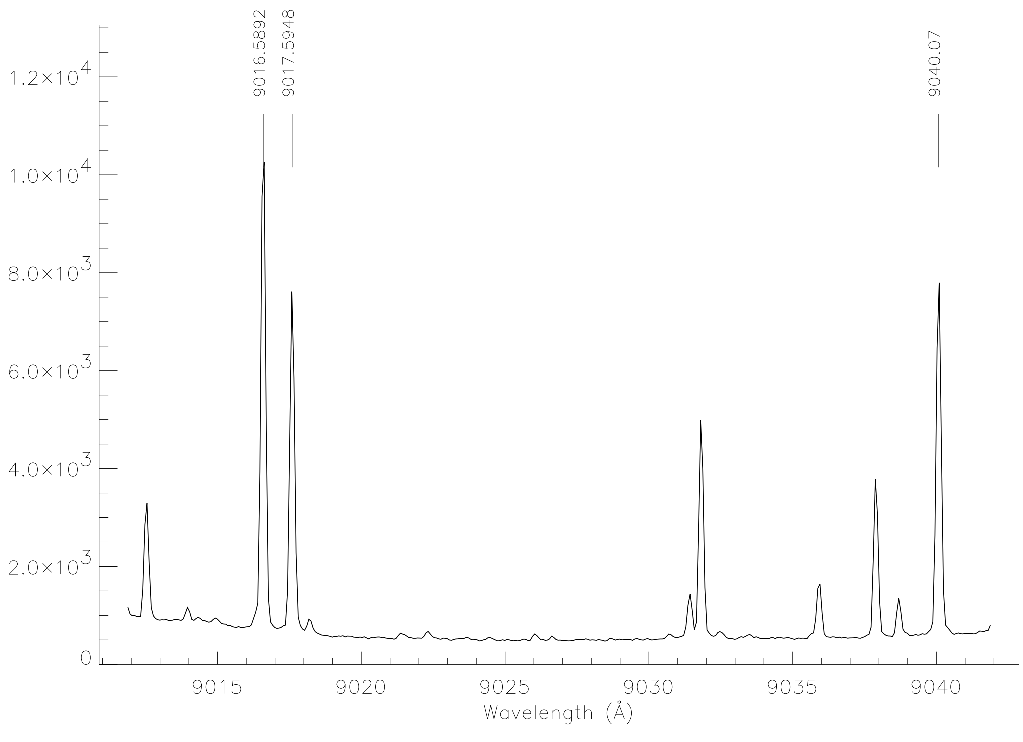


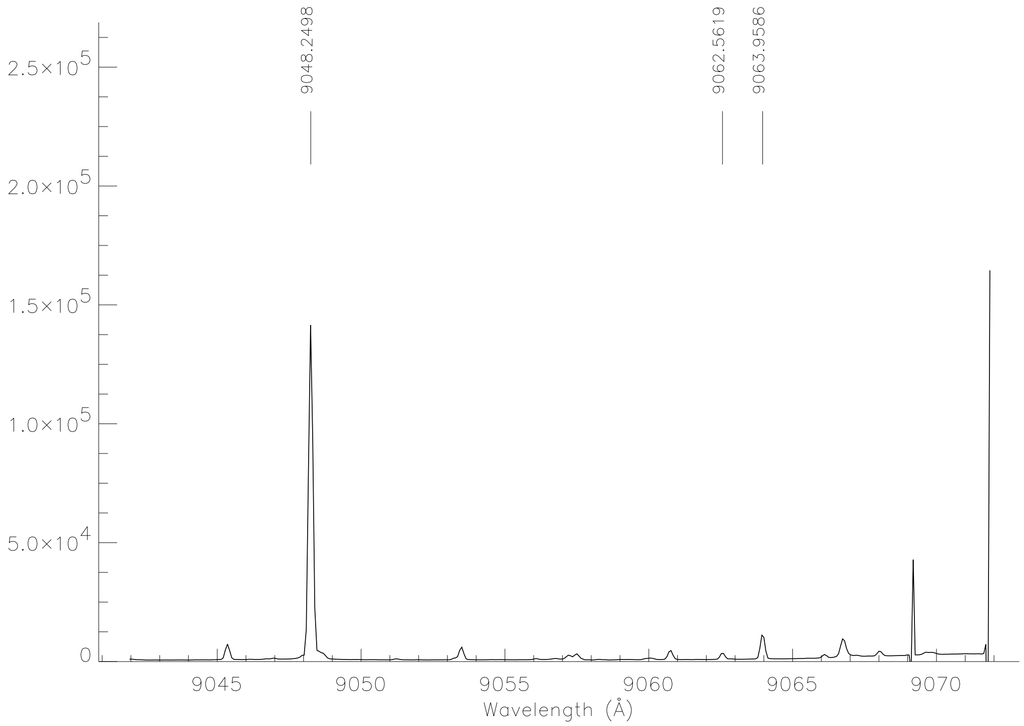
4000
3000
2000
1000
0
8925
8930
8935
8940
8945
8950
Wavelength (Å)

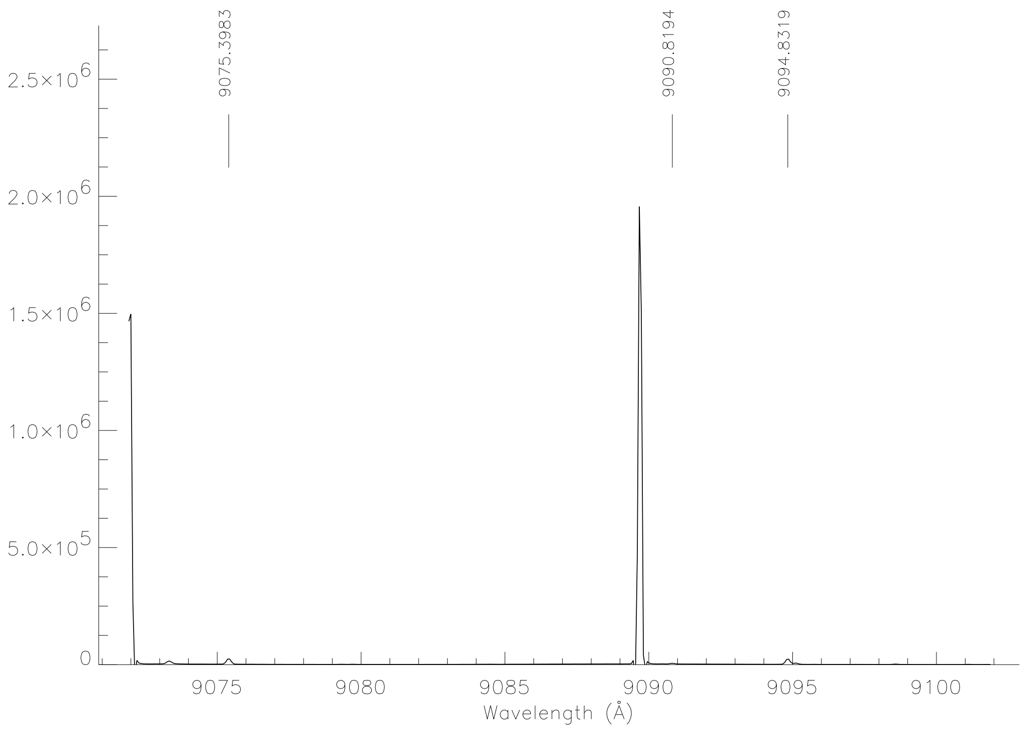


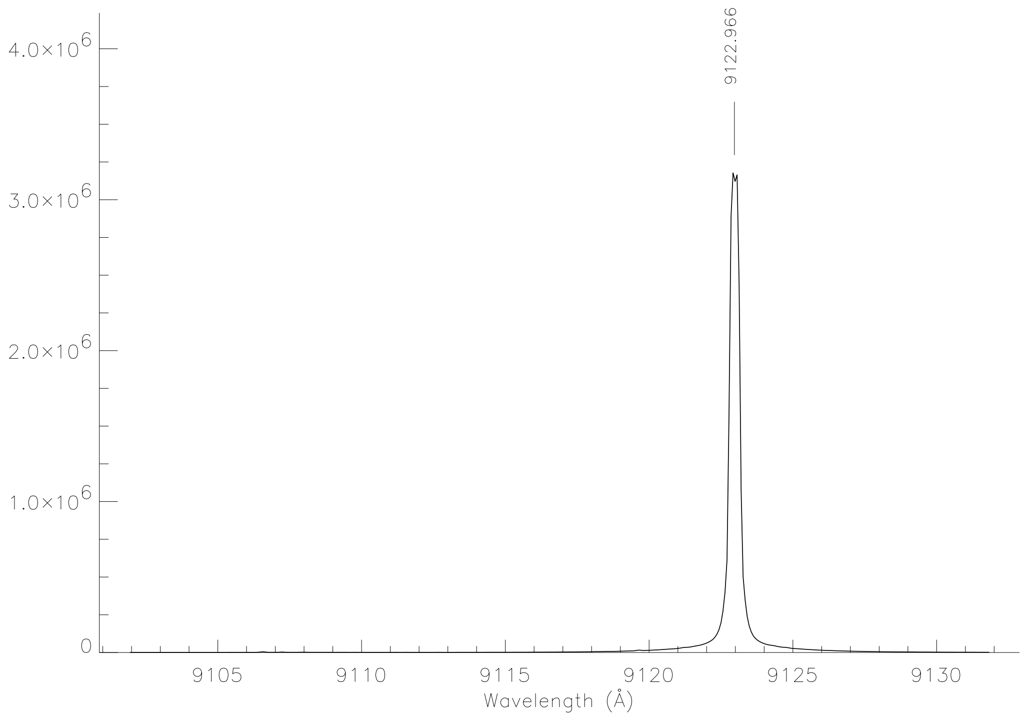
3.0×10⁶
2.5×10⁶
2.0×10⁶
1.5×10⁶
1.0×10⁶
5.0×10⁵
0
8955.8463
8967.6409
8955
8960
8965
8970
8975
8980
Wavelength (Å)

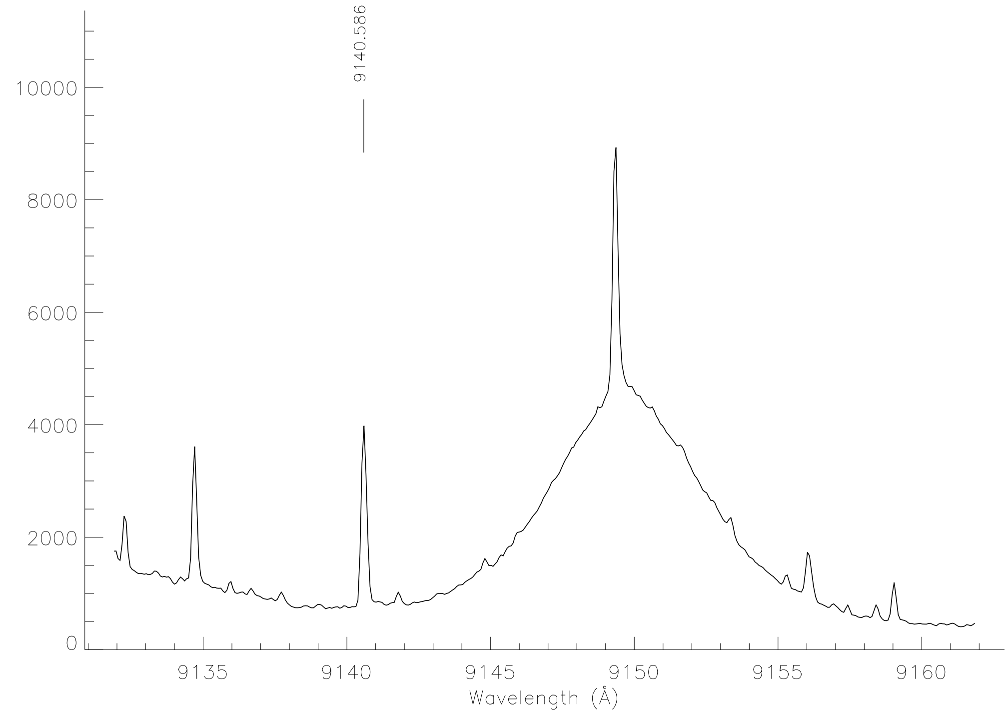

6.0×10^5
5.0×10^5
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
8985
8990
8995
9000
9005
9010
Wavelength (Å)

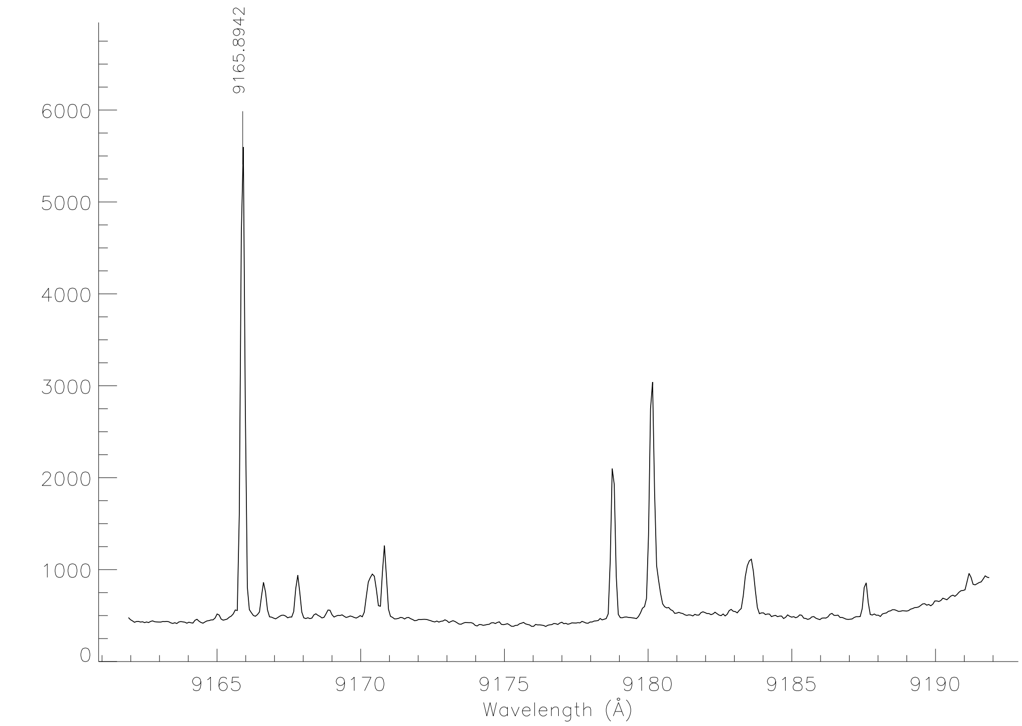

9016.5892
9017.5948
9040.07
1.2×10^4
1.0×10^4
8.0×10^3
6.0×10^3
4.0×10^3
2.0×10^3
0
9015
9020
9025
9030
9035
9040
Wavelength (Å)

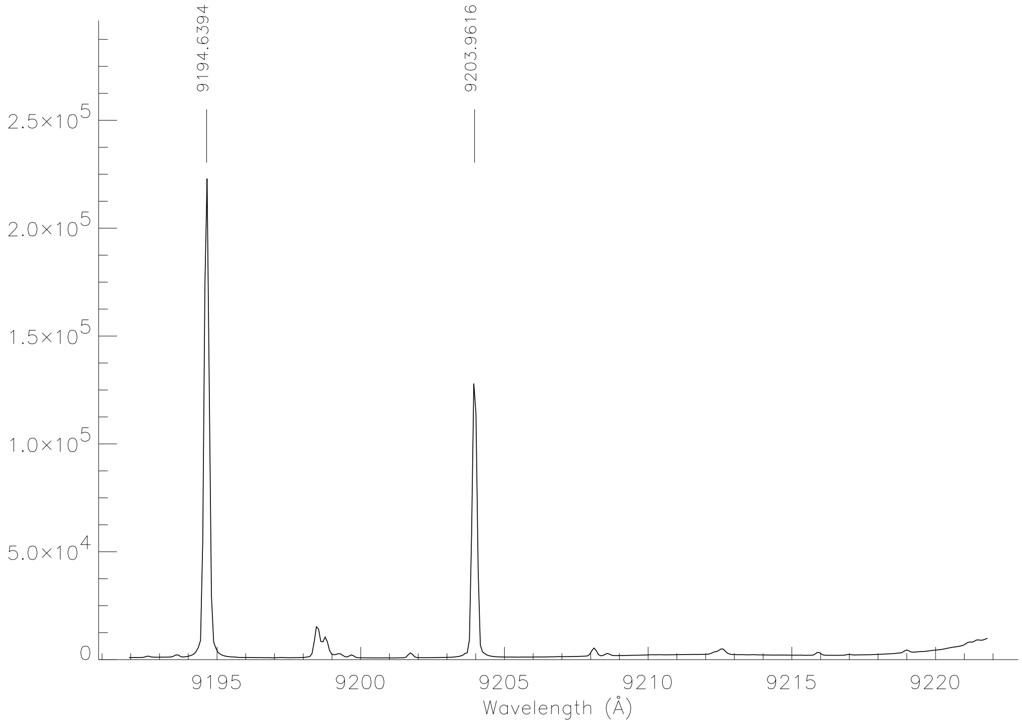

9048.2498
9062.5619
9063.9586
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
9045
9050
9055
9060
9065
9070
Wavelength (Å)

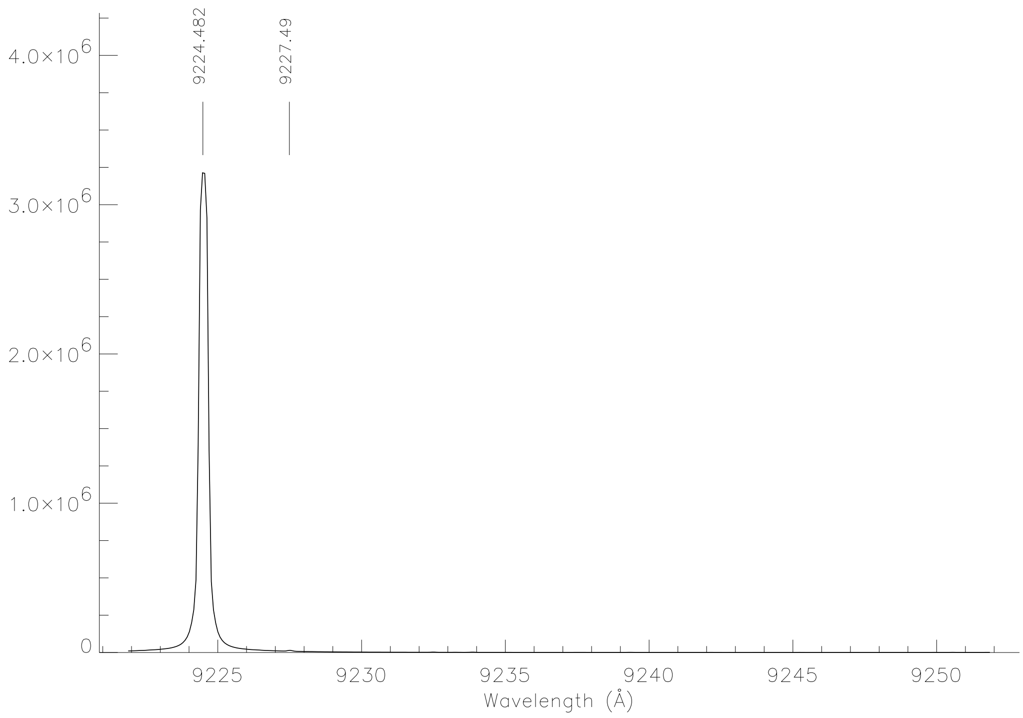

9075.3983
9090.8194
9094.8319
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
9075
9080
9085
9090
9095
9100
Wavelength (Å)

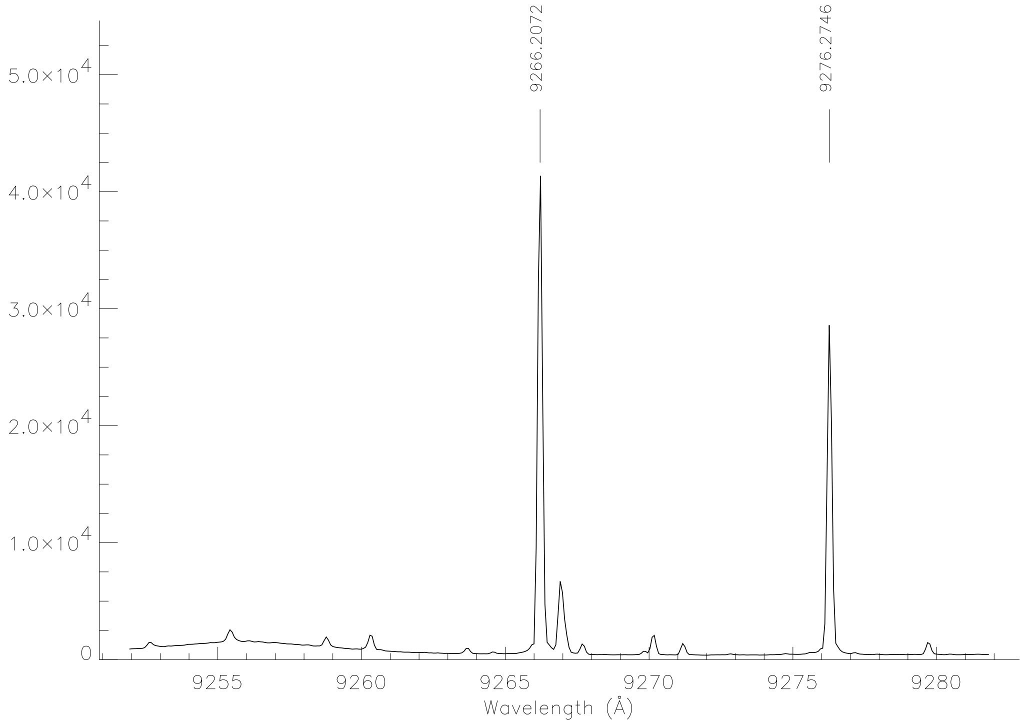

9122.966
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
9105
9110
9115
9120
9125
9130
Wavelength (Å)

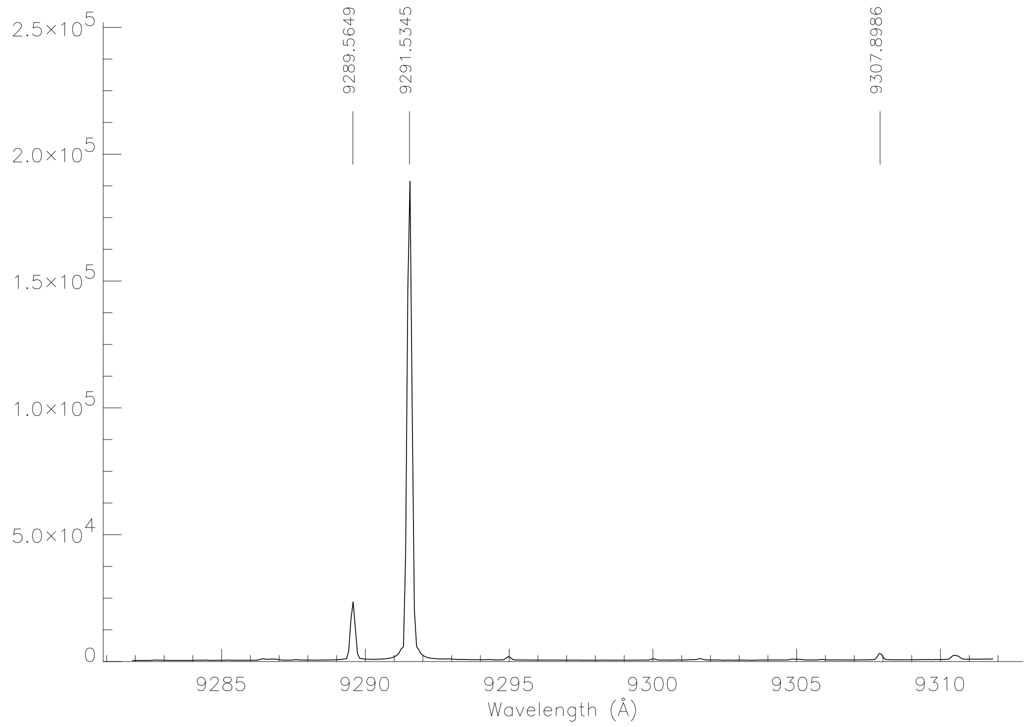

9140.586
10000
8000
6000
4000
2000
0
9135
9140
9145
9150
9155
9160
Wavelength (Å)

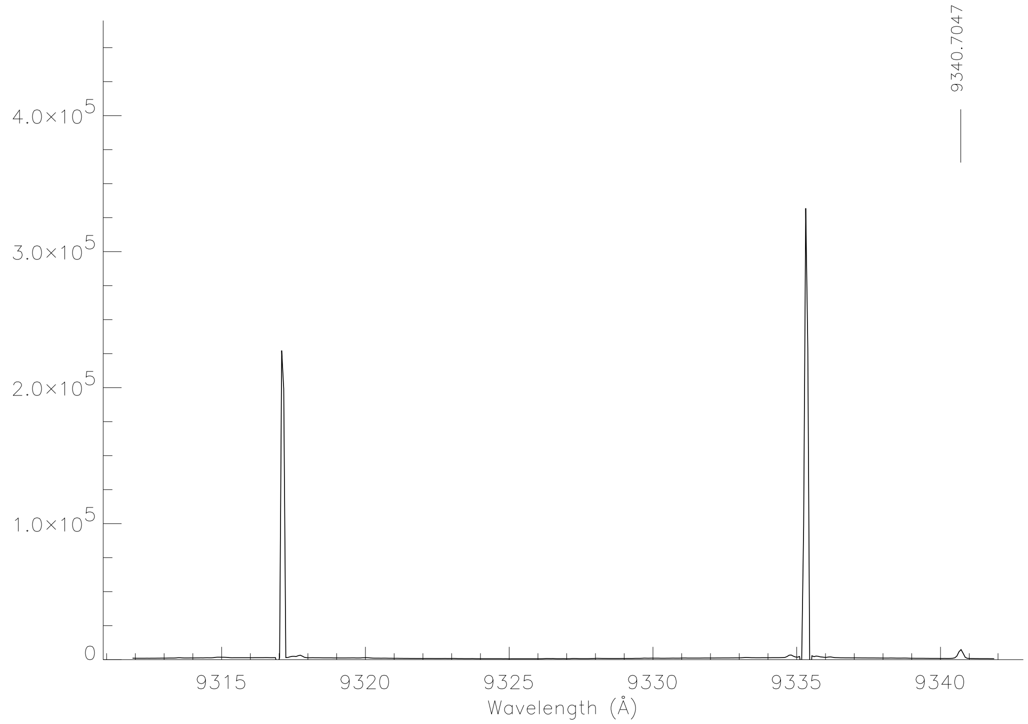

9165.8942
6000
5000
4000
3000
2000
1000
0
9165
9170
9175
9180
9185
9190
Wavelength (Å)

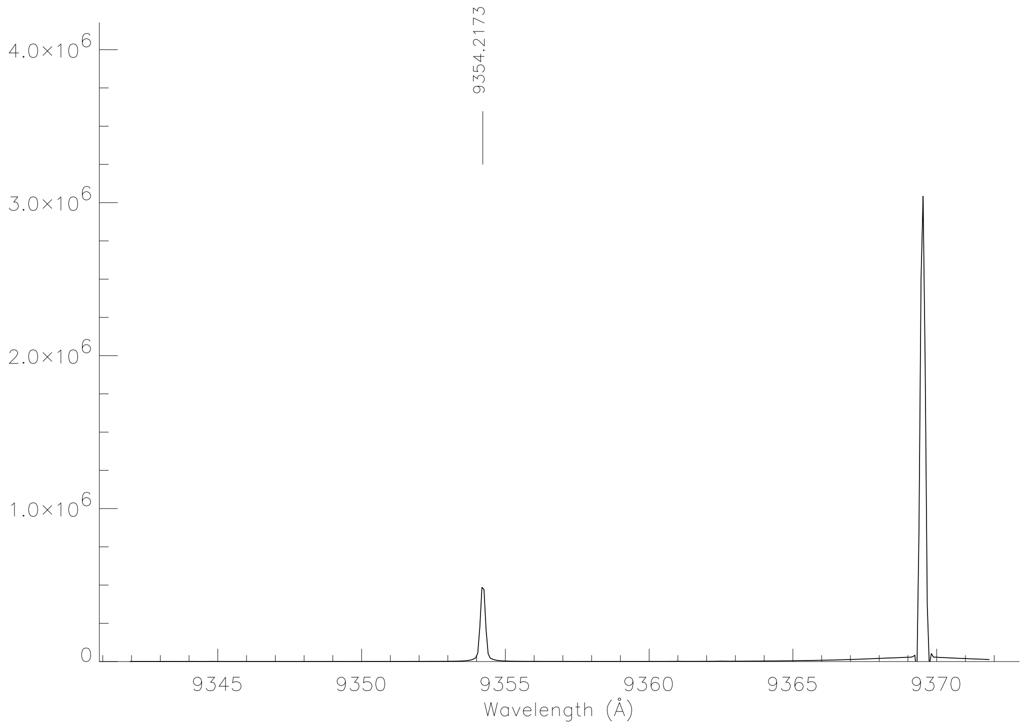

9194.6394
9203.9616
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
9195
9200
9205
9210
9215
9220
Wavelength (Å)

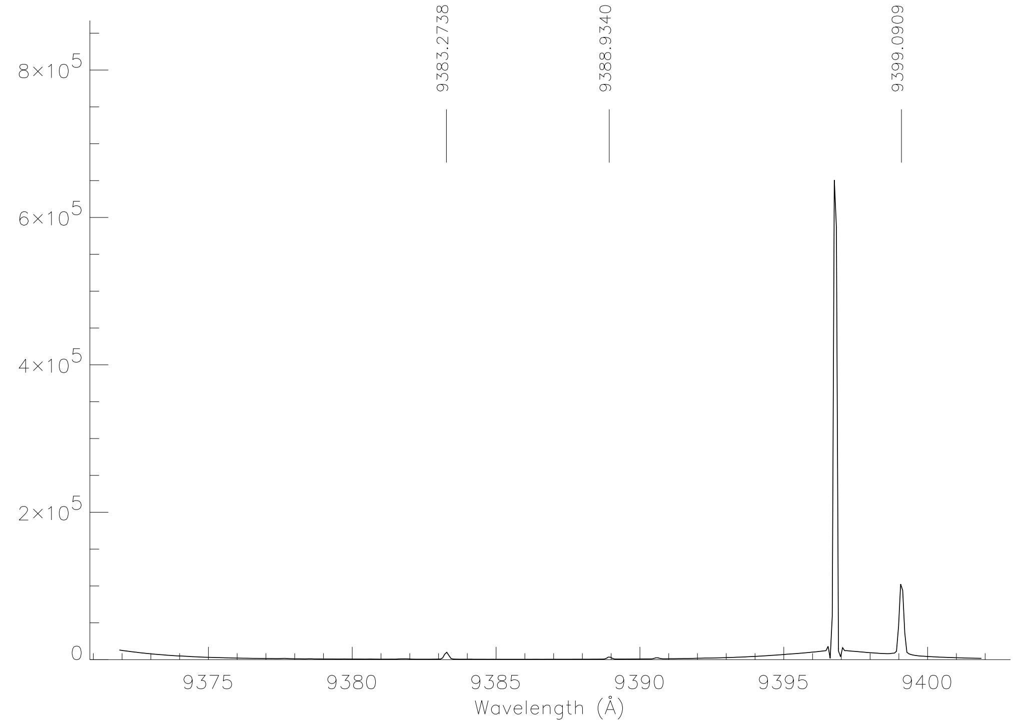

9224.482
9227.49
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
9225
9230
9235
9240
9245
9250
Wavelength (Å)

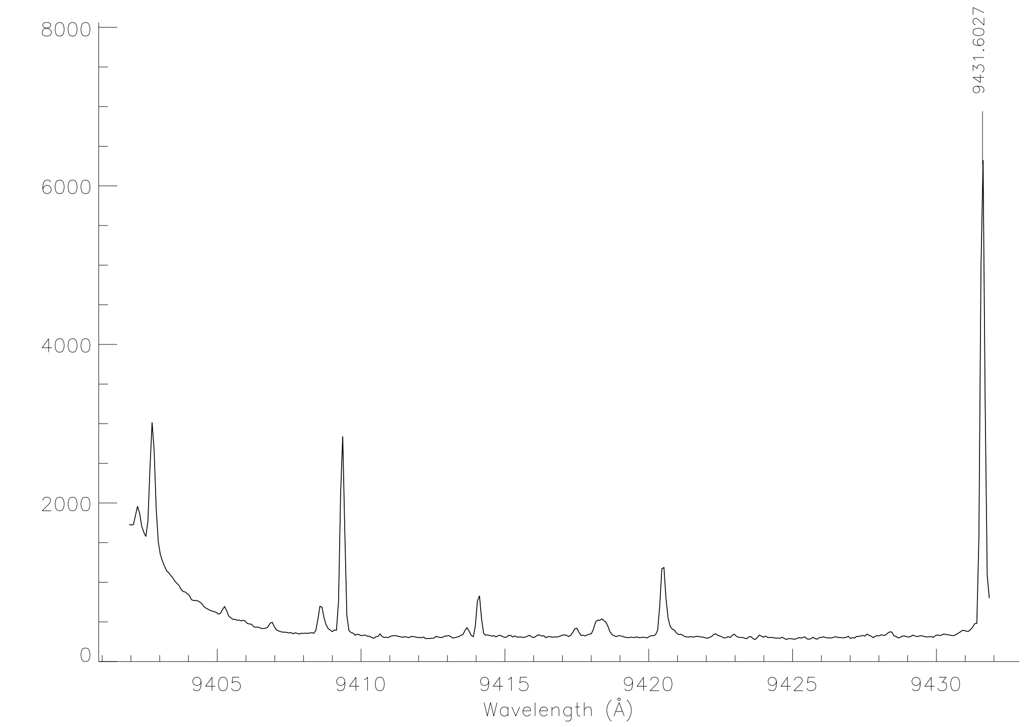

9266.2072
9276.2746
5.0×10^4
4.0×10^4
3.0×10^4
2.0×10^4
1.0×10^4
0
9255
9260
9265
9270
9275
9280
Wavelength (Å)

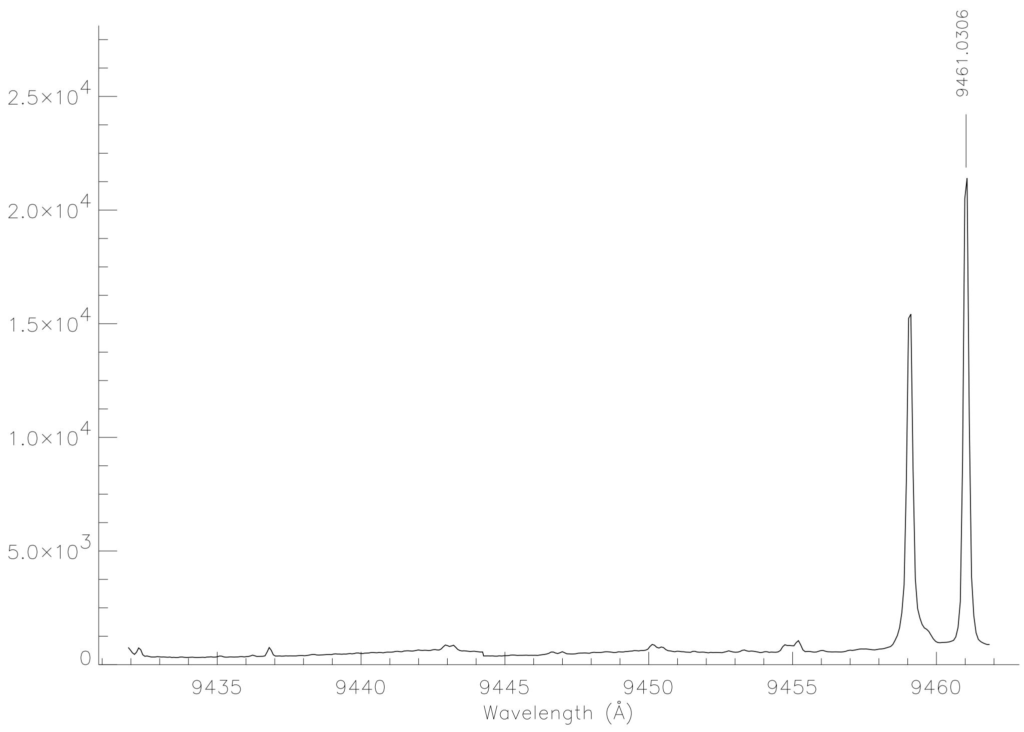

9289.5649
9291.5345
9307.8986
2.5×10^5
2.0×10^5
1.5×10^5
1.0×10^5
5.0×10^4
0
9285
9290
9295
9300
9305
9310
Wavelength (Å)

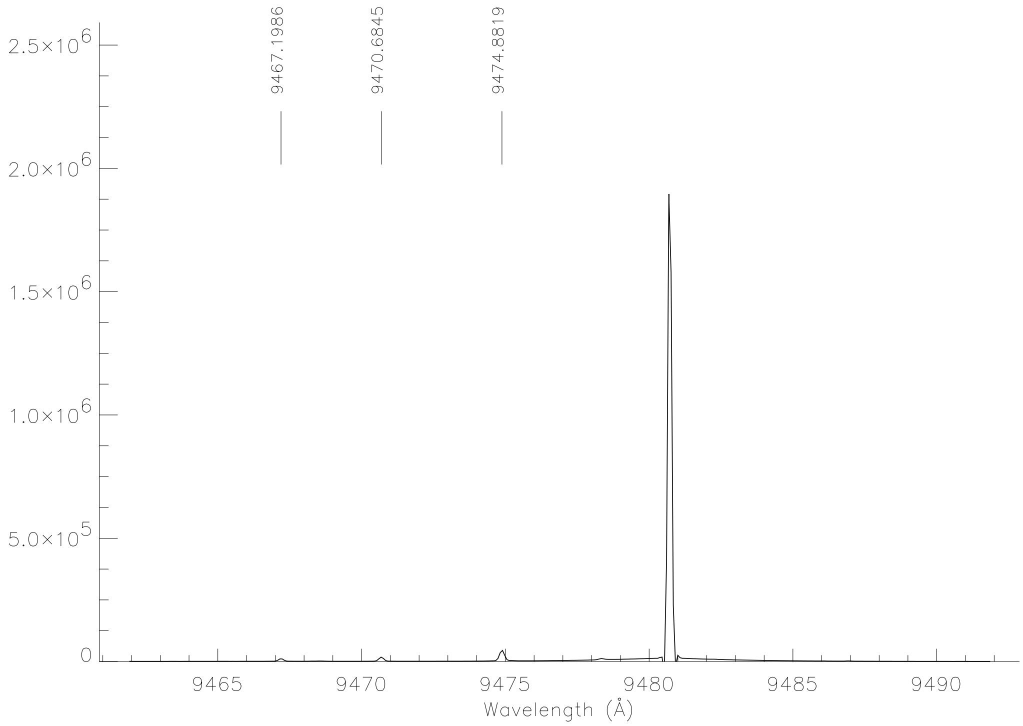

9340.7047
4.0×10^5
3.0×10^5
2.0×10^5
1.0×10^5
0
9315
9320
9325
9330
9335
9340
Wavelength (Å)


9354.2173
4.0×10^6
3.0×10^6
2.0×10^6
1.0×10^6
0
9345
9350
9355
9360
9365
9370
Wavelength (Å)

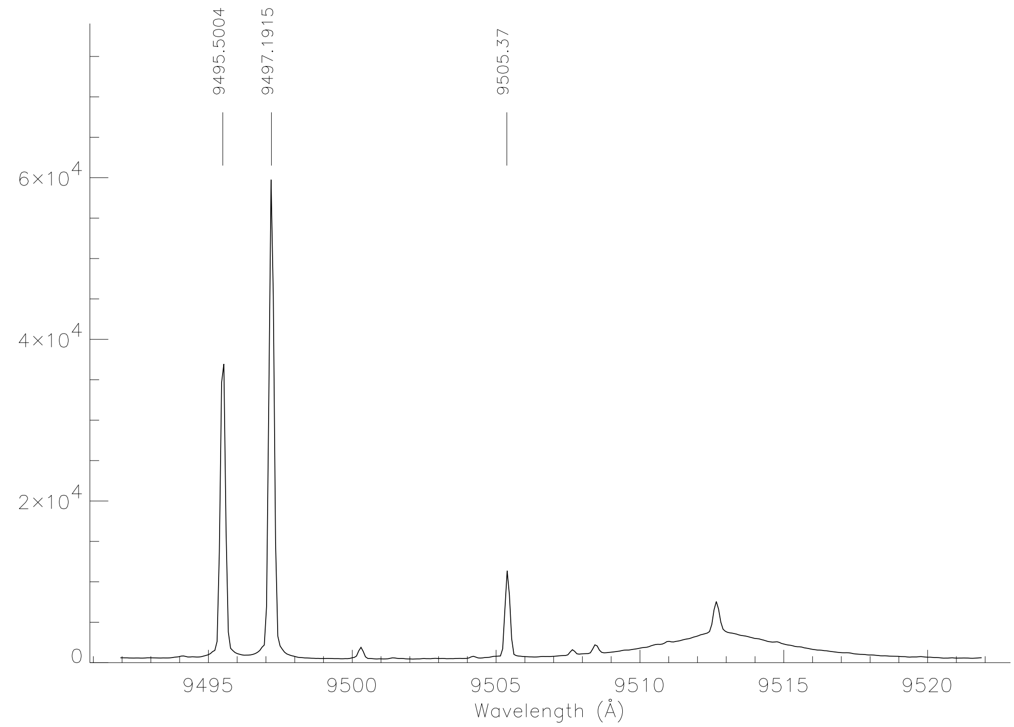

9383.2738
9388.9340
9399.0909
8×10^5
6×10^5
4×10^5
2×10^5
0
9375
9380
9385
9390
9395
9400
Wavelength (Å)


9431.6027
8000
6000
4000
2000
0
9405
9410
9415
9420
9425
9430
Wavelength (Å)

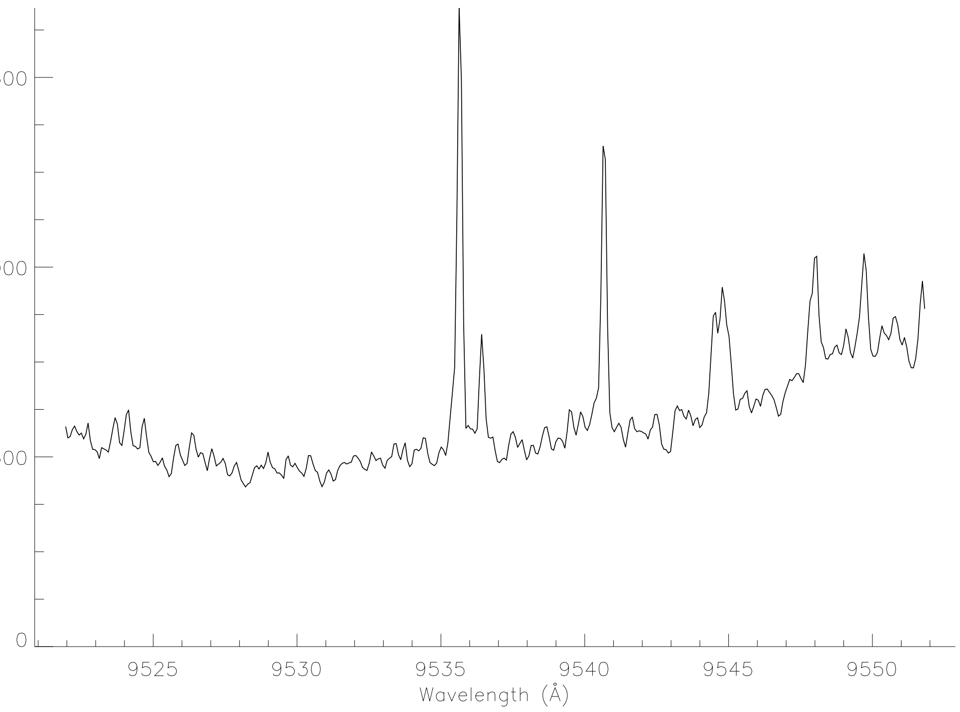

9461.0306
2.5×10^4
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
0
9435
9440
9445
9450
9455
9460
Wavelength (Å)



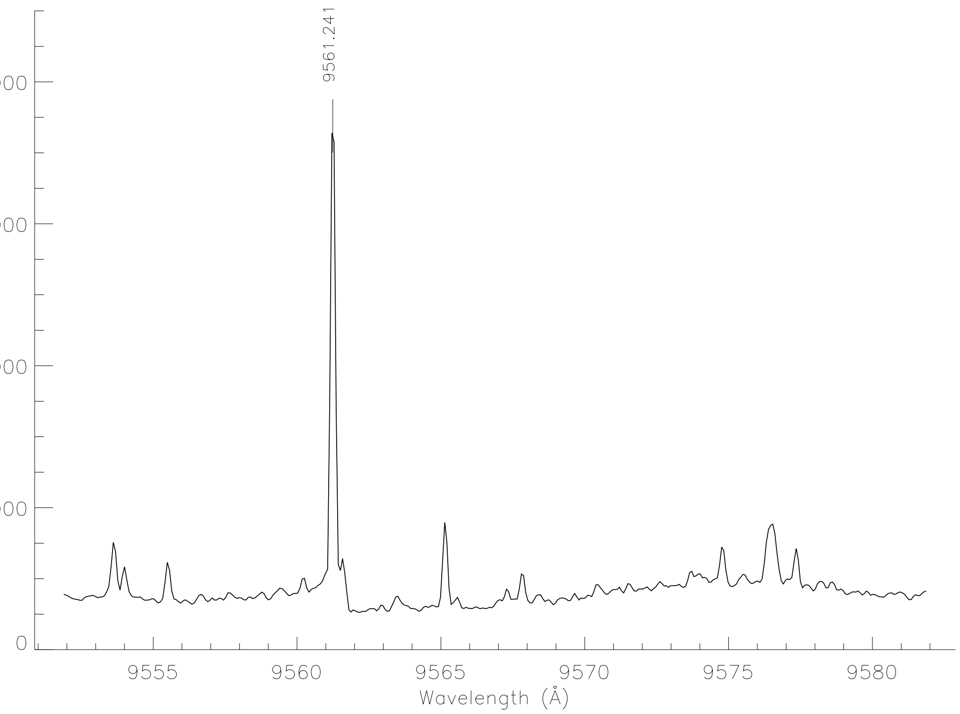
9467.1986
9470.6845
9474.8819
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
9465
9470
9475
9480
9485
9490
Wavelength (Å)



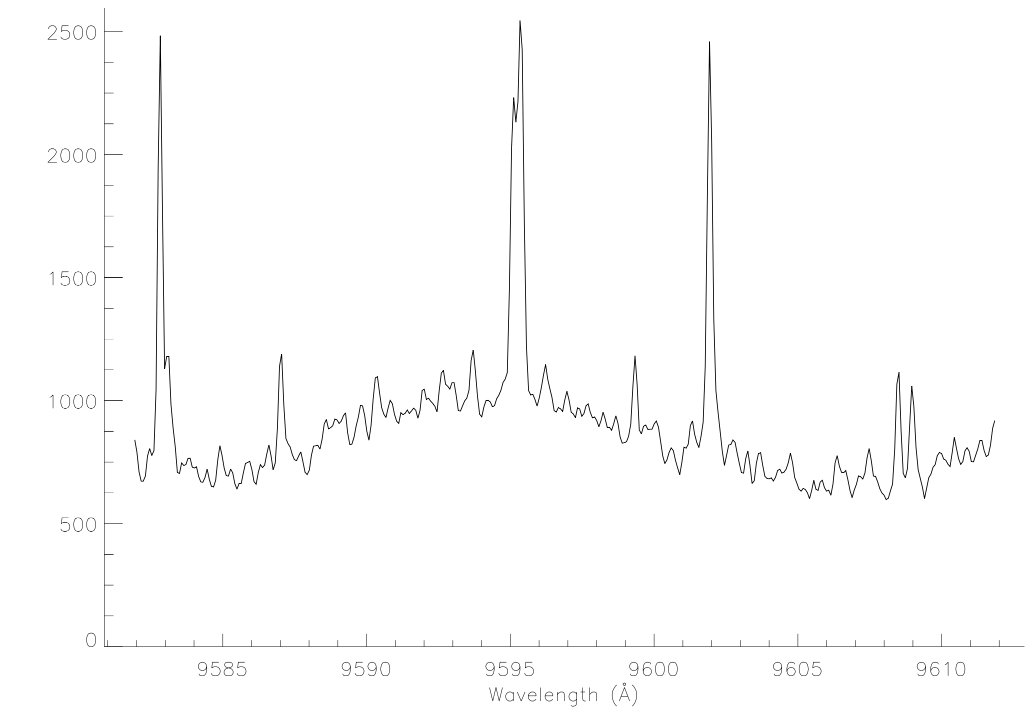
9495.5004
9497.1915
9505.37
6×10^4
4×10^4
2×10^4
0
9495
9500
9505
9510
9515
9520
Wavelength (Å)

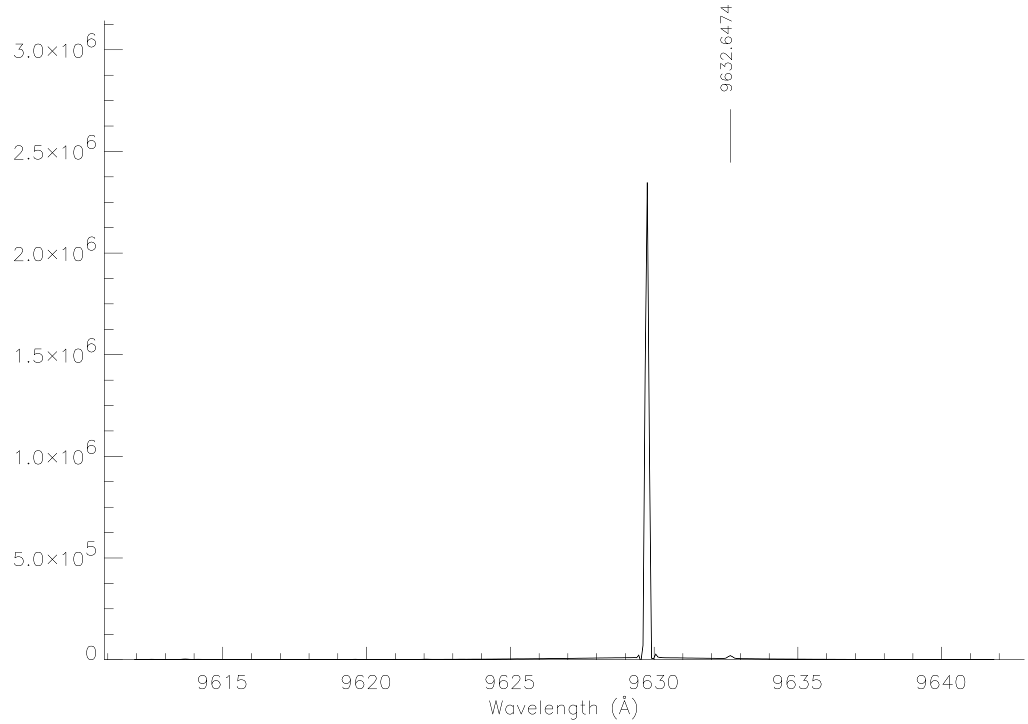


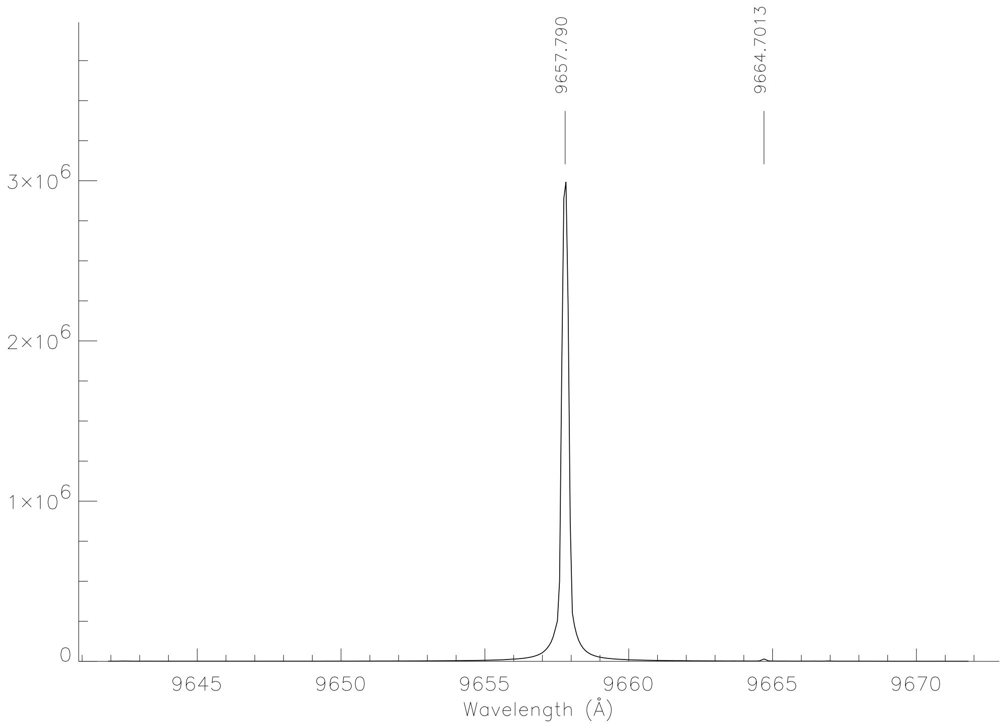
1500
1000
500
0
9525
9530
9535
9540
9545
9550
Wavelength (Å)



9561.241
8000
6000
4000
2000
0
9555
9560
9565
9570
9575
9580
Wavelength (Å)


2500
2000
1500
1000
500
0
9585
9590
9595
9600
9605
9610
Wavelength (Å)


9632.6474
3.0×10^6
2.5×10^6
2.0×10^6
1.5×10^6
1.0×10^6
5.0×10^5
0
9615
9620
9625
9630
9635
9640
Wavelength (Å)



9657.790
9664.7013
3×10^6
2×10^6
1×10^6
0
9645
9650
9655
9660
9665
9670
Wavelength (Å)

Part III

Table of Wavelengths

Table 1: Wavelengths of the emission lines identified in the *2dcoudé* Th-Ar spectrum.

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
3642.24853	0.00112	3825.12491	0.00654	3903.10183	0.00121
3659.62650	0.00130	3826.80854	0.00036	3911.91417	0.00022
3690.62366	0.00108	3828.38477	0.00017	3915.86455	0.01413
3700.97999	0.00068	3830.77388	0.00014	3916.41750	0.00015
3706.76779	0.00053	3834.67914	0.00086	3919.02226	0.00018
3718.20606	0.00022	3836.57938	0.00021	3923.80175	0.00115
3719.43450	0.00020	3837.87551	0.00016	3925.09364	0.00014
3721.82535	0.00015	3839.69598	0.00017	3925.71947	0.00014
3727.90288	0.00023	3840.80021	0.00036	3928.62424	0.00014
3729.30875	0.00032	3841.96102	0.00016	3929.66923	0.00013
3737.92561	0.01275	3845.40428	0.00036	3932.91121	0.00018
3741.18349	0.00023	3850.58136	0.00022	3933.66144	0.00013
3742.92365	0.00024	3852.13598	0.00026	3944.26888	0.00040
3751.02291	0.00059	3863.40900	0.00233	3946.10027	0.00012
3752.56886	0.00051	3867.24425	0.04600	3947.50427	0.00063
3754.56993	0.02304	3868.52835	0.00016	3948.03039	0.00015
3758.46779	0.00039	3869.66350	0.00050	3948.97726	0.00013
3765.26845	0.00016	3872.71423	0.00062	3950.39461	0.00015
3766.11705	0.00027	3873.14831	0.00038	3952.75460	0.00019
3771.37037	0.00036	3873.47211	0.00032	3956.68939	0.00023
3783.29770	0.00061	3873.82169	0.00015	3959.29976	0.00014
3785.60968	0.00780	3874.24485	0.00065	3962.41985	0.00166
3789.16546	0.00017	3874.86203	0.00016	3967.39246	0.00019
3790.79348	0.00204	3875.37316	0.00012	3968.46750	0.00015
3792.37284	0.00040	3879.64350	0.00597	3969.00320	0.00026
3798.10282	0.00028	3886.91636	0.00016	3972.15111	0.00233
3803.07444	0.00055	3891.97950	0.00040	3972.63889	0.00038
3809.45611	0.00031	3895.41889	0.00016	3973.19662	0.00022
3818.68780	0.00240	3898.44045	0.00088	3974.47744	0.00021
3820.80147	0.00894	3900.87941	0.00182	3979.35600	0.00019

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
3980.08941	0.00061	4049.94381	0.00022	4100.34139	0.00010
3990.49204	0.00017	4050.88726	0.00017	4102.61733	0.00015
3991.73098	0.00025	4052.92148	0.00011	4103.90823	0.00013
3994.54946	0.00025	4053.52770	0.00019	4104.38264	0.00042
3994.79207	0.00017	4059.25315	0.00011	4105.91154	0.00081
4001.05800	0.00017	4063.40734	0.00051	4107.05108	0.00041
4001.89316	0.00021	4064.33134	0.00017	4107.85865	0.00048
4003.30940	0.00022	4067.45098	0.00020	4108.41999	0.00010
4005.09284	0.00013	4069.20193	0.00014	4109.32385	0.00013
4007.02140	0.00029	4069.39009	0.02187	4110.83159	0.00030
4008.21038	0.00015	4070.23844	0.00008	4112.75454	0.00013
4009.04934	0.00010	4071.74729	0.00024	4115.75876	0.00014
4011.74252	0.00015	4072.00494	0.00010	4116.71320	0.00012
4012.49519	0.00013	4072.38508	0.00010	4127.41044	0.00020
4013.85758	0.00022	4075.50283	0.00012	4131.01065	0.00705
4014.71703	0.00034	4076.62903	0.00012	4131.72332	0.00010
4018.10663	0.00037	4076.94266	0.00019	4132.75302	0.00023
4019.12902	0.00012	4079.57448	0.00012	4134.07106	0.00013
4022.07774	0.00013	4080.68241	0.00051	4140.23543	0.00025
4024.80275	0.00016	4081.36752	0.00025	4142.70123	0.00014
4027.00805	0.00012	4082.38847	0.00026	4143.64878	0.00029
4029.82527	0.00029	4083.46851	0.00016	4148.18137	0.00027
4030.29152	0.00082	4085.04169	0.00060	4154.72045	0.00112
4030.84198	0.00013	4085.43359	0.00051	4156.51589	0.00015
4035.46067	0.00022	4086.52086	0.00013	4158.59044	0.00012
4036.04768	0.00013	4087.28528	0.00036	4159.51987	0.03208
4036.56509	0.00015	4088.72665	0.00023	4161.73971	0.00033
4038.23024	0.00105	4089.13772	0.00016	4162.50844	0.00025
4042.89399	0.00013	4094.74665	0.00038	4163.64922	0.00045
4043.39472	0.00014	4096.07566	0.00025	4164.18033	0.00011
4044.41706	0.00025	4097.74702	0.00012	4165.76641	0.00013
4045.95927	0.00584	4098.73077	0.00035	4168.63283	0.00005
4049.52934	0.00614	4098.93161	0.00044	4170.53195	0.00012

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
4178.05924	0.00033	4253.53882	0.00019	4308.12225	0.00012
4181.88383	0.00011	4255.23699	0.00029	4308.59488	0.00092
4190.71300	0.00011	4256.25389	0.00015	4309.23879	0.00015
4191.02972	0.00013	4257.49609	0.00010	4311.79937	0.00014
4192.36171	0.00031	4257.88808	0.00767	4312.99285	0.00009
4193.01636	0.00018	4258.52038	0.00009	4314.31853	0.00018
4194.93574	0.00015	4259.36182	0.00010	4315.25435	0.00010
4198.31668	0.00019	4260.33282	0.00011	4318.41523	0.00021
4200.67454	0.00011	4266.28641	0.00012	4320.12636	0.00016
4208.41051	0.00068	4266.52763	0.00017	4325.27282	0.00042
4208.88743	0.00009	4269.94248	0.00046	4328.91500	0.00019
4210.92313	0.00011	4272.16888	0.00010	4330.84369	0.00034
4213.06738	0.00025	4272.87452	0.00019	4331.19990	0.00011
4214.82838	0.00018	4273.35715	0.00012	4332.03000	0.00014
4216.37326	0.00099	4275.16072	0.00040	4333.56094	0.00012
4217.43185	0.00076	4276.80736	0.00043	4335.33774	0.00012
4218.66520	0.00017	4277.31373	0.00017	4337.07093	0.00016
4220.06882	0.00041	4277.52848	0.00010	4337.27698	0.00019
4222.63812	0.00038	4278.32336	0.00016	4338.10770	0.00027
4226.72669	0.00010	4280.56758	0.00017	4340.89577	0.00025
4226.98784	0.00013	4281.06707	0.00021	4342.44395	0.00017
4227.38689	0.00025	4281.41395	0.00036	4343.95127	0.00017
4228.15820	0.00012	4282.04361	0.00015	4344.32631	0.00019
4229.14752	0.00014	4282.89872	0.00017	4345.16818	0.00013
4229.86954	0.00032	4288.66904	0.00019	4346.43418	0.00028
4230.42614	0.00031	4291.80996	0.00018	4348.06425	0.00011
4235.46357	0.00019	4297.30778	0.00018	4349.07241	0.00018
4237.21991	0.00011	4299.83958	0.00018	4352.20521	0.00016
4247.98844	0.00041	4300.10080	0.00014	4352.61636	0.00028
4248.39049	0.00049	4300.64974	0.00015	4353.44712	0.00016
4250.31664	0.00010	4302.52594	0.00012	4357.61226	0.00043
4250.77613	0.00035	4304.95619	0.00062	4358.32005	0.00021
4251.18518	0.00012	4307.17631	0.00011	4359.37202	0.00019

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
4362.06693	0.00011	4430.99695	0.00012	4487.45300	0.01585
4363.79584	0.00099	4432.25179	0.00020	4488.31125	0.00076
4365.93006	0.00012	4432.96261	0.00016	4488.67864	0.00014
4367.83219	0.00015	4433.83839	0.00015	4489.66396	0.00024
4369.87594	0.00010	4434.95614	0.00016	4490.98206	0.00016
4370.75372	0.00009	4435.68121	0.00190	4493.33342	0.00012
4371.32988	0.00018	4438.74626	0.00091	4498.53939	0.00033
4374.12365	0.00012	4439.12316	0.00046	4498.94197	0.00014
4374.79298	0.00045	4439.46175	0.00014	4499.98319	0.00012
4375.95460	0.00011	4439.87998	0.00079	4502.92767	0.00018
4378.17647	0.00019	4440.57342	0.00037	4505.21639	0.00015
4379.66720	0.00011	4440.86592	0.00031	4506.47755	0.00044
4381.40017	0.00017	4443.66601	0.00053	4510.52664	0.00065
4381.85994	0.00013	4445.89960	0.00019	4510.73267	0.00018
4385.05714	0.00012	4447.83415	0.00032	4513.22287	0.00016
4391.11032	0.00012	4448.87957	0.00013	4513.67955	0.00018
4392.97414	0.00019	4450.79957	0.00047	4515.11813	0.00014
4397.91387	0.00043	4452.56501	0.00016	4519.25951	0.00017
4400.09682	0.00017	4454.77338	0.00015	4521.19544	0.00015
4400.98671	0.00011	4458.00141	0.00016	4522.32288	0.00015
4401.58122	0.00018	4460.55817	0.00027	4530.31920	0.00012
4402.92702	0.00016	4461.52817	0.00017	4530.55269	0.00012
4408.88277	0.00012	4463.66672	0.00042	4532.25782	0.00043
4414.48653	0.00010	4465.34073	0.00020	4533.07541	0.00015
4414.77592	0.01360	4469.52510	0.00019	4533.30233	0.00014
4416.23709	0.00031	4470.98976	0.00063	4534.12000	0.00044
4416.84512	0.00018	4474.76068	0.00011	4535.25475	0.00011
4421.54695	0.00071	4475.22221	0.00011	4535.50370	0.00053
4422.04789	0.00016	4478.59578	0.00027	4537.64425	0.00025
4423.72051	0.00029	4479.63798	0.00054	4540.99887	0.00028
4424.83753	0.00046	4481.81102	0.00010	4544.51387	0.00024
4426.00156	0.00010	4483.34690	0.00017	4545.05203	0.00011
4430.18933	0.00011	4486.89660	0.00016	4545.91513	0.00016

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
4547.24951	0.00035	4619.48172	0.00120	4694.09109	0.00015
4547.75946	0.00051	4621.16062	0.00019	4695.03717	0.00013
4552.15552	0.00020	4627.29726	0.00022	4695.45335	0.00033
4555.81194	0.00014	4628.20180	0.00026	4702.31601	0.00013
4558.34549	0.00044	4628.44084	0.00015	4703.98938	0.00014
4561.34857	0.00016	4631.75982	0.00019	4705.76026	0.00023
4563.66494	0.00020	4633.76969	0.00019	4708.29380	0.00020
4564.40584	0.00023	4637.23295	0.00012	4712.47941	0.00019
4564.83434	0.00050	4638.68421	0.00021	4712.84121	0.00028
4567.23994	0.00014	4640.04650	0.00042	4720.45845	0.00028
4568.14268	0.00039	4646.68605	0.00046	4720.78221	0.00044
4570.97184	0.00013	4647.25051	0.00020	4721.27635	0.00012
4579.35021	0.00012	4650.23576	0.00032	4721.59088	0.00017
4579.82764	0.00023	4651.55700	0.00015	4722.08844	0.00012
4581.17528	0.00047	4651.98883	0.00020	4723.43801	0.00010
4588.42535	0.00018	4655.21239	0.00031	4723.78377	0.00012
4589.89824	0.00014	4657.90169	0.00008	4724.77646	0.00028
4592.66617	0.00011	4659.57100	0.00037	4726.86863	0.00009
4593.64239	0.00020	4663.20227	0.00011	4728.13445	0.00102
4595.42072	0.00009	4666.00548	0.00015	4729.12739	0.00013
4596.09693	0.00010	4666.51579	0.00013	4729.88004	0.00034
4596.30760	0.00029	4666.79878	0.00011	4732.05400	0.00013
4598.76336	0.00011	4668.17152	0.00015	4735.90645	0.00013
4602.88563	0.00097	4669.98366	0.00014	4739.67669	0.00016
4603.14419	0.00012	4673.66062	0.00013	4740.53176	0.00013
4607.93463	0.00021	4675.37569	0.00088	4740.95412	0.00015
4608.55814	0.01884	4676.05657	0.00014	4741.30633	0.00061
4609.56750	0.00012	4680.23671	0.00026	4742.11827	0.00045
4611.85864	0.00058	4680.64144	0.00064	4743.69258	0.00024
4612.54617	0.00105	4683.35160	0.00018	4745.33146	0.00032
4613.60495	0.00019	4686.19425	0.00012	4749.19958	0.00013
4615.02466	0.00032	4690.62187	0.00016	4749.96976	0.00020
4615.33360	0.00020	4691.63231	0.00019	4752.41319	0.00014

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
4761.10935	0.00063	4823.99669	0.00016	4881.20375	0.00019
4764.34554	0.00016	4826.69912	0.00013	4882.24409	0.00021
4764.86507	0.00013	4829.79732	0.00032	4889.04262	0.00013
4765.59534	0.00022	4831.12096	0.00012	4892.76007	0.00034
4766.60048	0.00012	4831.59741	0.00013	4893.44309	0.00072
4773.24070	0.00027	4832.80197	0.00018	4894.95430	0.00013
4775.31365	0.00038	4840.47426	0.00028	4899.24211	0.00045
4775.79380	0.00020	4840.84265	0.00015	4902.04754	0.00021
4777.19097	0.00024	4843.92486	0.00024	4902.79341	0.00029
4778.29317	0.00012	4844.16609	0.00029	4904.75083	0.00021
4779.72634	0.00024	4845.16227	0.00035	4910.15735	0.00018
4782.76081	0.00029	4847.81016	0.00013	4910.79689	0.00023
4783.86361	0.00015	4848.36222	0.00013	4911.37963	0.00028
4786.53108	0.00013	4849.13777	0.00017	4912.52866	0.00021
4787.14773	0.00017	4849.86150	0.00018	4919.81522	0.00012
4789.38648	0.00012	4850.43949	0.00012	4921.61418	0.00013
4792.08246	0.00046	4852.86858	0.00016	4922.94368	0.00021
4793.24495	0.00020	4858.33211	0.00017	4924.42178	0.00026
4795.91372	0.00013	4861.21675	0.00014	4925.42187	0.00091
4800.17137	0.00065	4861.71645	0.00016	4925.94985	0.00035
4806.02133	0.00012	4863.16691	0.00010	4927.29803	0.00071
4808.13364	0.00013	4865.47714	0.00013	4927.77955	0.00015
4809.61409	0.00014	4865.91446	0.00018	4929.08445	0.00036
4812.37582	0.00075	4867.55484	0.00017	4929.98590	0.00015
4813.00690	0.00100	4868.88115	0.00021	4933.20931	0.00011
4813.72041	0.00058	4871.28924	0.00018	4933.85009	0.00028
4813.89598	0.00016	4872.91928	0.00012	4936.77487	0.00020
4819.19174	0.00027	4874.36442	0.00014	4937.82895	0.00020
4820.46440	0.00038	4876.49607	0.00042	4938.50546	0.00080
4820.88500	0.00014	4877.81025	0.00032	4939.64197	0.00016
4821.58747	0.00016	4878.00941	0.00015	4943.06406	0.00015
4822.85406	0.00015	4878.73258	0.00014	4945.45810	0.00016
4823.60559	0.00014	4879.86402	0.00014	4946.66283	0.00019

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
4947.57191	0.00042	5041.60720	0.00057	5115.04406	0.00014
4950.24872	0.00045	5044.72013	0.00015	5122.49794	0.00040
4950.62541	0.00019	5045.24743	0.00020	5125.49003	0.00031
4952.71868	0.00922	5047.04335	0.00014	5125.94829	0.00022
4961.72560	0.00037	5048.93238	0.00045	5128.48953	0.00025
4965.07985	0.00012	5049.79714	0.00016	5134.74547	0.00019
4965.73033	0.00019	5050.78383	0.00014	5137.47354	0.00017
4968.77257	0.00815	5051.88833	0.00038	5140.76410	0.00019
4970.08385	0.00248	5055.34649	0.00021	5141.78314	0.00013
4972.16127	0.00022	5057.98555	0.00022	5143.26758	0.00018
4980.18557	0.00023	5059.86060	0.00018	5143.91591	0.00014
4982.48636	0.00017	5061.65593	0.00019	5145.30889	0.00017
4985.37142	0.00018	5062.03748	0.00013	5146.05606	0.00092
4987.14683	0.00035	5062.93166	0.00029	5148.21191	0.00016
4989.30823	0.00013	5063.51462	0.00014	5149.20665	0.00072
4993.74878	0.00022	5064.00660	0.00015	5151.61137	0.00012
4994.10668	0.00048	5064.60152	0.00014	5154.24280	0.00012
4999.93980	0.00074	5064.94510	0.00012	5158.60442	0.00012
5002.09648	0.00012	5066.13565	0.00014	5161.53993	0.00019
5003.59786	0.00030	5066.77781	0.00015	5162.28755	0.00016
5004.12596	0.00031	5067.13887	0.00031	5163.45810	0.00015
5009.33558	0.00013	5067.97358	0.00012	5165.77350	0.00025
5009.97422	0.00760	5069.33388	0.00109	5168.92125	0.00094
5015.89003	0.00023	5081.44671	0.00023	5173.67123	0.00030
5017.17430	0.00033	5084.99374	0.00050	5175.32407	0.00020
5017.56235	0.01289	5090.05130	0.00096	5175.91068	0.00075
5019.80600	0.00020	5090.51420	0.00026	5176.96170	0.00014
5021.16500	0.01821	5095.06292	0.00036	5177.61618	0.00032
5022.00649	0.00050	5096.48440	0.00016	5183.98797	0.00047
5028.64948	0.00013	5098.04337	0.00017	5186.41290	0.00062
5029.89112	0.00014	5100.61837	0.00014	5187.33734	0.00021
5039.22982	0.00013	5101.12941	0.00026	5187.74726	0.00012
5041.12231	0.00049	5111.27767	0.00020	5190.87169	0.00016

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
5193.82555	0.00022	5277.49953	0.00022	5369.28172	0.00026
5194.45699	0.00016	5281.06841	0.00022	5370.70886	0.00020
5195.81303	0.00016	5286.88721	0.00039	5372.70201	0.00024
5198.80186	0.00015	5291.81685	0.00022	5374.82120	0.00021
5199.16365	0.00016	5294.39641	0.00020	5375.35222	0.00021
5203.84440	0.00039	5296.27879	0.00014	5375.76859	0.00051
5205.15220	0.00021	5297.74423	0.00015	5376.12997	0.00020
5209.72393	0.00021	5298.28179	0.00016	5376.77727	0.00021
5211.22975	0.00014	5300.52341	0.00015	5378.83490	0.00014
5213.34863	0.00020	5301.40402	0.00036	5379.11026	0.00013
5216.59628	0.00014	5306.98711	0.00028	5382.92698	0.00014
5218.52722	0.00016	5307.46511	0.00018	5384.03563	0.00020
5219.10929	0.00014	5310.26506	0.00014	5386.61027	0.00017
5220.70515	0.00058	5312.00130	0.00012	5388.05097	0.00015
5220.92737	0.00017	5312.52882	0.00013	5392.57274	0.00015
5221.28012	0.00015	5312.90394	0.00014	5393.97122	0.00017
5228.22547	0.00017	5317.49486	0.00020	5394.76023	0.00013
5231.15912	0.00012	5320.76846	0.00085	5397.51841	0.00028
5233.22600	0.00023	5325.14280	0.00026	5398.70192	0.00022
5234.10887	0.00103	5325.43139	0.00037	5398.91892	0.00025
5238.81361	0.00015	5326.27581	0.00022	5399.17469	0.00022
5239.55076	0.00017	5326.97545	0.00016	5399.62076	0.00077
5240.19694	0.00023	5329.37506	0.00089	5400.14535	0.00038
5247.65382	0.00017	5330.07869	0.00024	5402.60736	0.00030
5258.35965	0.00014	5337.01748	0.00150	5403.20024	0.00025
5260.10335	0.00017	5343.58022	0.00016	5407.34550	0.00032
5261.47309	0.00053	5347.97127	0.00022	5407.65329	0.00015
5265.55127	0.00020	5349.46007	0.00017	5410.76862	0.00016
5266.70955	0.00018	5351.12598	0.00019	5415.51568	0.00019
5270.26556	0.00018	5355.63469	0.00047	5417.48538	0.00014
5272.92546	0.00029	5360.14965	0.00018	5421.35855	0.00020
5274.11843	0.00017	5361.15589	0.00049	5424.00702	0.00026
5277.14585	0.00039	5362.57480	0.00021	5425.67729	0.00013

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
5431.11142	0.00015	5524.58810	0.00020	5590.11345	0.00027
5434.15071	0.00018	5524.95986	0.00041	5593.61279	0.00020
5435.89123	0.00030	5527.29559	0.00032	5594.46056	0.00015
5437.38634	0.00032	5528.22926	0.00060	5595.06352	0.00018
5439.99248	0.00037	5537.55654	0.00045	5598.47925	0.00015
5440.59978	0.00035	5538.60527	0.00027	5599.65380	0.00064
5443.12166	0.00030	5539.26123	0.00016	5601.60285	0.00016
5447.15333	0.00023	5539.90999	0.00017	5602.84575	0.00027
5449.47893	0.00029	5541.14488	0.00025	5604.51443	0.00016
5451.65459	0.00018	5541.58287	0.00049	5606.38608	0.00017
5452.21827	0.00014	5542.88973	0.00023	5606.73537	0.00015
5461.73682	0.00046	5548.17498	0.00014	5610.68027	0.00018
5462.61255	0.00045	5551.37121	0.00021	5612.06761	0.00016
5464.20517	0.00014	5552.62182	0.00019	5615.31909	0.00015
5470.75872	0.00017	5555.53118	0.00031	5619.98246	0.00032
5479.07596	0.00028	5557.04518	0.00013	5633.29476	0.00027
5484.14420	0.00024	5558.34277	0.00015	5639.74573	0.00020
5488.63106	0.00032	5558.70396	0.00014	5641.73436	0.00050
5492.64292	0.00021	5559.89126	0.00015	5645.52770	0.00024
5493.20295	0.00020	5564.20156	0.00016	5645.66478	0.00026
5494.33090	0.00020	5568.00573	0.00016	5645.89043	0.00039
5495.87880	0.00015	5571.19371	0.00017	5646.45182	0.00034
5496.13658	0.00018	5572.48204	0.00041	5648.69478	0.00027
5499.25518	0.00015	5573.35344	0.00016	5648.98922	0.00015
5499.64682	0.00025	5576.20481	0.00018	5650.70626	0.00013
5501.28035	0.00030	5577.68526	0.00021	5654.02370	0.00026
5504.30142	0.00017	5579.35786	0.00017	5657.92557	0.00015
5506.11880	0.00020	5580.07662	0.00023	5659.13584	0.00024
5507.54095	0.00029	5580.75540	0.00053	5663.04243	0.00026
5508.55830	0.00050	5581.96215	0.00025	5664.62029	0.00098
5509.99315	0.00016	5583.76116	0.00024	5665.17978	0.00018
5514.87287	0.00017	5587.02649	0.00014	5665.62860	0.00024
5518.99023	0.00030	5588.74874	0.00015	5667.12822	0.00024

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
5673.83538	0.00030	5800.82882	0.00018	5916.72356	0.00034
5674.99096	0.00023	5802.08209	0.00022	5918.94550	0.00023
5677.05193	0.00018	5804.14072	0.00017	5925.40320	0.00025
5681.90698	0.00035	5812.96678	0.00492	5928.81689	0.00023
5685.19203	0.00021	5815.42149	0.00022	5929.93408	0.00023
5700.91517	0.00014	5830.82690	0.00027	5936.38328	0.00033
5707.10256	0.00016	5832.37019	0.00019	5937.16137	0.00031
5717.17111	0.00046	5834.26411	0.00017	5937.66305	0.00016
5719.62213	0.00017	5838.94864	0.00028	5938.45759	0.00017
5720.18247	0.00016	5840.64004	0.00017	5938.82448	0.00017
5724.46185	0.00028	5843.80680	0.00021	5944.64751	0.00018
5725.38828	0.00017	5845.91892	0.00021	5948.79981	0.00020
5736.02966	0.00022	5852.68177	0.00019	5955.56266	0.00030
5739.52153	0.00016	5853.47526	0.00019	5969.73655	0.00023
5741.16987	0.00017	5854.12094	0.00024	5973.66474	0.00014
5741.82853	0.00016	5857.44973	0.00024	5975.06461	0.00017
5742.08163	0.00070	5860.31183	0.00015	5986.26502	0.00051
5748.74125	0.00014	5863.71773	0.00018	5987.30453	0.00018
5749.38869	0.00016	5868.37289	0.00023	5989.04454	0.00015
5749.78382	0.00017	5869.85012	0.00023	5991.00717	0.00016
5753.02643	0.00022	5870.54867	0.00027	5994.12837	0.00016
5760.55006	0.00018	5871.18126	0.00025	5999.00219	0.00024
5763.52837	0.00016	5882.62588	0.00015	6001.20306	0.00018
5767.77833	0.00024	5885.70158	0.00020	6005.16514	0.00019
5768.18101	0.00018	5886.53089	0.00029	6007.07144	0.00017
5771.75872	0.00045	5888.58792	0.00014	6010.16091	0.00017
5772.11704	0.00031	5891.45063	0.00017	6015.42167	0.00022
5773.94830	0.00017	5895.28069	0.00024	6021.03551	0.00017
5777.39944	0.00030	5899.84409	0.00017	6025.15551	0.00024
5789.64463	0.00017	5905.57004	0.00019	6030.44487	0.00025
5792.42989	0.00019	5912.08689	0.00013	6032.12993	0.00023
5796.06717	0.00018	5914.38569	0.00017	6032.86784	0.00443
5798.47716	0.00028	5914.67637	0.00015	6035.19242	0.00024

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
6037.69770	0.00024	6121.40961	0.00031	6224.52658	0.00017
6038.68023	0.00022	6122.21475	0.00016	6226.36959	0.00017
6042.58974	0.00016	6124.48113	0.00018	6234.85468	0.00018
6043.22648	0.00014	6138.65313	0.00024	6240.95247	0.00036
6044.43617	0.00017	6145.44387	0.00024	6243.12129	0.00025
6049.05118	0.00018	6150.68244	0.00031	6257.42342	0.00024
6050.98221	0.00015	6151.99255	0.00017	6258.60455	0.00035
6052.72420	0.00019	6154.06864	0.00018	6261.41715	0.00015
6053.38100	0.00014	6154.51618	0.00017	6266.17281	0.00031
6055.59209	0.00048	6155.24347	0.00018	6271.54485	0.00018
6059.37466	0.00021	6155.58023	0.00016	6274.11670	0.00015
6061.53539	0.00044	6157.08734	0.00021	6276.16339	0.00021
6069.02017	0.00024	6161.35072	0.00018	6277.23959	0.00027
6073.10168	0.00022	6162.17075	0.00014	6279.16383	0.00020
6077.10420	0.00025	6164.47948	0.00018	6279.95815	0.02006
6077.87264	0.00016	6169.82270	0.00024	6285.27663	0.00127
6078.42064	0.00023	6170.17949	0.00021	6287.25504	0.00031
6079.22189	0.00021	6172.27964	0.00022	6291.19032	0.00057
6085.37309	0.00020	6173.10040	0.00021	6292.89014	0.00021
6087.26165	0.00031	6178.43005	0.00019	6293.24105	0.00024
6088.03072	0.00021	6180.70447	0.00024	6296.87351	0.00016
6098.12136	0.00035	6182.62060	0.00018	6300.91548	0.00036
6098.80757	0.00017	6188.12400	0.00016	6303.24983	0.00023
6099.08327	0.00027	6191.90566	0.00018	6307.66070	0.00017
6101.72476	0.00018	6193.85553	0.00028	6310.81016	0.00035
6105.63759	0.00019	6198.22297	0.00017	6315.77577	0.00030
6107.53309	0.00019	6200.43240	0.00028	6317.18415	0.00043
6112.83657	0.00018	6203.49284	0.00016	6326.36631	0.00019
6114.53839	0.00028	6205.86084	0.00027	6327.27676	0.00018
6114.92457	0.00016	6207.22028	0.00017	6337.62094	0.00020
6116.16586	0.00024	6208.68747	0.00031	6339.66814	0.00021
6119.68735	0.00519	6215.94022	0.00017	6342.85884	0.00018
6120.55610	0.00029	6220.01159	0.00032	6348.73711	0.00016

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
6355.63063	0.00032	6512.36386	0.00017	6662.26723	0.00019
6355.91060	0.00020	6522.04265	0.00034	6664.05185	0.00022
6364.88931	0.00550	6531.34069	0.00020	6666.35982	0.00019
6369.13373	0.00030	6538.10300	0.00018	6668.81741	0.00032
6369.57728	0.00026	6551.70566	0.00032	6673.58170	0.00142
6371.94376	0.00026	6554.16121	0.00020	6674.69727	0.00020
6376.92960	0.00027	6558.87597	0.00031	6677.28267	0.00016
6379.67332	0.00029	6564.44542	0.00035	6678.70706	0.00022
6384.71862	0.00018	6577.21371	0.00021	6683.36804	0.00020
6387.39657	0.00018	6577.65272	0.00033	6684.29492	0.00028
6388.81349	0.00019	6583.90583	0.00017	6697.71165	0.00024
6389.39022	0.00030	6588.53872	0.00018	6711.25077	0.00032
6394.04855	0.00032	6591.48330	0.00025	6713.96925	0.00022
6399.20918	0.00040	6593.46310	0.00032	6719.20842	0.00022
6400.70010	0.00021	6593.93918	0.00019	6727.45692	0.00029
6406.44530	0.00027	6599.48251	0.00033	6728.11878	0.00034
6411.89776	0.00020	6604.85513	0.00030	6733.74893	0.00034
6413.61336	0.00018	6605.41664	0.00028	6752.83453	0.00019
6416.30827	0.00016	6613.38169	0.00027	6753.65887	0.00036
6437.76094	0.00022	6618.16486	0.00031	6756.45413	0.00030
6439.07058	0.00019	6619.94388	0.00023	6757.10840	0.00028
6446.77133	0.00042	6632.08648	0.00039	6758.20311	0.00026
6457.28144	0.00017	6638.22298	0.00028	6766.61445	0.00019
6483.08320	0.00025	6638.91179	0.00019	6772.18758	0.00025
6490.73704	0.00028	6639.74143	0.00016	6778.31194	0.00027
6493.19749	0.00026	6643.70019	0.00026	6780.12490	0.00027
6493.77771	0.00027	6644.66317	0.00027	6780.41222	0.00024
6499.64525	0.00018	6646.54026	0.00026	6787.73546	0.00026
6501.99214	0.00020	6648.49457	0.00033	6788.83897	0.00029
6503.51070	0.00032	6648.95744	0.00029	6791.23392	0.00034
6506.98714	0.00019	6654.36651	0.00044	6824.67783	0.00034
6508.36040	0.00036	6658.67582	0.00023	6827.25189	0.00025
6509.05150	0.00018	6660.67681	0.00023	6829.03478	0.00027

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
6834.92380	0.00019	7036.28056	0.00019	7206.48347	0.00124
6854.10972	0.00028	7045.79659	0.00021	7206.98230	0.00025
6861.27018	0.00031	7053.61867	0.00025	7208.00456	0.00029
6863.53598	0.00032	7054.42986	0.00043	7212.68817	0.00037
6866.36215	0.00471	7058.48837	0.00031	7218.05109	0.00026
6866.76329	0.00033	7060.04077	0.00030	7219.14938	0.00030
6868.45137	0.00030	7060.65320	0.00025	7230.15410	0.00158
6871.29027	0.00029	7061.39273	0.00041	7230.85929	0.00050
6874.75253	0.00029	7064.45018	0.00026	7233.53434	0.00050
6879.58367	0.00024	7067.21482	0.00404	7242.09254	0.00036
6886.40775	0.00022	7068.73683	0.00027	7244.69650	0.00026
6887.08903	0.00021	7072.39289	0.00026	7255.35518	0.00042
6888.17461	0.00019	7075.33176	0.00033	7258.17713	0.00040
6889.30231	0.00024	7084.16842	0.00019	7265.17418	0.00024
6909.84840	0.00026	7086.70711	0.00026	7270.66199	0.00021
6911.22682	0.00024	7089.33875	0.00033	7272.93621	0.00023
6916.12760	0.00042	7107.48057	0.00025	7284.90131	0.00034
6925.01202	0.00035	7124.55894	0.00028	7285.44659	0.00041
6937.66520	0.00020	7125.82190	0.00025	7311.71720	0.00024
6942.53635	0.00024	7142.33139	0.00045	7316.00613	0.00030
6943.61029	0.00020	7147.04243	0.00028	7324.80657	0.00088
6945.49050	0.00028	7148.55867	0.00030	7326.14847	0.00020
6951.48094	0.00020	7150.28452	0.00028	7328.28361	0.00019
6954.65671	0.00040	7156.93525	0.00030	7341.15102	0.00017
6960.25246	0.00019	7158.83995	0.00025	7342.57825	0.00042
6965.43053	0.00132	7159.93729	0.00034	7350.81673	0.00024
6989.65517	0.00019	7162.55991	0.00029	7353.29306	0.00024
6992.20887	0.00661	7168.89453	0.00029	7372.11899	0.00027
6993.02748	0.00780	7173.37091	0.00019	7376.87597	0.00037
7000.80384	0.00027	7176.72263	0.00030	7380.42486	0.00029
7002.88334	0.00036	7191.21965	0.00304	7383.98007	0.00210
7018.56696	0.00027	7200.04543	0.00026	7385.49880	0.00025
7030.25248	0.00014	7202.19014	0.00032	7392.98242	0.00020

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
7393.43702	0.00034	7618.33739	0.00740	7847.53805	0.00021
7402.25238	0.00035	7625.70435	0.00030	7848.45556	0.00040
7412.33824	0.00021	7628.88264	0.00035	7861.91474	0.00188
7418.54959	0.00019	7630.30957	0.00037	7864.02084	0.00039
7425.29315	0.00016	7635.09038	0.00894	7865.96753	0.00025
7428.93895	0.00021	7647.37820	0.00028	7868.19662	0.00023
7430.25331	0.00024	7652.31691	0.00034	7886.28177	0.00029
7435.36906	0.00022	7653.82650	0.00020	7891.07597	0.00029
7436.29816	0.00020	7654.69804	0.00035	7899.74621	0.00141
7444.73883	0.00830	7660.88562	0.00163	7900.31764	0.00028
7447.83970	0.00712	7670.05996	0.00019	7916.44318	0.00040
7469.13112	0.00432	7676.21805	0.00052	7937.73350	0.00046
7471.16233	0.00035	7678.12619	0.00027	7941.72630	0.00034
7481.35258	0.00038	7685.30561	0.00045	7948.16952	0.00490
7483.61823	0.00653	7693.70909	0.00087	7972.59469	0.00044
7484.32757	0.00036	7699.78372	0.00153	7978.97178	0.00031
7487.97285	0.00043	7704.81806	0.00032	7987.97377	0.00030
7500.65736	0.00022	7710.26810	0.00032	7993.67897	0.00049
7503.86889	0.00093	7712.25355	0.01838	8006.15066	0.00132
7508.48582	0.00070	7713.93678	0.00067	8014.78272	0.00253
7510.41083	0.00029	7723.76161	0.00205	8022.20821	0.00033
7511.34918	0.00062	7724.20358	0.00225	8024.25334	0.00043
7511.79109	0.00045	7728.95089	0.00025	8030.19900	0.00041
7514.64648	0.00744	7742.56189	0.00072	8032.43517	0.00589
7523.13350	0.00032	7782.30221	0.01090	8037.22179	0.00032
7525.50449	0.00028	7788.93215	0.00030	8046.11798	0.00033
7531.14070	0.00150	7798.33466	0.01343	8053.30881	0.00023
7549.31259	0.00024	7814.31631	0.00814	8062.62858	0.00046
7567.74122	0.00021	7817.76829	0.00040	8075.64915	0.00034
7569.50997	0.00046	7834.45599	0.00197	8085.21832	0.00041
7589.31400	0.00022	7840.30431	0.00042	8093.62265	0.00035
7598.19133	0.01118	7841.79020	0.00021	8094.05854	0.00038
7607.81417	0.00712	7842.26577	0.00055	8103.68081	0.00295

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
8115.29404	0.00421	8510.62203	0.00061	8955.84626	0.00039
8119.18040	0.00024	8516.55260	0.00044	8967.64092	0.00042
8129.40427	0.00028	8521.43880	0.00232	9016.58923	0.00034
8138.45512	0.01231	8539.79200	0.00037	9017.59481	0.00049
8143.12447	0.01095	8554.94195	0.00038	9040.06594	0.01217
8159.72579	0.00036	8573.11869	0.00039	9048.24982	0.00037
8169.78545	0.00038	8605.77640	0.00028	9062.56189	0.00044
8186.90997	0.00029	8620.46163	0.00022	9063.95860	0.00027
8231.40608	0.00048	8639.43962	0.00035	9075.39825	0.00024
8252.39320	0.00030	8645.30800	0.00036	9090.81937	0.00062
8254.74043	0.00059	8662.14057	0.00059	9094.83187	0.00027
8259.51060	0.00070	8665.48488	0.00031	9122.96613	0.00981
8264.51084	0.00544	8667.94386	0.00121	9140.58609	0.00220
8275.60738	0.01353	8678.40931	0.00040	9165.89420	0.00035
8320.85458	0.00026	8709.23307	0.00049	9194.63939	0.00041
8330.44762	0.00031	8723.71188	0.01298	9203.96161	0.00052
8358.72415	0.00051	8732.42418	0.00052	9224.48188	0.00509
8384.72476	0.00035	8748.03016	0.00031	9227.48883	0.01661
8401.98907	0.00047	8758.24142	0.00027	9266.20720	0.00044
8403.80056	0.00078	8761.68807	0.00025	9276.27463	0.00037
8408.19936	0.00604	8766.74271	0.00029	9289.56488	0.00045
8411.89995	0.00082	8771.86105	0.00029	9291.53446	0.00044
8416.72734	0.00025	8772.79392	0.01001	9307.89861	0.00045
8417.99749	0.00033	8775.57120	0.00029	9340.70467	0.00045
8421.22566	0.00023	8784.54554	0.00949	9354.21727	0.00063
8424.62916	0.00795	8799.08923	0.00040	9383.27381	0.00037
8445.48570	0.00032	8841.18314	0.00044	9388.93399	0.00036
8446.50974	0.00032	8842.07056	0.00038	9399.09087	0.00037
8456.48348	0.00337	8849.91144	0.00026	9431.60272	0.00086
8464.23685	0.00029	8868.83358	0.00034	9461.03063	0.00063
8471.82321	0.00035	8889.06206	0.00466	9467.19863	0.00064
8478.35795	0.00038	8892.98159	0.00051	9470.68455	0.00044
8490.30694	0.00045	8905.65688	0.00039	9474.88188	0.00040

Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)	Wavelength (Å)	err (Å)
9495.50044	0.00038				
9497.19152	0.00043				
9505.37191	0.01645				
9561.24113	0.00889				
9632.64737	0.00058				
9657.79030	0.00379				
9664.70129	0.00074				