

Glow Starter RELCO SC480

Atlas of Emission Lines

Recorded by the Spectrographs
SQUES Echelle and DADOS

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1 Calibration Light Sources for Echelle Spectrographs

Due to the split-up of the highly resolved broadband-spectrum to numerous overlapping orders, Echelle spectrographs require calibration light sources, producing a huge number of evaluable emission lines, which are more or less evenly distributed over the entire wavelength range, reaching from blue to red. In the professional sector, but partly also in the amateur field, mostly hollow cathode lamps with eg iron, argon or thorium are used. Such are usually quite expensive and some of these substances, released by a possible lamp break, not really harmless. In addition, a specific high voltage supply is required.

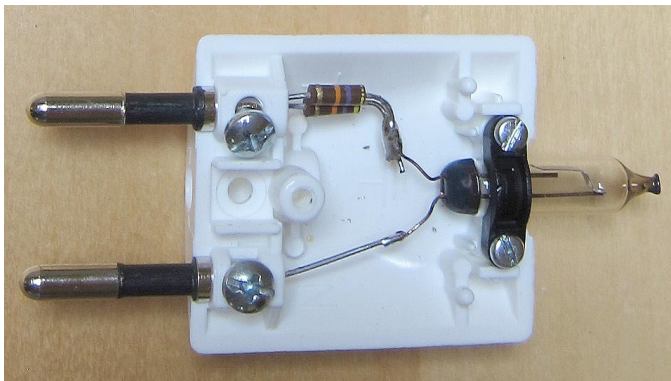
2 Low Cost Alternative

The popular neon glow lamp, particularly used in amateur circles, produces the main part of the useable emission lines in the red- or long wavelength range of the spectrum. Here it can possibly be used for the calibration of some individual orders, but it is useless for the overall calibration of an entire Echelle spectrum.

The glass bulb of the glow starter RELCO SC480, produced by the Italian lighting manufacturer RELCO, houses a bimetal switch and contains also strongly different portions of the noble gases *He*, *Ne* and *Ar*, as well as H (probably generated by dissociation of remaining water vapour within the bulb). By a simple modification of the starter these gases can be excited to produce several hundreds of evaluable emission lines. There exist also professional calibration lamps, using this gas mixture.

3 Modification of the Glow Starter

With minimal electrical knowledge, this unit can, as a makeshift solution and clearly restricted to first indoor tests, be modified to a calibration light source by supplying it with 230V via a series resistor of about 24 k Ω . The following illustration shows my modified version with 2x47 k Ω connected in parallel. For our purposes, the capacitor, applied to prevent radio interference, can be removed. Before soldering, the oxide layer must be grinded from the connecting wires. If the switch opens and closes periodically, the value of the series resistor must be increased (up to >30k Ω). The glass bulb of the RELCO starter is so small that it may be mounted even in to the spectrograph as a fixed calibration light source. However, for such applications and particularly for outdoor operation instead of a mains supply the feeding by a low power voltage inverter e.g. 12VDC/230VAC is highly recommended! Anyway all such modifications remain of course at your own risk!



Modified in such a way, the excited gases in the bulb generate some 240 evaluable emission lines. Counting also those on all overlapped Echelle orders, this number increases even to approximately 370. Between the individual starters, the intensity of the hydrogen Balmer series can vary very strongly. Numerous additional lines, which are not listed here, are gen-

erated by alloying elements, coatings and dopants, such as tungsten (W), lanthanum (La), cerium (Ce), hafnium (Hf), thorium (Th), and Fe, Cr, Sn, Ni, Mn. Their identification is difficult and highly speculative, since for a given line, almost always *several* plausible determination options exist in the immediate vicinity.

4 Application for the Echelle Calibration ($R \approx 20'000$)

Within the entire range of $\lambda\lambda$ 3888 - 8136 [Å], and distributed to 30 SQUES Echelle orders, all usable emission lines are documented in the following tables. As an absolute exception, within the order 29 ($\lambda\lambda$ 7600-7900), only two evaluable emission lines are generated by noble gases, which however are supplemented here by a striking oxygen triplet. In addition, there are still other calibration options eg with known H₂O and/or O₂ lines of the daylight spectrum, during the night reflected by the moon and planets.

The SQUES Echelle spectrograph produces nearly straight running orders which can be simply processed also individually and applying conventional methods, eg the Vspec or RSpec Software [25, [26]. This way the modified RELCO starter allows the quick and easy wavelength calibration for the analysis of individual, highly resolved lines. Also possible is the somewhat demanding processing and calibration of the entire spectrum with ISIS or corresponding MIDAS routines, because significantly more than the minimum required three emission lines are available here. Line pairs which appear scarcely resolved here and therefore can hardly be selectively marked with the cursor are referred with "Blend" in the tables. Lines which, due to overlapping orders, appear twice, are labelled in colour. As a supplement and with relatively high probability, in the rather sparsely populated orders 39, 40 and 43, Ti- emissions could be identified. These lines are additionally labelled with "?".

5 Application for the Broadband-Calibration ($R \approx 900/4'000$)

Since neon as well as argon generate numerous and strong emission lines, the formation of many blends, particularly in the red part of *low-resolution spectra*, is inevitable. Nevertheless within the entire wideband spectrum still more than sufficient isolated lines are available for a reliable calibration of the wavelength axis. The corresponding commented DA-DOS profiles, recorded with 200- and 900L mm⁻¹, are attached at the end of this document in sect. 8.

Since version 5 additionally the infrared domain is covered up to 10,000 Å. Relco SC480 generates here several Argon emissions, sufficient for a reliable calibration. The according profile was recorded by Joan Guarro Flo (E) – many thanks!

6 H α Analysis with Conventional Grating Spectrographs

The H α line is located within the Echelle order No 34. Here also the calibration lines, located adjacent to H α , can be found. For the users of Lhires III and ISIS, directly adjacent to the well known neon triple $\lambda\lambda$ 6506/6532/6598, two additional argon lines at $\lambda\lambda$ 6538.112 and 6604.853, as well as the H α emission are available.

7 RELCO Calibration Lines and SQUES Echelle Orders ($R \approx 20'000$)

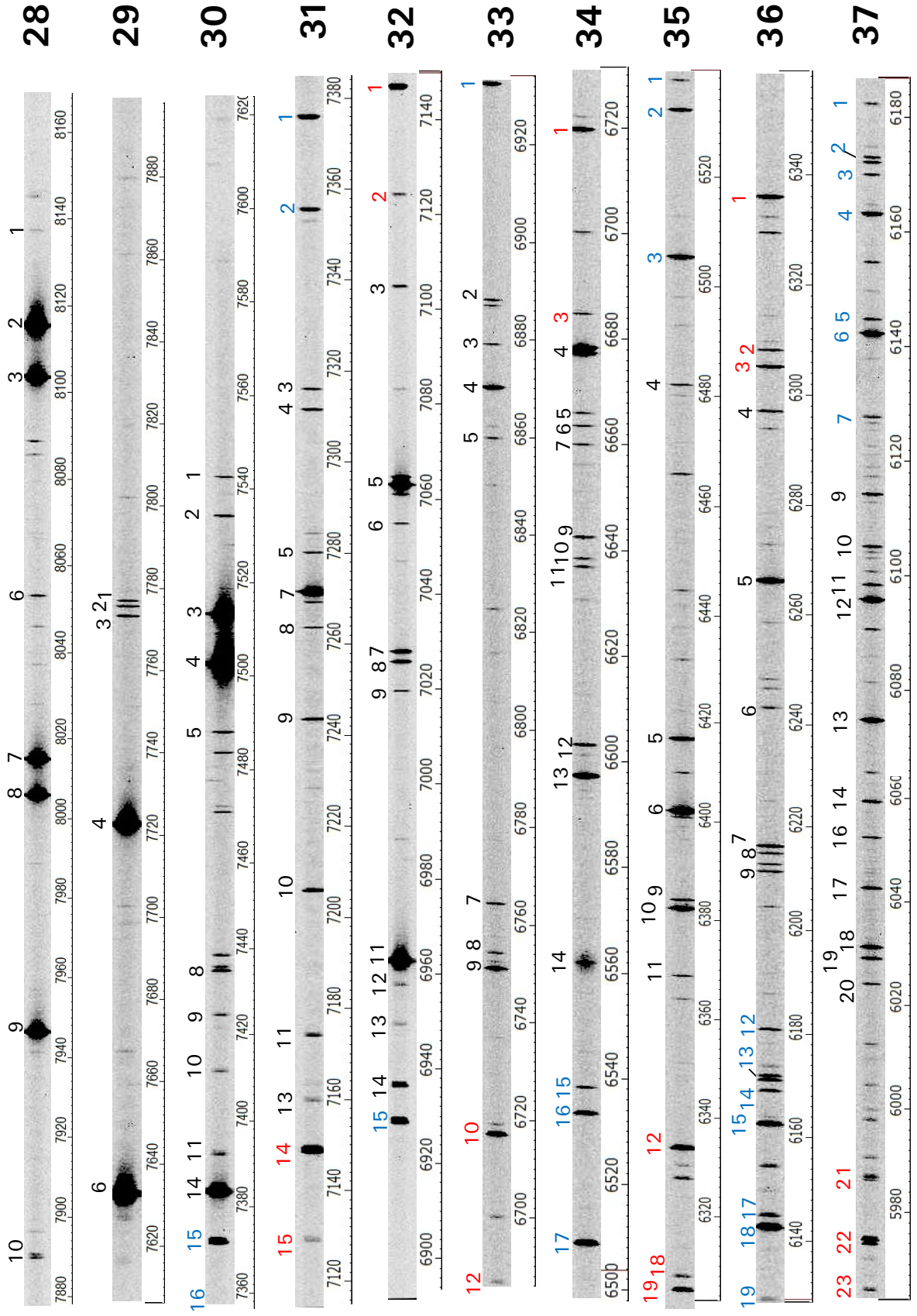
The following charts and tables show the positions of the individual emission lines, distributed to the orders of the SQUES Echelle spectrograph ($R \approx 20'000$). These can be used eg for the calibration of the entire spectrum with ISIS or MIDAS. The appropriate wavelengths have been copied in to these tables from the "Elements" tool of Vspec. For the calibration, limited to only one individual Echelle order, the labelled profiles are applicable.

Practical Notes:

To improve the visibility of the weaker calibration lines a stronger zoom in the intensity axis is required. For the overall processing and calibration of the entire spectrum, eg with ISIS, it is recommended to select the more intense lines only. Applying different Echelle spectrographs with comparable or even the same grating configuration, some of the emission lines, located here at the outermost edges of the orders, may appear to be moved in the neighbouring orders. Further the line intensity, not only of the hydrogen Balmer series, is noticeably subjected to the manufacturing tolerance of the starter production.

Tip: To avoid transmission errors, the wavelength data can be copied with *ctrl c* from the pdf file and transferred to the Vspec calibration field with *shift insert*.

Glowstarter RELCO SC480 Calibration Lines SQUES Echelle Orders 28 - 37



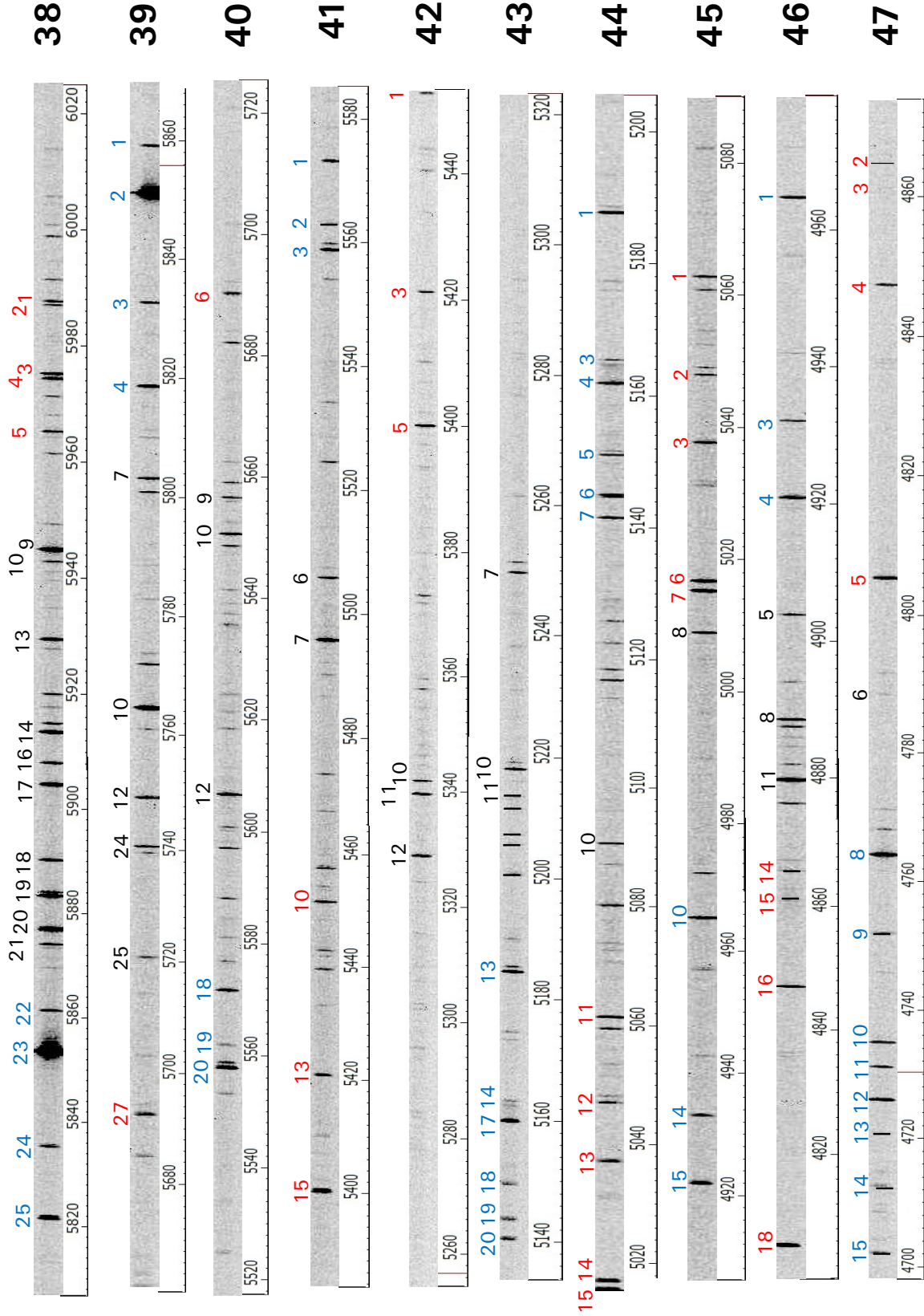
RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 28 – 34

28	1	8136.406	Ne	31	1	7372.118	Ar	33	1	6929.467	Ne
28	2	8115.311	Ar	31	2	7353.293	Ar	33	2	6888.174	Ar
28	3	8103.693	Ar	31	3	7316.005	Ar	33	3	6879.582	Ar
28	6	8053.308	Ar	31	4	7311.716	Ar	33	4	6871.289	Ar
28	7	8014.786	Ar	31	5	7281.35	He	33	5	6861.269	Ar
28	8	8006.157	Ar	31	7	7272.936	Ar	33	7	6766.612	Ar
28	9	7948.176	Ar	31	8	7265.172	Ar	33	8	6756.163	Ar
28	10	7891.075	Ar	31	9	7245.167	Ne	33	9	6752.834	Ar
29	1	7775.39	O	31	10	7206.98	Ar	33	10	6717.043	Ne
29	2	7774.17	O	31	11	7173.938	Ne	33	12	6684.293	Ar
29	3	7771.94	O	31	14	7147.042	Ar	34	1	6717.043	Ne
29	4	7723.761	Ar	31	15	7125.82	Ar	34	3	6684.293	Ar
29	6	7635.106	Ar	32	1	7147.042	Ar	34	4	BLEND	Ar / Ne
30	1	7544.044	Ne	32	2	7125.82	Ar	34	5	6666.359	Ar
30	2	7535.774	Ne	32	3	7107.478	Ar	34	6	6664.051	Ar
30	3	7514.652	Ar	32	5	7067.218	Ar	34	7	6660.676	Ar
30	4	7503.869	Ar	32	6	7059.107	Ne	34	9	6643.698	Ar
30	5	7488.871	Ne	32	7	7032.413	Ne	34	10	6639.74	Ar
30	8	BLEND	Ar	32	8	7030.251	Ar	34	11	6638.221	Ar
30	9	7425.294	Ar	32	9	7024.05	Ne	34	12	6604.853	Ar
30	10	7412.337	Ar	32	11	6965.431	Ar	34	13	6598.953	Ne
30	11	7392.98	Ar	32	12	6960.25	Ar	34	14	6562.82	H α
30	14	7383.98	Ar	32	13	6951.478	Ar	34	15	6538.112	Ar
30	15	7372.118	Ar	32	14	6937.664	Ar	34	16	6532.882	Ne
30	16	7353.293	Ar	32	15	6929.467	Ne	34	17	6506.528	Ne

RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 35 – 37

35	1	6538.112	Ar	36	1	6334.428	Ne	37	1	6182.146	Ne
35	2	6532.882	Ne	36	2	6307.657	Ar	37	2	BLEND	Ar
35	3	6506.528	Ne	36	3	6304.789	Ne	37	3	6170.174	Ar
35	4	6483.082	Ar	36	4	6296.872	Ar	37	4	6163.594	Ne
35	5	6416.307	Ar	36	5	6266.495	Ne	37	5	6145.441	Ar
35	6	6402.246	Ar	36	6	6243.12	Ar	37	6	6143.063	Ne
35	9	6384.717	Ar	36	7	6217.281	Ne	37	7	6128.45	Ne
35	10	6382.992	Ne	36	8	6215.938	Ar	37	9	6114.923	Ar
35	11	6369.575	Ar	36	9	6212.503	Ar	37	10	6105.635	Ar
35	12	6334.428	Ne	36	12	6182.146	Ne	37	11	6098.803	Ar
35	18	6307.657	Ar	36	13	BLEND	Ar	37	12	6096.163	Ne
35	19	6304.789	Ne	36	14	6170.174	Ar	37	13	6074.338	Ne
				36	15	6163.594	Ne	37	14	6059.372	Ar
				36	17	6145.441	Ar	37	16	6052.723	Ar
				36	18	6143.063	Ne	37	17	6043.223	Ar
				36	19	6128.45	Ne	37	18	6032.127	Ar
								37	19	6029.997	Ne
								37	20	6025.15	Ar
								37	21	BLEND	Ne/Ar
								37	22	BLEND	Ne
								37	23	5965.471	Ne

Glowstarter RELCO SC480 Calibration Lines SQUES Echelle Orders 38 - 47



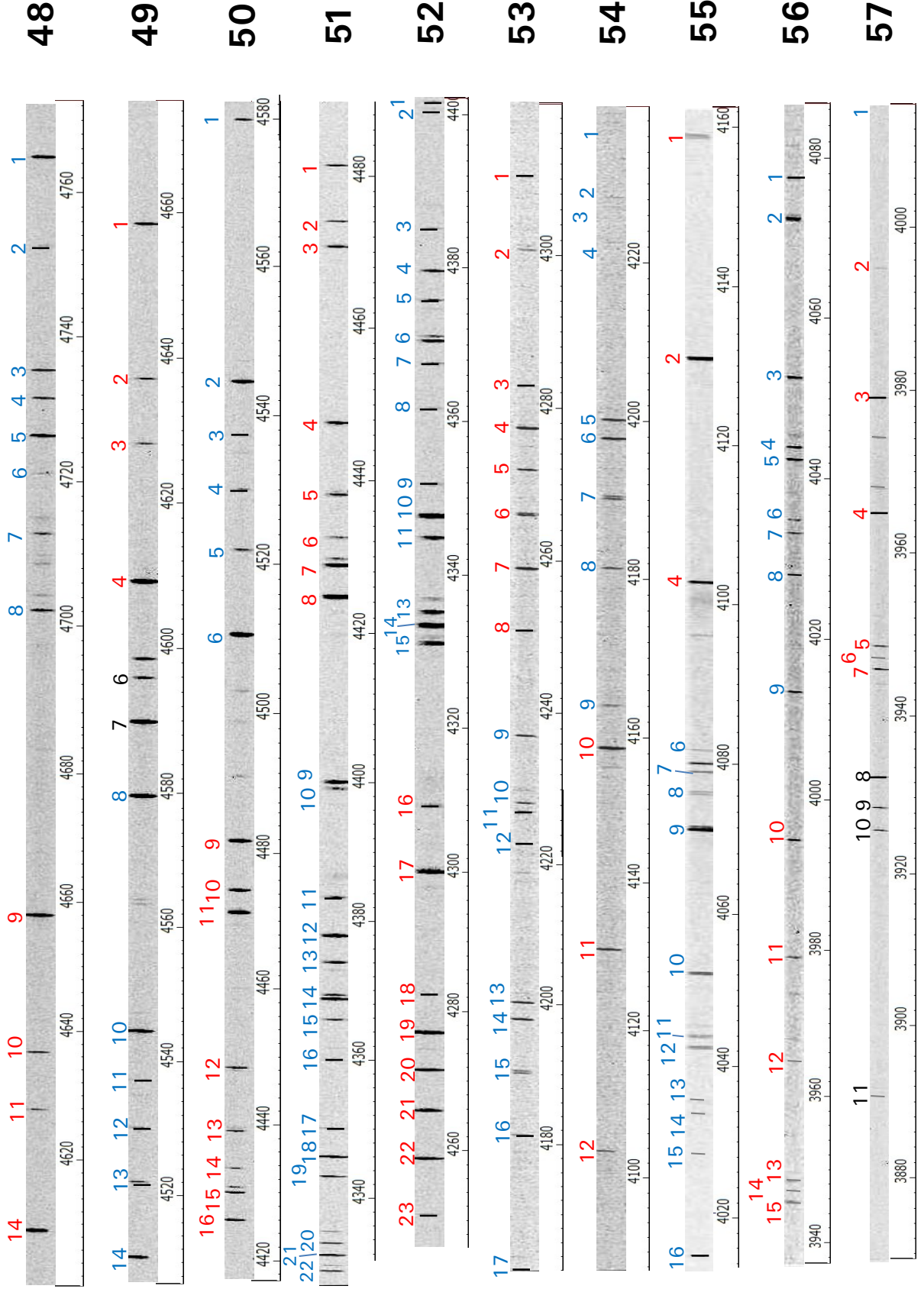
RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 38 – 45

38	1	5987.907	Ne	40	6	5689.47	Ti?	44	1	5187.746	Ar
38	2	5987.302	Ar	40	9	5656.659	Ne	44	3	5165.773	Ar
38	3	5975.534	Ne	40	10	5650.704	Ar	44	4	5162.285	Ar
38	4	5974.627	Ne	40	12	5606.733	Ar	44	5	5151.391	Ar
38	5	5965.471	Ne	40	18	5572.541	Ar	44	6	BLEND	Ne/Ar
38	9	5944.834	Ne	40	19	5562.766	Ne	44	7	5141.783	Ar
38	10	5942.669	Ar	40	20	5558.702	Ar	44	10	5090.495	Ar
38	13	5928.813	Ar	40	1	5572.541	Ar	44	11	5062.037	Ar
38	14	5912.085	Ar	41	2	5562.766	Ne	44	12	5047.74	He
38	16	5906.429	Ne	41	3	5558.702	Ar	44	13	5037.751	Ne
38	17	5902.462	Ne	41	6	5506.113	Ar	44	14	5017.163	Ar
38	18	5888.584	Ar	41	7	5495.874	Ar	44	15	5015.678	He
38	19	BLEND	Ne/Ar	41	10	5451.652	Ar	45	1	5062.037	Ar
38	20	5875.62	He	41	13	5421.352	Ar	45	2	5047.74	He
38	21	5872.828	Ne	41	15	5400.562	Ne	45	3	5037.751	Ne
38	22	5860.31	Ar	41	1	5451.652	Ar	45	6	5017.163	Ar
38	23	5852.488	Ne	42	3	5421.352	Ar	45	7	5015.678	He
38	24	5834.263	Ar	42	5	5400.562	Ne	45	8	5009.334	Ar
38	25	5820.156	Ne	42	10	5343.283	Ne	45	10	4965.08	Ar
39	1	5860.31	Ar	42	11	5341.094	Ne	45	14	4933.209	Ar
39	2	5852.488	Ne	42	12	5330.778	Ne	45	15	4921.931	He
39	3	5834.263	Ar	42	7	5252.11	Ti?				
39	4	5820.156	Ne	43	10	5221.271	Ar				
39	7	5804.45	Ne	43	11	5216.814	Ar				
39	10	5764.419	Ne	43	13	5187.746	Ar				
39	12	5748.298	Ne	43	14	BLEND	Ar				
39	24	5739.52	Ar	43	17	5162.285	Ar				
39	25	5719.225	Ne	43	18	5151.391	Ar				
39	27	5689.47	Ti?	43	19	BLEND	Ne/Ar				
				43	20	5141.783	Ar				

RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 46 – 47

46	1	4965.08	Ar	47	2	4865.91	Ar
46	3	4933.209	Ar	47	3	4861.33	H β
46	4	4921.931	He	47	4	4847.81	Ar
46	5	4904.752	Ar	47	5	4806.02	Ar
46	8	4889.042	Ar	47	6	4788.927	Ne
46	11	4879.864	Ar	47	8	4764.865	Ar
46	14	4865.91	Ar	47	9	4752.732	Ne
46	15	4861.33	H β	47	10	4735.906	Ar
46	16	4847.81	Ar	47	11	4732.053	Ar
46	18	4806.02	Ar	47	12	4726.868	Ar
				47	13	4721.591	Ar
				47	14	4713.146	He
				47	15	4702.316	Ar

Glowstarter RELCO SC480 Calibration Lines SQUES Echelle Orders 48 – 57

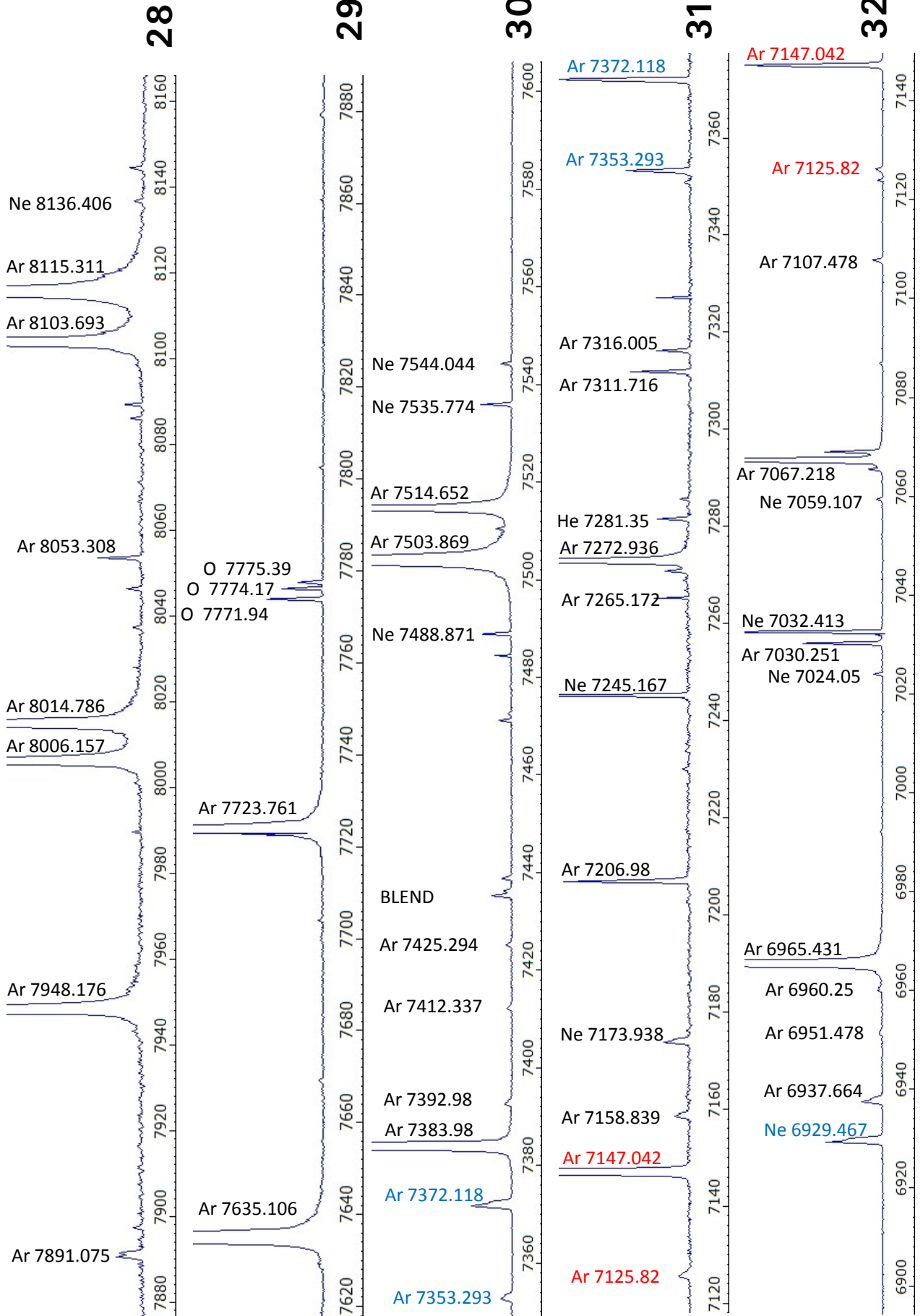


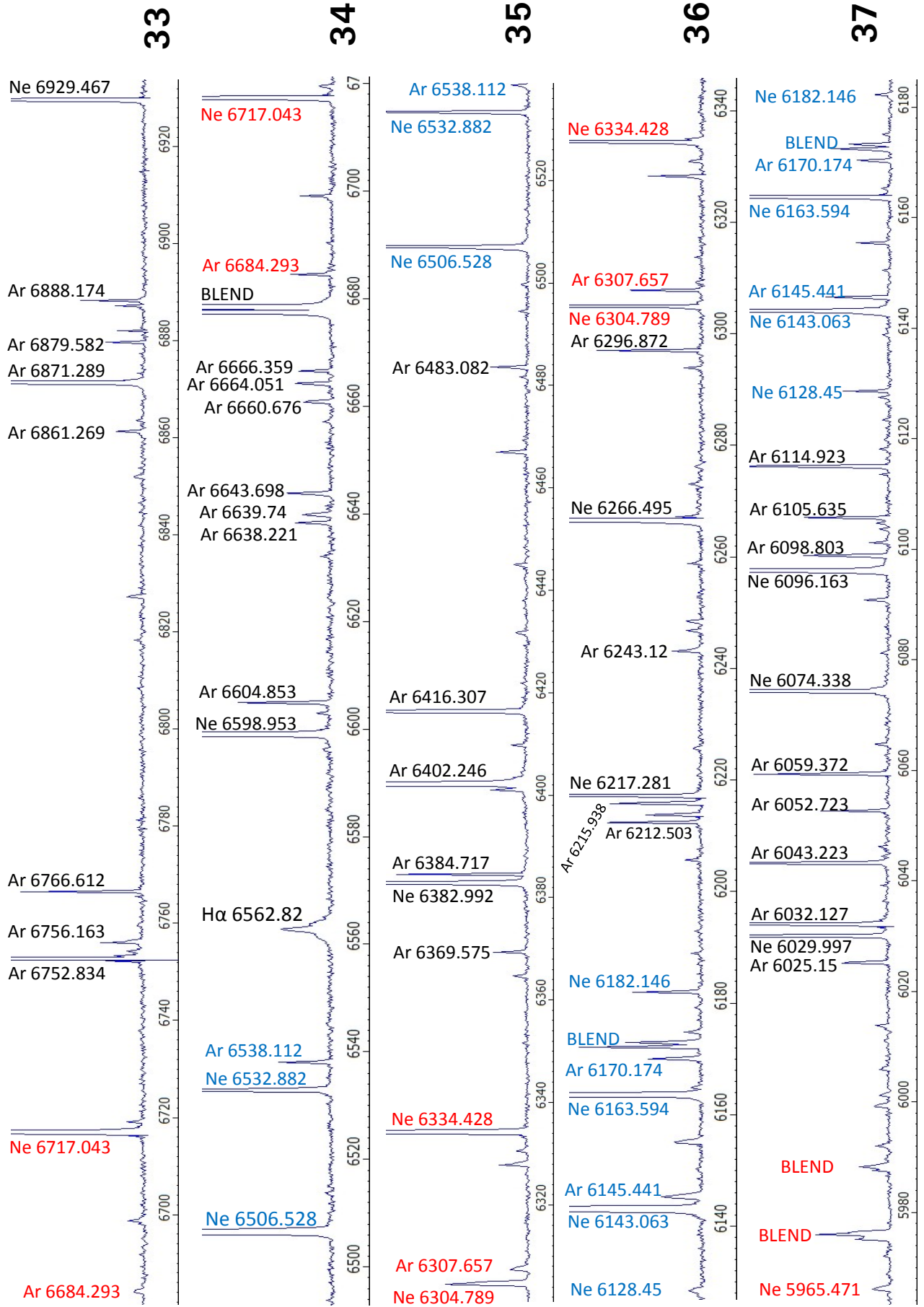
RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 52 – 55

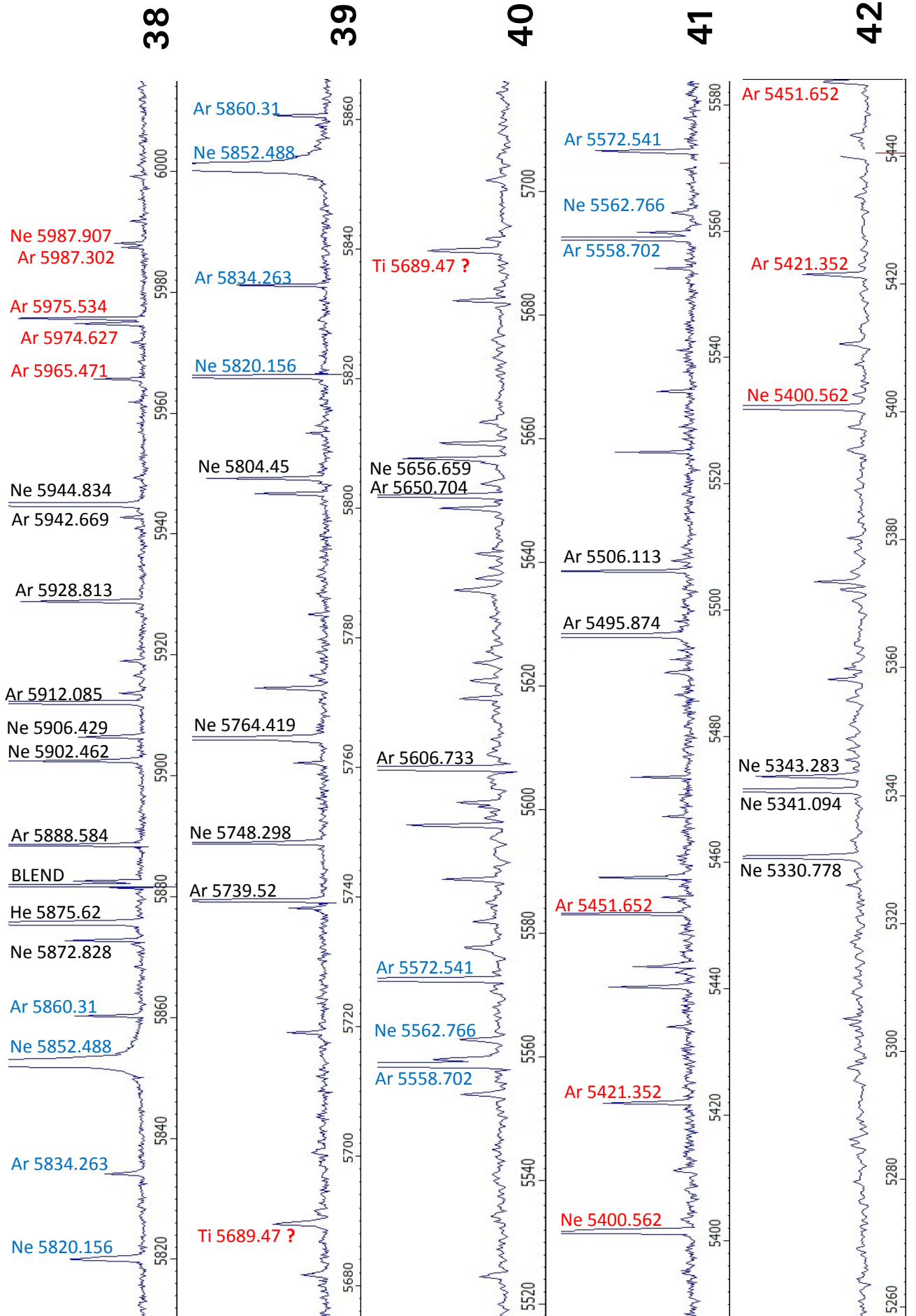
52	1	4400.986	Ar	53	1	4309.239	Ar	55	1	4158.59	Ar
52	2	4400.097	Ar	53	2	4300.101	Ar	55	2	4131.724	Ar
52	3	4385.057	Ar	53	3	4282.898	Ar	55	4	4103.912	Ar
52	4	4379.667	Ar	53	4	4277.528	Ar	55	6	4082.387	Ar
52	5	4375.954	Ar	53	5	4272.169	Ar	55	7	4079.574	Ar
52	6	BLEND	Ar	53	6	4266.286	Ar	55	8	BLEND	Ar/?
52	7	4367.832	Ar	53	7	4259.362	Ar	55	9	BLEND	Ar/Ar
52	8	4362.066	Ar	53	8	4251.185	Ar	55	10	4052.921	Ar
52	9	4352.205	Ar	53	9	4237.22	Ar	55	11	4044.418	Ar
52	10	4348.064	Ar	53	10	4228.158	Ar	55	12	4042.894	Ar
52	11	4345.168	Ar	53	11	4226.988	Ar	55	13	4035.46	Ar
52	13	4335.338	Ar	53	12	4222.637	Ar	55	14	4033.809	Ar
52	14	4333.561	Ar	53	13	4200.674	Ar	55	15	4026.36	He
52	15	4331.2	Ar	53	14	4198.317	Ar	55	16	4013.857	Ar
52	16	4309.239	Ar	53	15	BLEND	Ar/Hf				
52	17	4300.101	Ar	53	16	4181.884	Ar				
52	18	4282.898	Ar	53	17	4164.18	Ar				
52	19	4277.528	Ar								
52	20	4272.169	Ar	54	1	4237.22	Ar				
52	21	4266.286	Ar	54	2	4228.158	Ar				
52	22	4259.362	Ar	54	3	4226.988	Ar				
52	23	4251.185	Ar	54	4	4222.637	Ar				
				54	5	4200.674	Ar				
				54	6	4198.317	Ar				
				54	7	BLEND	Ar/Hf				
				54	8	4181.884	Ar				
				54	9	4164.18	Ar				
				54	10	4158.59	Ar				
				54	11	4131.724	Ar				
				54	12	4103.912	Ar				

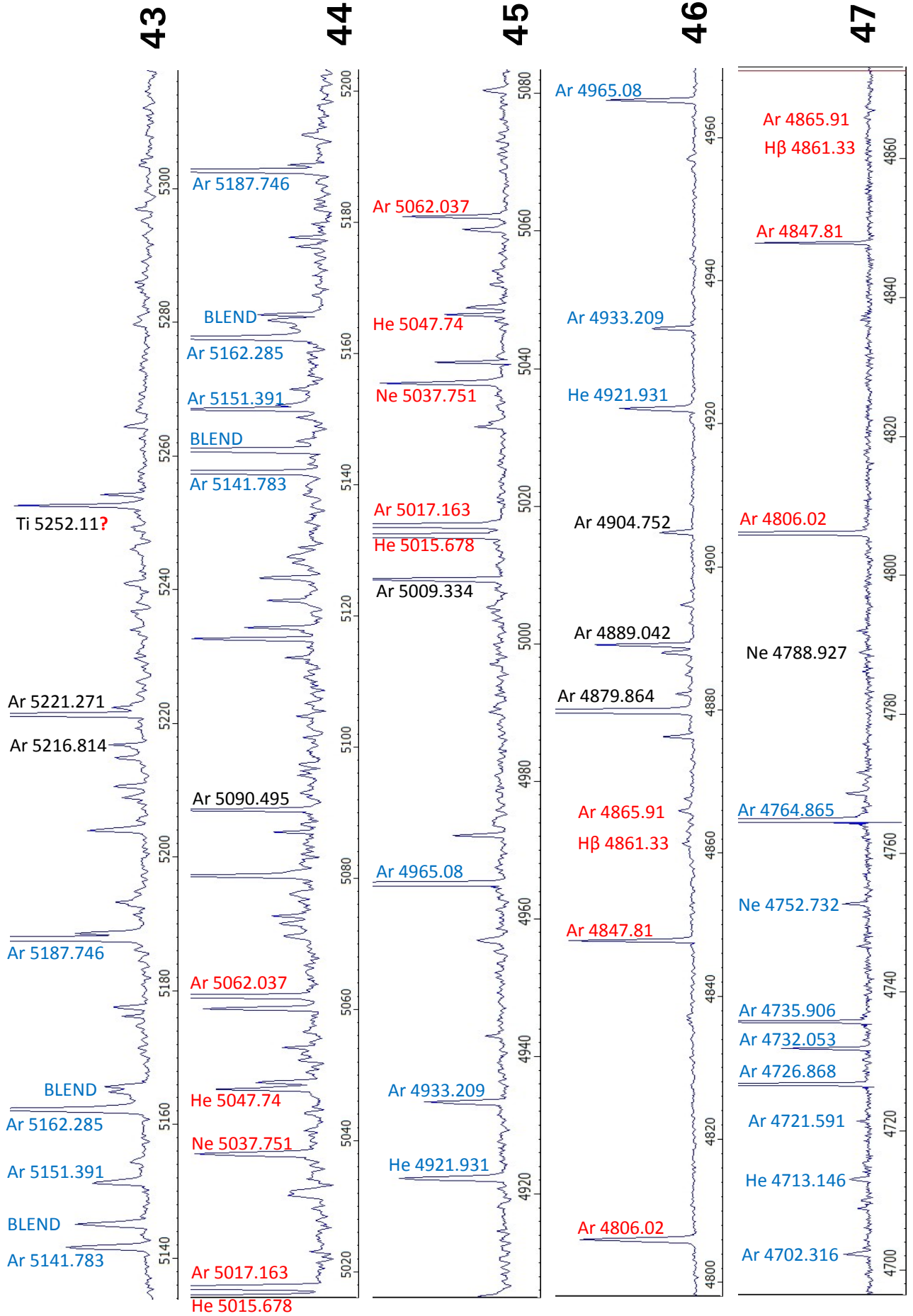
RELCO SC480 Glowstarter Emissionlines SQUES Echelle Orders 56 – 57

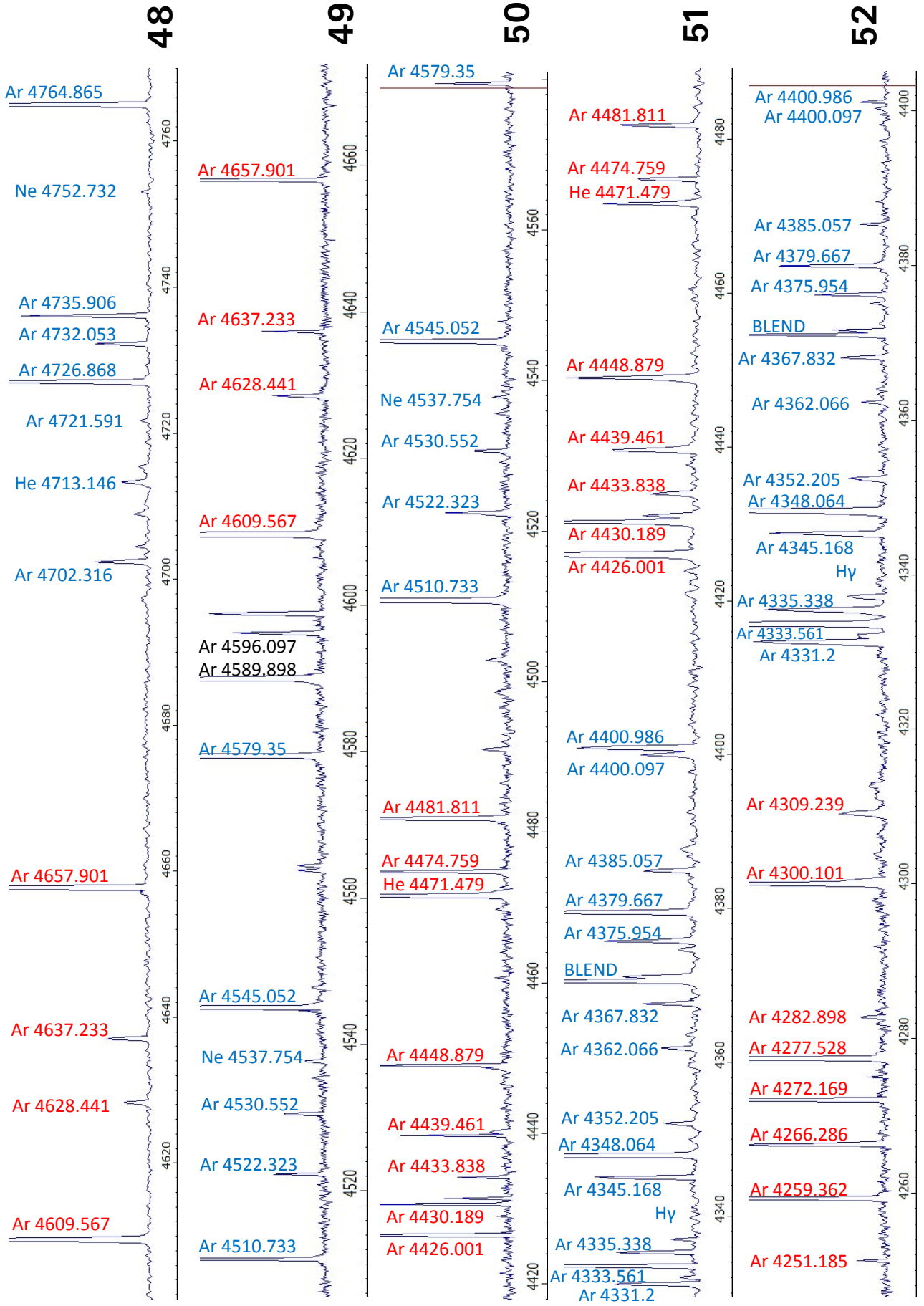
56	1	BLEND	Ar/?	57	1	4013.857	Ar
56	2	BLEND	Ar/Ar	57	2	3994.792	Ar
56	3	4052.921	Ar	57	3	3979.356	Ar
56	4	4044.418	Ar	57	4	3964.729	He
56	5	4042.894	Ar	57	5	3948.979	Ar
56	6	4035.46	Ar	57	6	3947.505	Ar
56	7	4033.809	Ar	57	7	3946.097	Ar
56	8	4026.36	He	57	8	3932.547	Ar
56	9	4013.857	Ar	57	9	3928.623	Ar
56	10	3994.792	Ar	57	10	3925.719	Ar
56	11	3979.356	Ar	57	11	3888.65	He
56	12	3964.729	He				
56	13	3948.979	Ar				
56	14	3947.505	Ar				
56	15	3946.097	Ar				

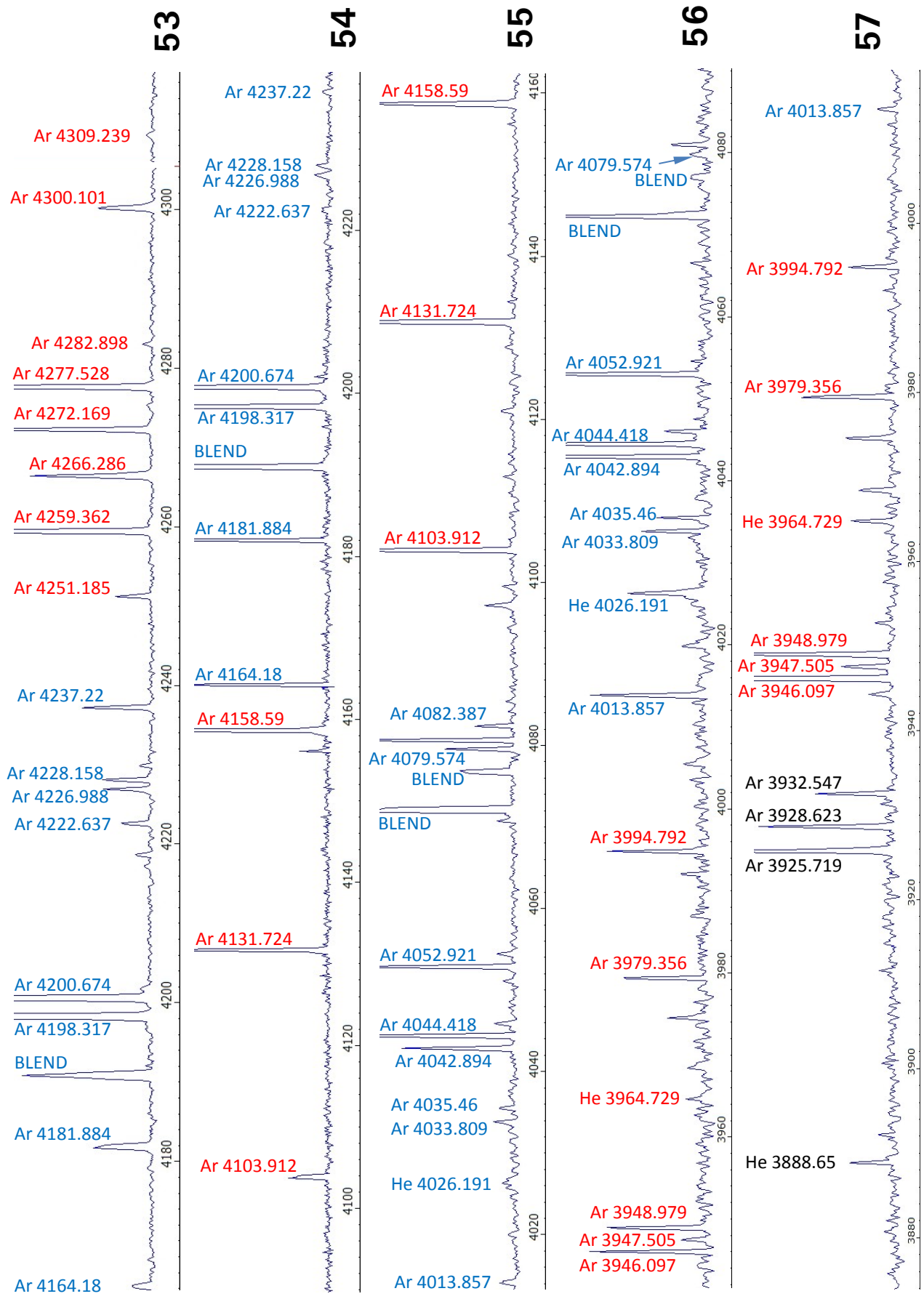








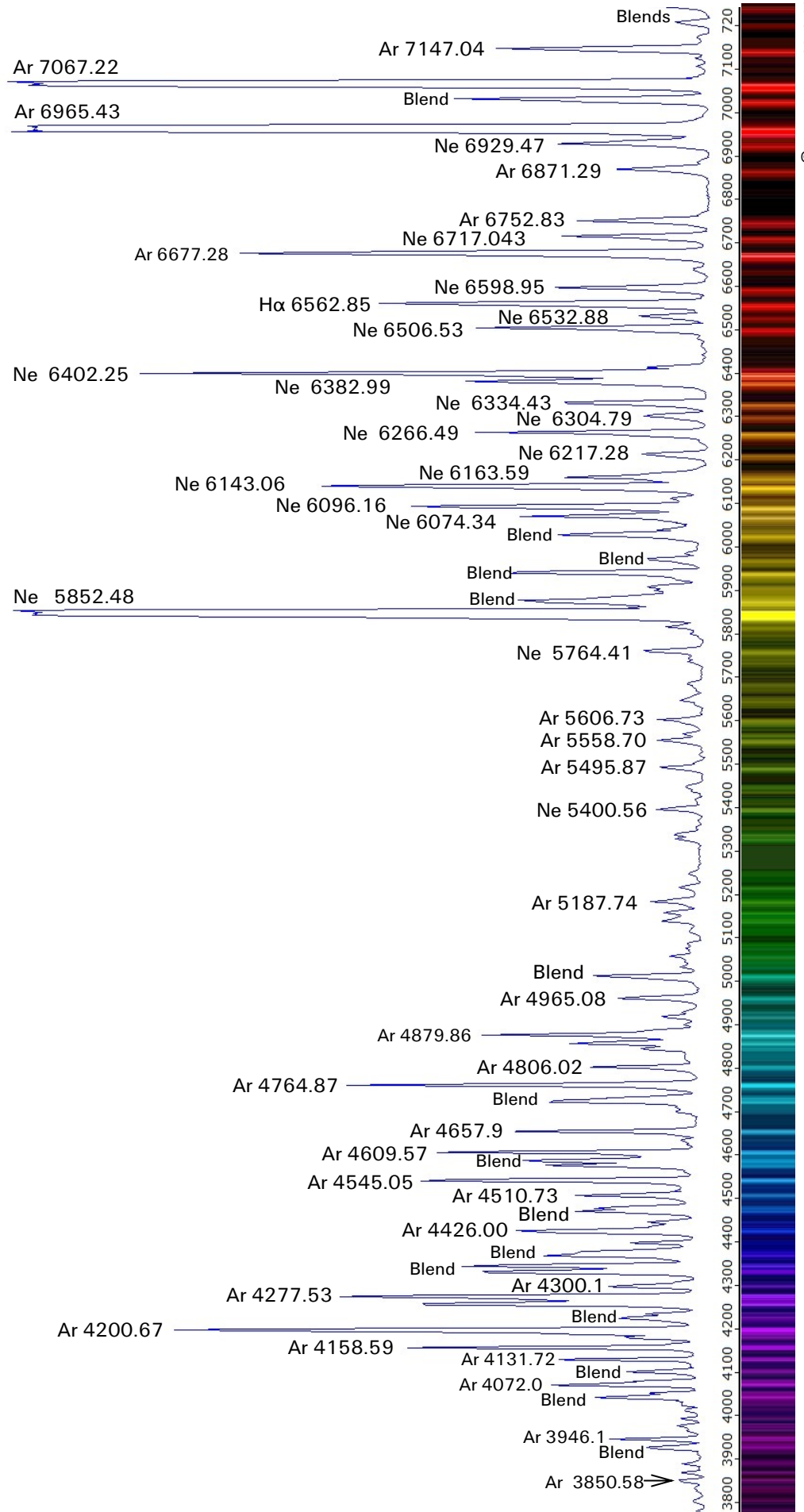




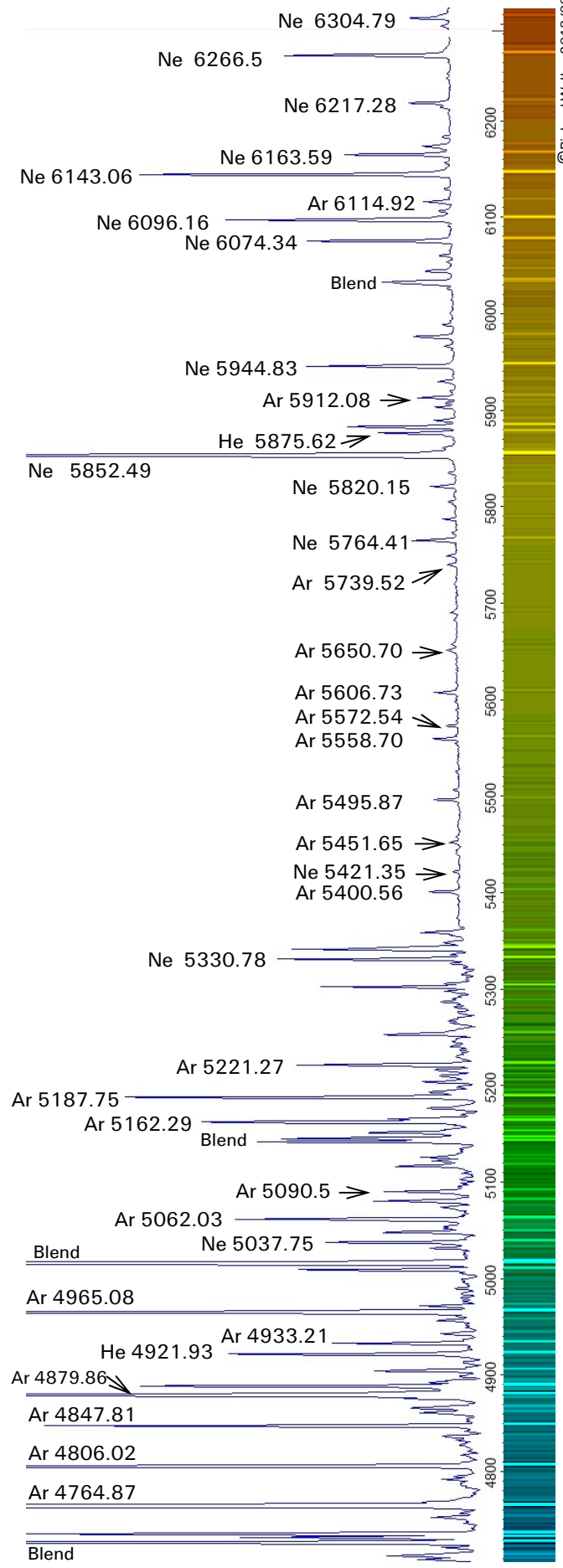
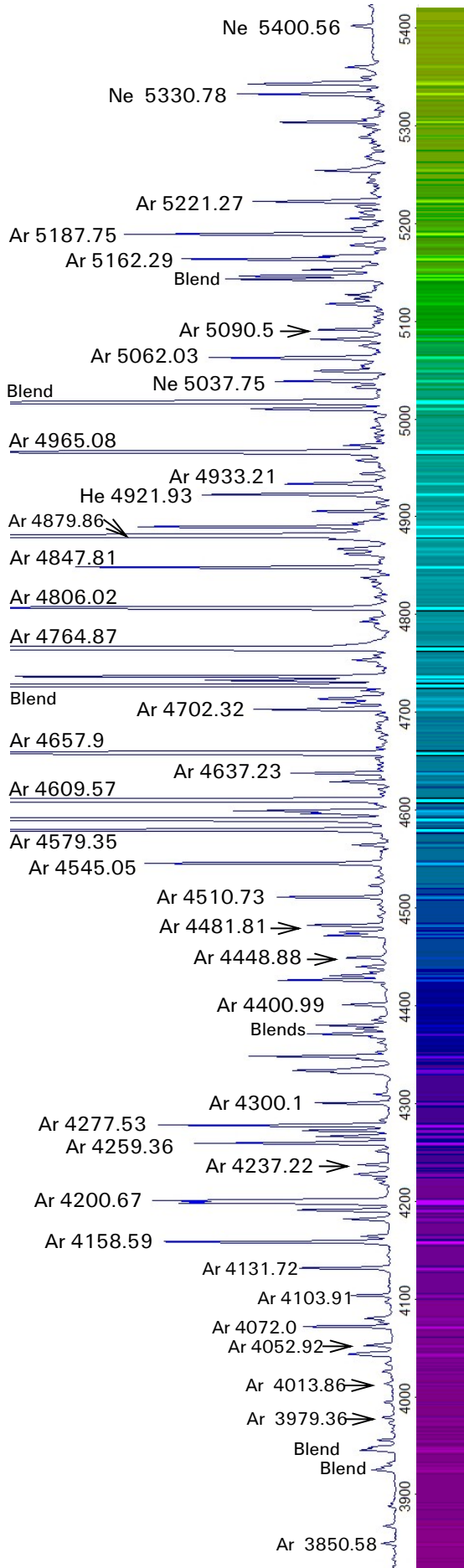
8 Relco Broadband-Calibration Lines ($R \approx 900 / 4'000$)

The following tables show the Relco calibration lines for resolutions of $R \approx 900$ and $\approx 4,000$. Only those emissions are labelled here, which are suitable for the calibration of a spectral profile. The profile for the infrared domain was recorded by Joan Guarro Flo (E) with a resolution of $R \approx 1300$.

RELCO SC480 Emission Lines DADOS Spectrograph 200L mm⁻¹ R ≈ 800

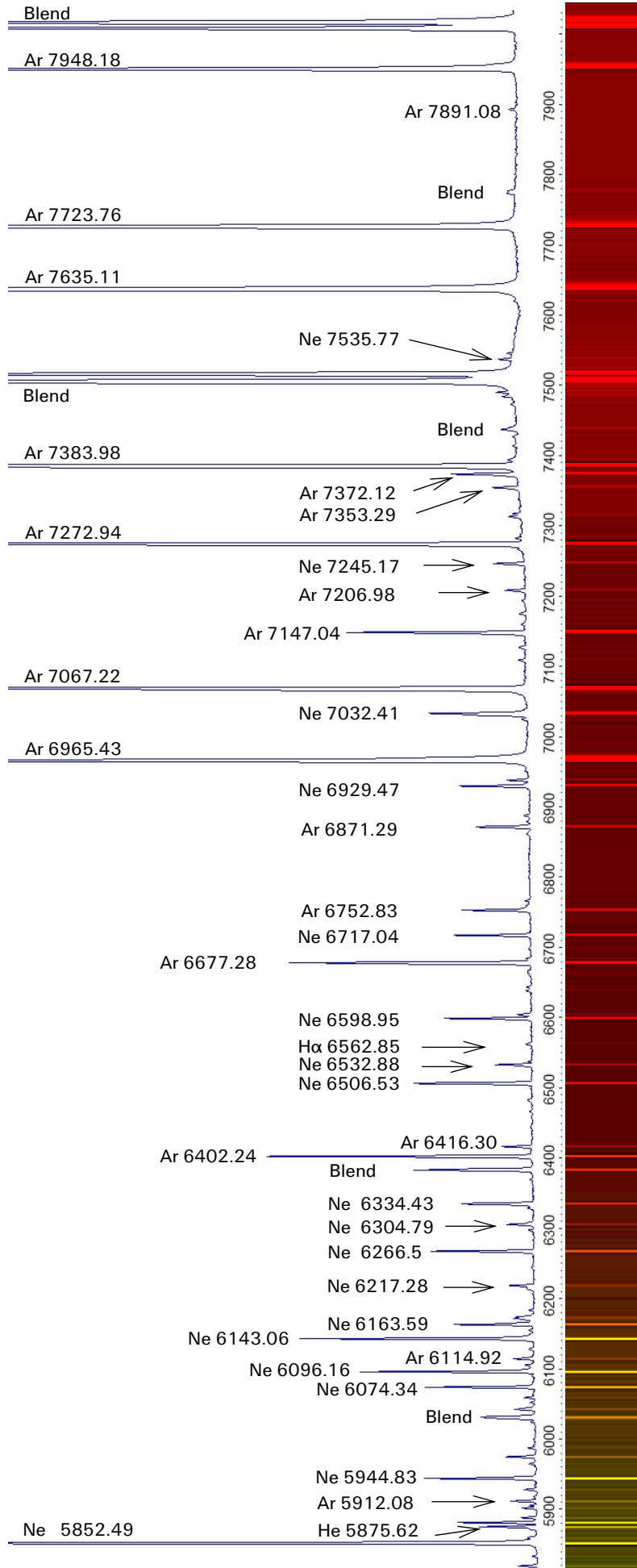


RELCO SC480 Emission Lines DADOS Spectrograph 900L mm⁻¹ R ≈ 4000

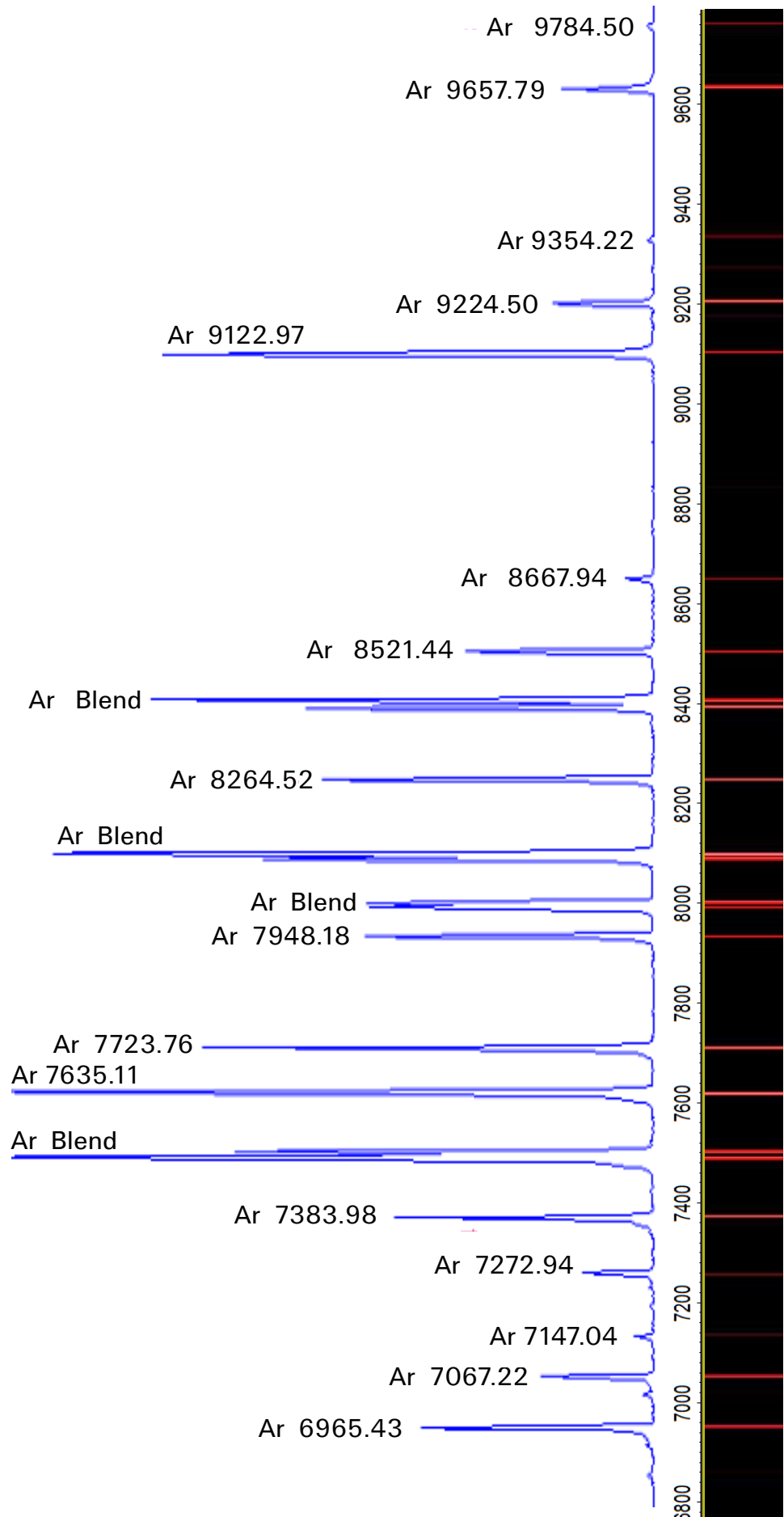


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RELCO SC480 Emission Lines DADOS Spectrograph 900L mm⁻¹ R ≈ 4000



RELCO SC480: Emission Lines in the Infrared Domain
 Recorded by Joan Guarro Flo, $R \approx 1300$



9 Literature and Internet Links

[1] Richard Walker: *Spectral Atlas for Amateur Astronomers, A Guide to the Spectra of Astronomical Objects and Terrestrial Light Sources*, Cambridge University Press 2017

<https://www.cambridge.org/core/books/spectral-atlas-for-amateur-astronomers/32126CD730EBA49238F9318C16B90523>

[2] Marc Trypsteen, Richard Walker: *Spectroscopy for Amateur Astronomers, Recording, Processing, Analysis and Interpretation*, Cambridge University Press 2017

<https://www.cambridge.org/core/books/spectroscopy-for-amateur-astronomers/8723E6F224E339B5A94966C5D0F19A20>

Presentation of the books by Marc Trypsteen:

<https://www.docdroid.net/7cGnKxA/-spectroscopiedag-2016-twin-book-project-door-marc-trypsteen.pdf.html>

The following scripts on the subject (some of them in German only) are downloadable under this link:

<http://www.ursusmajor.ch/astropektroskopie/richard-walkers-page/index.html>

[10] *Atomic Emission Spectroscopy with Spark- or Arc Excitation, Experiments with the DADOS Spectrograph and Simple Makeshift Tools*

[11] *Kalibrierung von Spektren mit dem Glimmstarter ST 111 von OSRAM*

[12] *Speisung von Glimmlampen mit niedriger Gleichspannung*

Internet Links

Spectrographs:

[20] SQUES Echelle Spectrograph, Eagleowloptics Switzerland,
<http://www.eagleowloptics.com/>

[21] DADOS Spectrograph, Baader Planetarium, Germany:
http://www.baader-planetarium.com/pdf_download.htm

[22] Shelyak Instruments: <http://www.shelyak.com/>

[23] SBIG Spectrograph DSS-7, <http://ftp.sbig.com/dss7/dss7.htm>

Spectrographic software:

[24] IRIS / ISIS: Webpage of *Christian Buil*
<http://www.astrosurf.com/buil/>

[25] Vspec: Webpage of *Valerie Désnoux*
<http://astrosurf.com/vdesnoux/>

[26] RSpec: Webpage of *Tom Field*
<http://www.rspec-astro.com/>

[27] MIDAS, ESO
<http://www.eso.org/sci/software/esomidass/>

Database:

[28] *NIST Atomic Spectra Database*:
http://physics.nist.gov/PhysRefData/ASD/lines_form.html

[29] *Spectral Atlas Central NOAO*, Linienatlas der Kalibrierlichtquellen
<http://www.noao.edu/kpno/specatlas/>