HISTORICAL BACKGROUND ABOUT URANUS AND NEPTUNE SPECTRA

A SYNTHETIC GUIDE FOR STUDENTS & AMATEUR OBSERVERS

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in collaboration with J.J.Pueyo
(v.01)

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Introduction

This publication summarizes the observations taken on the spectra of Uranus and Neptune between 1861 and 1935, as well as the theoretical predictions of the absorption lines and bands of methane**,** that lead to the accurate interpretation of their spectra. Due to the difference in the resolution of the instruments and the limitations of the photographic material, not all of them were able to encompass the same wavelength, nor to obtain precise measurements. Nevertheless, it is easy to understand which details refer to one or the other, due to the proximity of values and the descriptions made. The first observers described the spectrum from the longest to the shortest wavelength (from red to blue). This order was later reversed, remaining as such to date.

The synthetic tables are made of articles published by their authors which are available today through online databases. This publication is an extension of the content of the book by Alexander (The Planet Uranus, 1965, Cap 11-18-23). These tables will enable observers to establish useful historical correlations and help calibrate the quality of their equipment.

I have included, alongside with historical data, my own observations (2019-2020), as well as those provided by J.J.Pueyo (2020), to whom I would like to thank his generous collaboration. Conducted with instruments that today one can consider common among amateurs devoted to spectroscopy, these tables will guide observers on how to study and learn these works. Such knowledge will be useful to begin further projects on spectra in remote planets within the framework of Pro-Am collaborations at all levels. This guide will be regularly updated with additional observations, or bibliographical investigations.

Please do not hesitate to contact us if you wish to receive further information, or collaborate with our projects. Any new insights are much appreciated.

The Tables are as follows:

- Table I: Uranus_1869-1889 (Secchi-Huggins-Taylor)
- Table II: Uranus_1885-1899 (Vögel-Keeler)
- Table III: Uranus_1909 (Slipher)
- Table IV: Methane lines predicted_1935 (Adel- Slipher)
- Table V: Methane lines laboratory_1933 (Wildt-Mecke)
- Table VI: Neptune_1904 (Slipher)

PART I

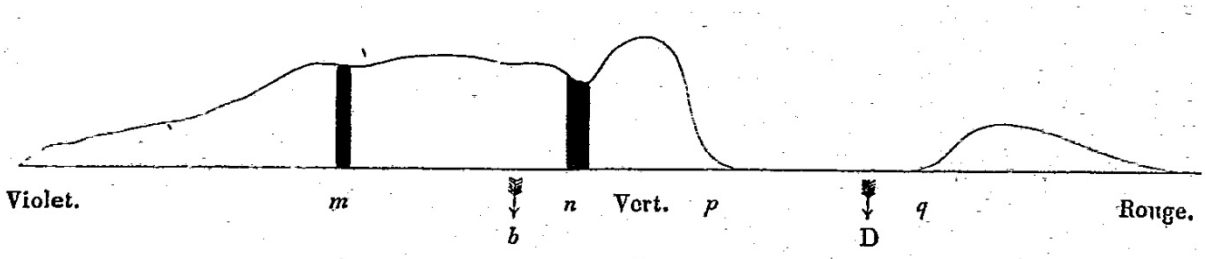
THE SPECTRA OF URANUS

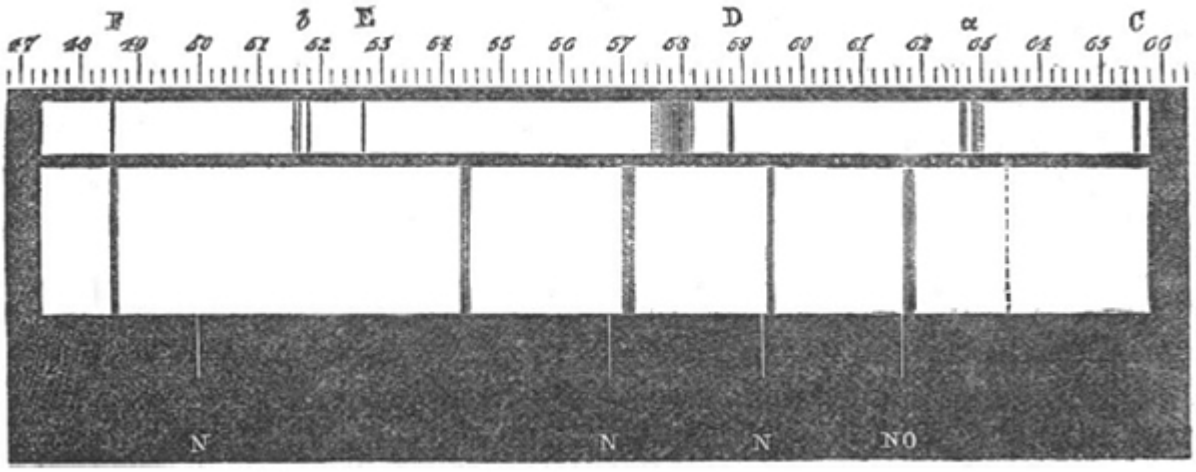
TABLE I: TAYLOR (1899) –HUGGINS (1871) –SECCHI (1869)

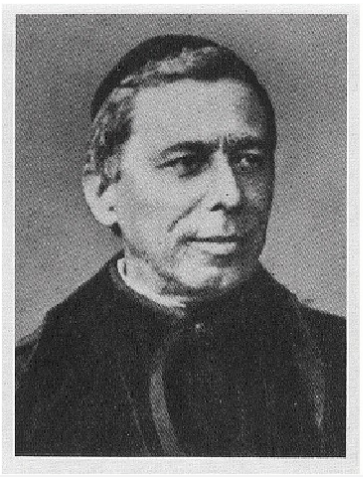
Author	λ	Description	Taylor (1899	Huggins (1871)	Secchi (1869)
Tobal	7546				
Tobal	7339				
Tobal	7282				
Tobal	7216				
Tobal	7051				
Tobal	7001				
Tobal	6817				
Tobal	6688				
Tobal	6641				
Tobal	6443				
Huggins	6350	The least line was in the faint part of spectrum and could not be measured, and its position, shown by a dotted line, was estimated.	-	6	-
Taylor	6332	Very faint dark band	I	6	-
Tobal	6196				
Taylor	6194	Dark band stronger. broader	II	5	-
Tobal	6190				
Taylor	(6170)	Bright fluting, fading towards blue	(I)		
Huggins	6180	A band	-	5	
Taylor	6010	Very faint broad band	III	4	-
Tobal	6002				
Tobal	5760				
Huggins	5950	A little longer in wavelength than Fraunhofer D line (5890)	-	4	-
Taylor	(5863)	Bright band, fainter on red edge	(II)		
Taylor	(5761)	Brightening at edge of a dark band, fades towards the red	(III)		
Tobal	5760				
Taylor	5754-5730 Max 5740	Very strong, very broad band of apparently unequal intensity	IV	3	-
Huggins	5720	Was nearly as broad but so dark	-	3	-
Taylor	(5601)	Very strong bright band, fairly sharp towards the blue and fading slightly towards the red	(IV)		
Taylor	(5473)	Strong bright band, fading both ways, but most towards the red	(V)		
Taylor	5543	Very faint and narrow	V	-	-

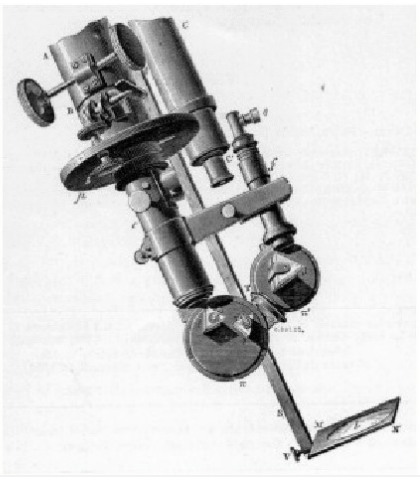
Huggins	5440	The strongest line had a wavelength of about 5440	-	2	n
Taylor	(5302)	Faint bright band, fading both ways, but most towards the red	(VI)		
Taylor	5428-5399	Broad band of uniform intensity	VI	2	n
Tobal	5434				
Secchi	(near 5270)	Very near the solar line E	-	-	n
Tobal	5258				
Taylor	5210-5200	Rather narrow band	VII	-	-
Taylor	(5190)	Brightest, strongest fluting, sharp on its red edge	(VII)		
Tobal	5104				
Taylor	(5068)	Faint fluting, sharp on its red edge	(VIII)		
Secchi	(near 4861)	Less distinct than the band n, near solar line F but not coincide with this	-	-	m
Taylor	4868-4860	Strong rather broad band of uniform intensity	VIII	1	m
Tobal	4862				
Huggins	4861	Very near Fraunhofer F line in the blue. Appeared coincident with the hydrogen bright line.	-	1	m
Taylor	(4826)	Strong fluting, sharp towards red	(IX)		
Taylor	(4741)	Faint fluting, sharpest on red edge	(XI)		
Tobal	4684				
Tobal	4615				
Taylor	4614-4594	Fairly strong broad band, not so dark as either VIII, VI or IV	IX	-	-
Taylor	(4510)	Faint broad band fading both ways, but sharpest to the red	(XI)		
Tobal	4410				
Tobal	4350				
Taylor	from 4350	Another faint band very difficult to measure	X	-	-
Taylor	(4345)	Faint fluting, sharpest to red	(XII)		
Huggins (1895)	4308-6563	...the feebleness of the light allowed it to be traced only from C to G (Fraunhofer's lines)			
Huggins (1899)	4340-3565	measured 15 lines between this wavelengths on Potsdam photography			
Tobal	4290				

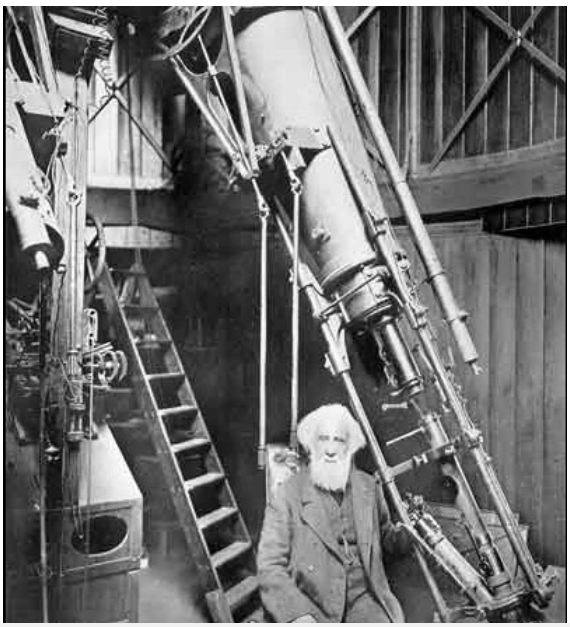
Taylor	(4100)	Faint band seen occasionally, but not measured	(XIII)		
Tobal	4158				
Tobal	4016				
Tobal	3966				







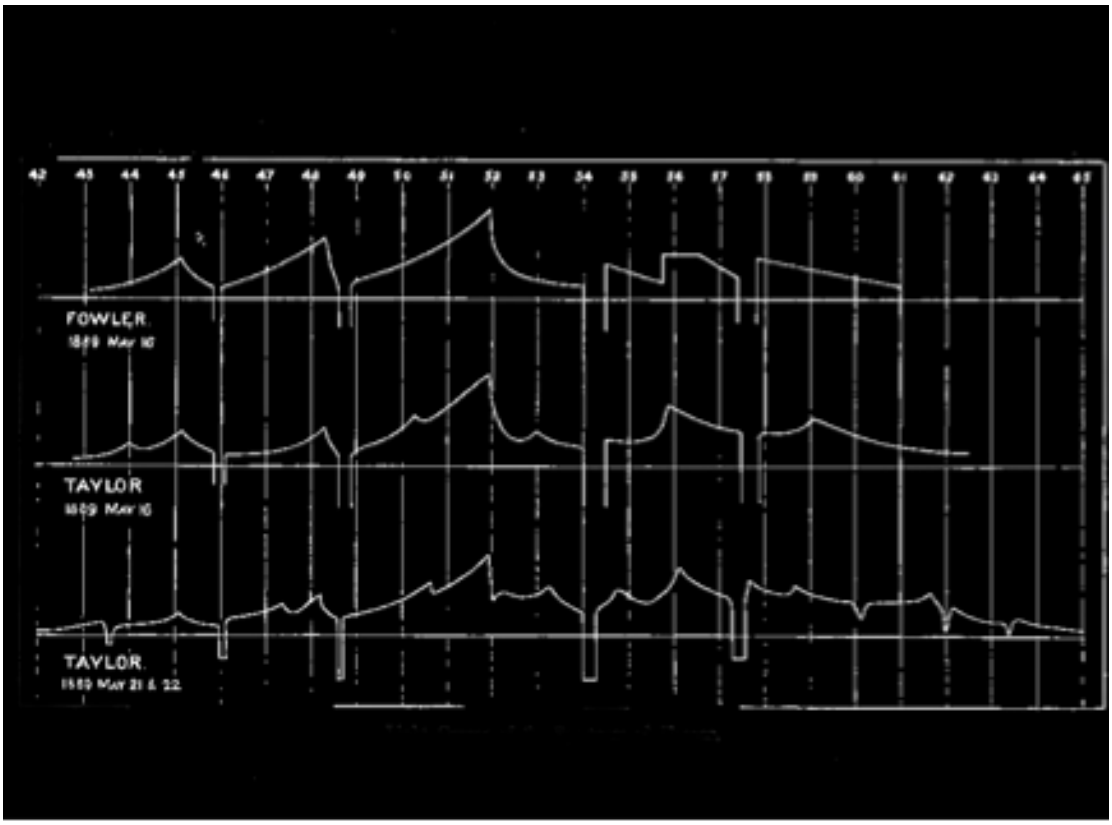




Spectra of Uranus by Angelo Secchi (1818-1878) and William Huggins (1824-1910)

James Edward Keeler (1857-1900)

Herman Carl Vogel (1841 – 1907)



A.Taylor and A. Fowler: light-curves of Uranus spectra (1889)

Norman Lockyer (1836-1929)

Percival Lowell (1855-1916)

Alfred Fowler (1868 – 1940)

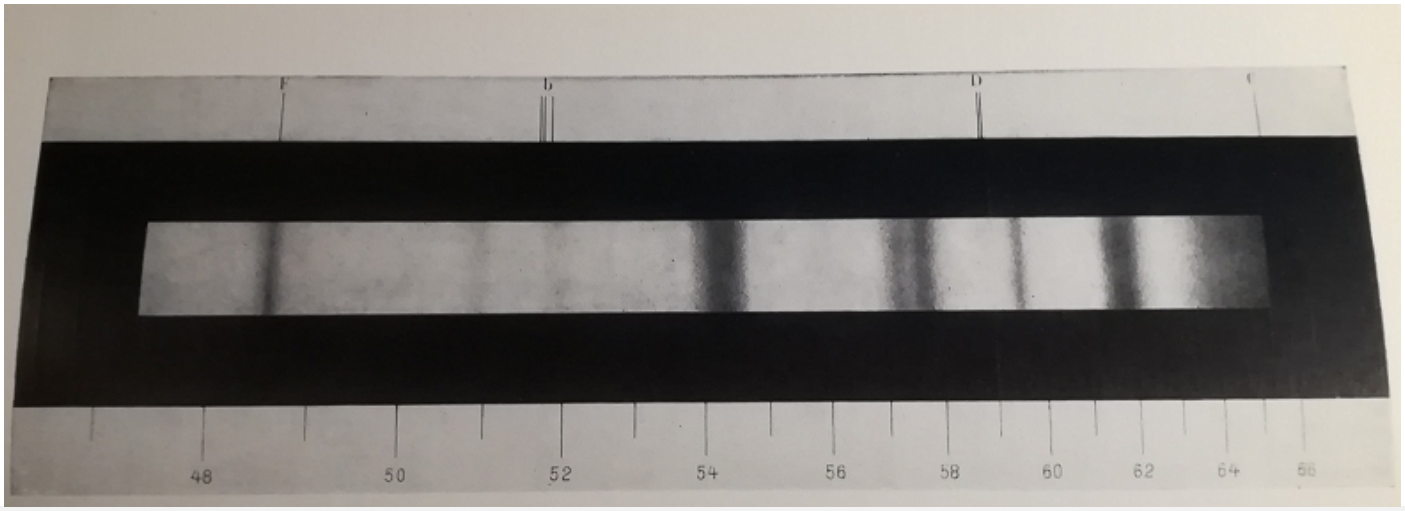
Albert Taylor (1865-1930)

TABLE II: VOGEL (1895) & KEELER (1899) DESCRIPTIONS

Author	λ	Description
Tobal	7546	
Tobal	7339	
Tobal	7282	
Tobal	7216	
Tobal	7051	
Tobal	7001	
Tobal	6817	
Tobal	6688	
Tobal	6641	
Tobal	6443	
Keeler	6540:	About the lower limit of the spectrum
Keeler	6380	Near this point the brightness appears to increase somewhat more rapidly than would be expected, as if it were the upper edge of a broad absorption band covering the lower end of the spectrum
Tobal	6196	
Vogel	6180	Darkest place of an absorption band, breadth 5 to 6 nm (rather less conspicuous than band at 543 nm)
Keeler	6182	Middle of a great absorption band...to me the strongest in the spectrum. The edges are fairly well defined. With the narrowest slit that could be used the breadth of this band was but little altered, showing that it is really a broad band, like the corresponding bands...of Jupiter and Saturn
Keeler	6085	Brightest place in the red
Tobal	6002	
Vogel	5961	Rather weak, narrow band
Keeler	5961	Dark absorption band, which narrow s with the slit, and is therefore a comparatively sharp line
Vogel	5880	Weak line
Keeler	5868	Brightest part in the yellow
Tobal	5760	
Vogel	5738	Darkest place of an absorption band which is diffuse on both sides, though more definitely bounded towards the red; breadth 10nm
Keeler	5768	Darkest part of a broad absorption band with ill-defined borders. The middle band is at about 575nm, and at this place there is a slight increase in brightness. The band has the appearance of being made up of

		several smaller one. It is better defined on the lower...side
Keeler	5640-5520	Bright place in the green. A faint shade between them
Tobal	5434	
Keeler	5425	Middle of a great absorption band, almost as dark as that at 618, but somewhat broader, and with edges not so well defined
Vogel	5425	Middle of broad absorption band, width about 5nm; somewhat diffuse towards violet. The most conspicuous absorption band in the spectrum
Tobal	5258	
Keeler	5180:	Very faint band, position estimated
Tobal	5104	
Keeler	5090:	Very faint band, position estimated
Vogel	5080	Weak band
Tobal	4862	
Vogel	4861	Broad diffuse band
Keeler	4850	Decided band, but dim with large spectroscope. Probably in the place of F (4861) but too strong for the solar line, and without doubt due to absorption in the atmosphere of Uranus
Vogel	4861-4380	...of greatest intensity between F and G (λ λ 4861-4308), the violet and ultraviolet parts being much weakened by absorption trough low altitude of Uranus, trough the spectrum was traceable to H (λ 3968). In this regions was measured 19 solar lines
Vogel	4860:	-
Tobal	4684	
Tobal	4615	
Vogel	4460:	Rather broad band
Vogel	4440:	Rather broad band
Tobal	4410	
Vogel	4383	Narrow band
Tobal	4350	
Vogel	4341	Narrow band
Vogel	4340	-
Vogel	4325	Broad line
Vogel	4320	Conspicuous dark space on the negative
Vogel	4310	Broad diffuse band
Vogel	4305	Broad band, diffuse toward violet
Vogel	4300	Narrow band
Vogel	4291	Narrow band

Tobal	4290	
Vogel	4288	Narrow band
Vogel	4275	Broad and strong
Vogel	4260	Easily visible
Vogel	4200	Easily visible
Vogel	4101	Distinct line
Tobal	4158	
Vogel	4157	Very weak and faint
Vogel	4145	Very weak
Vogel	4135	Very weak
Vogel	4101	Distinct line
Tobal	4016	
Tobal	3966	
Vogel	3972	Broad bright band (on negative)
Vogel	3970:	-
Vogel	3935	Broad bright band (on negative)
Vogel	3880	Weak band
Vogel	3833	Broad band
Vogel	3750	Lines just visible
Vogel	3737	Lines just visible
Vogel	3725	Lines just visible
Vogel	3795	Band
Vogel	3630:	Band
Vogel	3580	Broad band scarcely visible
Vogel	3565	Band scarcely visible

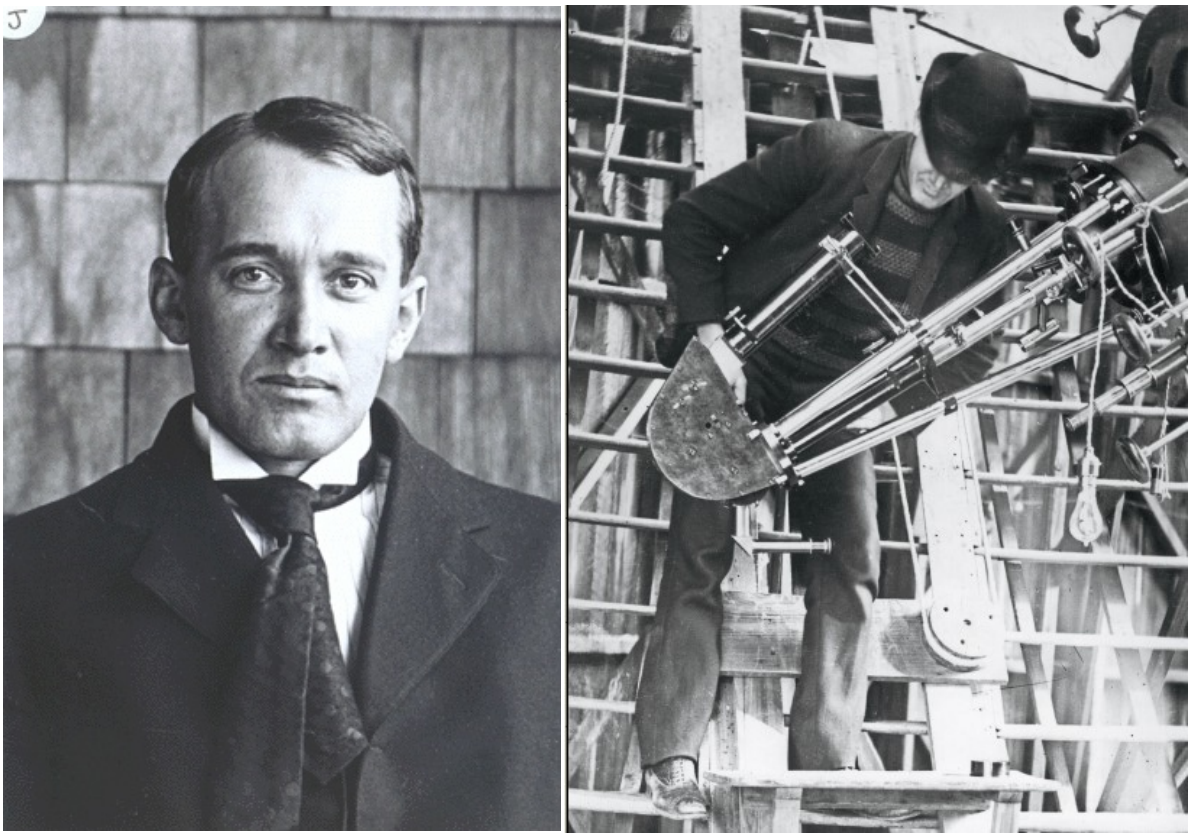


Spectra of Uranus by J.E. Keeler (1899)

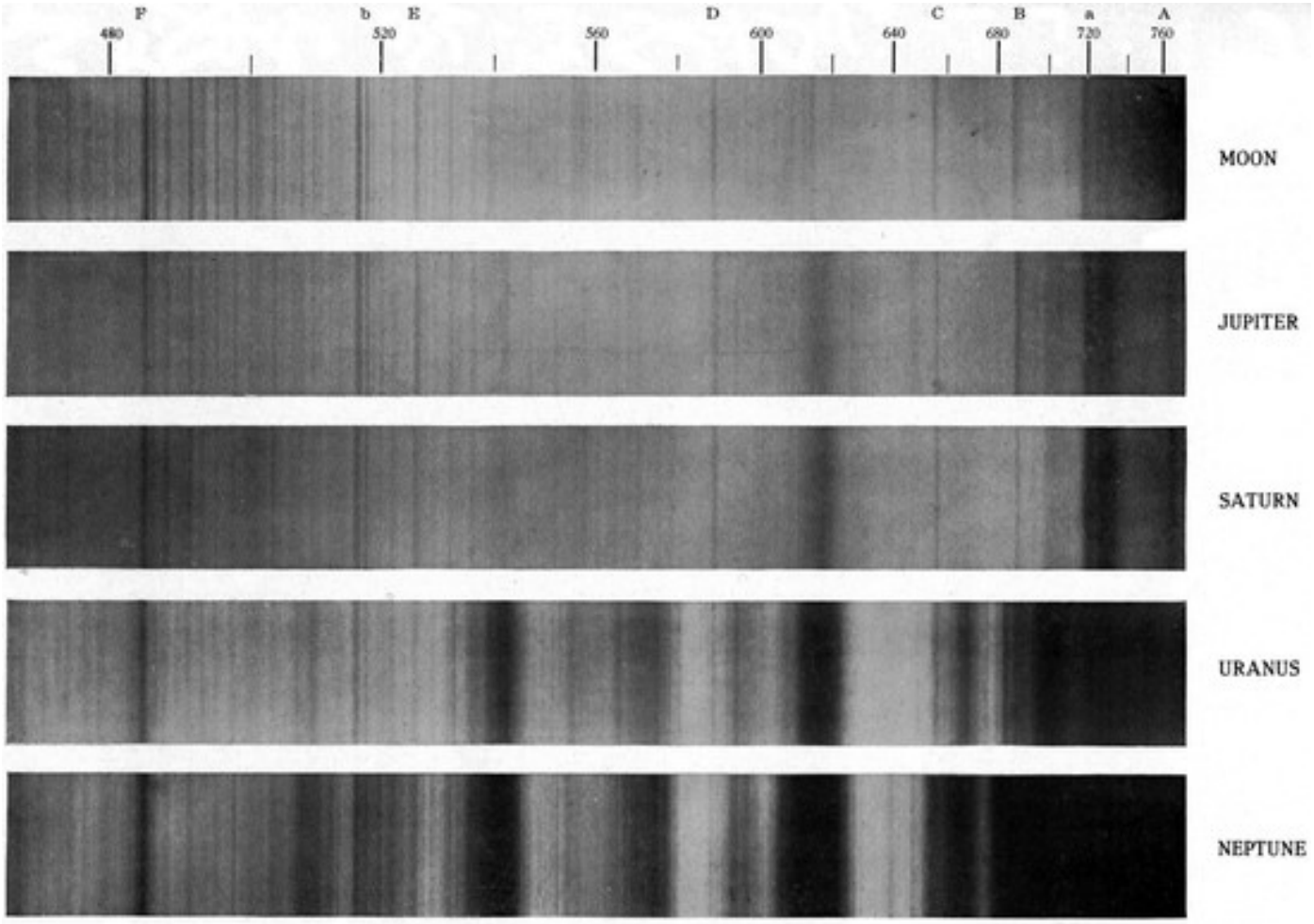
Arthur Adel
(1908 – 1994)

Rupert Wildt
(1905-1976)

Reinhard Mecke
(1895–1969)



Vesto Melvin Slipher (1875 – 1969)



THE SPECTRA OF THE MAJOR PLANETS.

Spectroscopic observations by V.M.Slipher

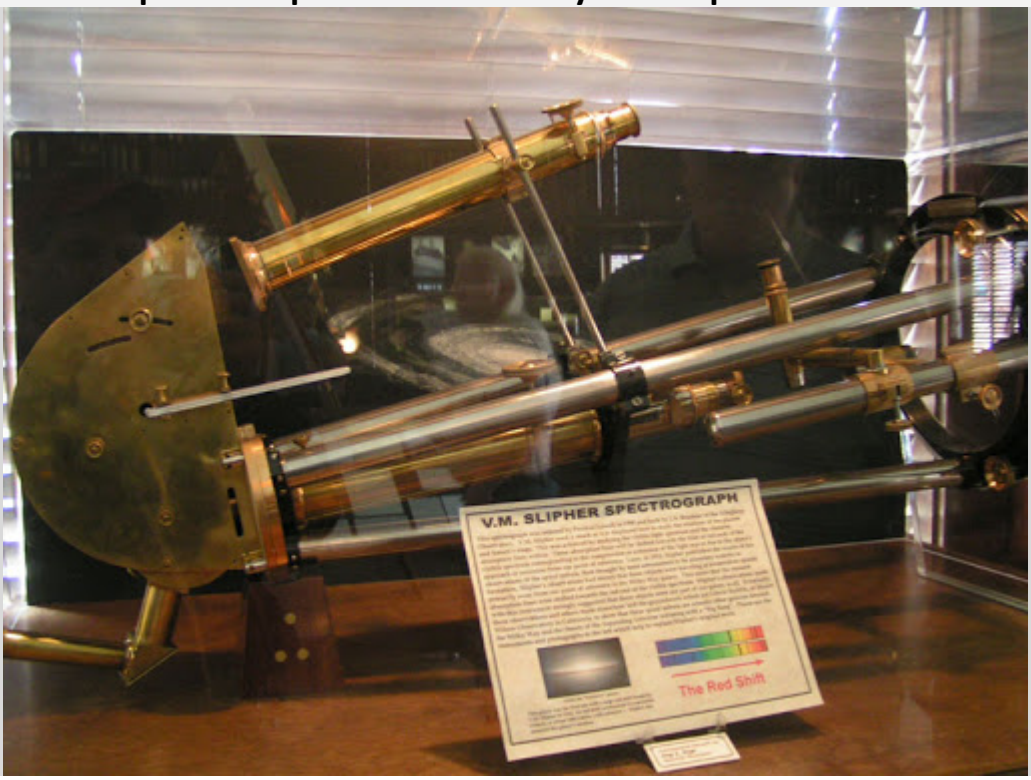


TABLE III URANUS: SLIPHER (1904) DESCRIPTIONS

Author	λ	Description	Lowell Intensity
Pueyo	3737		
Pueyo	3829		
Pueyo	3829		
Pueyo	3869		
Pueyo	3930		
Pueyo	3964		
Tobal	3966		
Tobal	4016		
Pueyo	4094		
Tobal	4158		
Tobal	4290		
Pueyo	4304		
Tobal	4350		
Pueyo	4402		
Tobal	4410		
Pueyo	4590		
Tobal	4615		
Slipher	4647	Solar line	
Tobal	4684	Slight drop in intensity from the continuous	
Slipher	4704	The middle one three solar lines. Between this F are a number of lines and bands, which appear to be due to solar absorption	
Pueyo	4861		
Slipher	4861	F line stronger and broader than in Sun: no certain deviation from solar spectrum in wavelengths shorter than this. Band, due to solar absorption. F, stronger and slightly broader than same line in the lunar comparison spectrum	
Lowell	4861		U6, H
Tobal	4862	Medium intensity. Various lines suspected	
Slipher	4872	Solar line	
Slipher	4878	Solar line	
Slipher	4891	Band, due to solar absorption	
Slipher	4911	Solar line	

Slipher	4921	Solar line	
Slipher	4937	Middle of ban, apparently due to solar lines partially blended	
Slipher	4957	Line; solar origin	
Slipher	4983	Band of solar origin	
Slipher	5004	Middle of band, apparently due to partial blending of a pair of solar lines	
Slipher	5040	Band of solar origin	
Slipher	5051	Weak band: solar origin	
Pueyo	5076		
Slipher	5091	Broad weak band	
Slipher	5092	Solar absorption. A weak band, due to planet's absorption	
Pueyo	5106		
Slipher	5101	Solar absorption. A weak band, due to planet's absorption	
Tobal	5104	Faint line. Various lines suspected	
Lowell	5110	Narrow	U12
Slipher	5111	Solar absorption. A weak band, due to planet's absorption	
Slipher	5126	Solar absorption	
Pueyo	5170		
Slipher	5170	b2 and b3, blended together	
Slipher	5184	b1	
Slipher	5230	Band, due wholly or in part to solar absorption	
Tobal	5258	Very slight drop in intensity from the continuous	
Slipher	5267	Solar ban including E	
Pueyo	5268		
Pueyo	5328		
Slipher	5300	Solar band	
Slipher	5324	Solar line	
Slipher	5328	Solar line	
Lowell	5340	Narrow. But Slipher said this band in Neptune only	U9
Slipher	5370	Solar line	
Slipher	5392	What appears lik a bright (emission) line, likely due to defect of film	
Slipher	5404	Increased absorption; there are strong solar lines at this place	

Slipher	5427	Maximum of the strongest absorption band in the spectrum	
Slipher	5430	Middle part of very strong and broad band: unsymmetrical and apparently composite; rather weak in Jupiter, Saturn	U2
Pueyo	5431		
Tobal	5434	Very strong and broad. Medium intensity in blue edge, faint in red edge	
Slipher	5567	Weak and diffuse	U11
Lowell	5430	Absent from de Moon, present in Jupiter, and darker an darker in Saturn, Uranus, Neptune	
Slipher	5710	Weak band: edge of following one	
Pueyo	5712		
Slipher	5755	A first maximum in the strongest absorption band 5769	
Tobal	5760	Broad and strong band. Medium intensity, red edge faint. Lines suspected.	
Slipher	5763	One of strongest bands in spectrum - this the densest point in a broad band. Weak in Jupiter, Saturn	U5
Pueyo	5765		
Slipher	5769	Strong absorption band (see 5755 and 5783)	
Lowell	5780	First appeared in Saturn and were wider in Uranus and Neptune; others more numerous began in Uranus and darkened in Neptune	
Slipher	5783	A second maximum in this strong band 5769. There are groups of solar lines corresponding to these maxima which may cause the band to appear double	
Slipher	5815	Reinforced	
Slipher	5835	Slight increase in absorption	
Slipher	5858	Solar line	
Slipher	5875	Reinforced	? He
Slipher	5890	D line	
Pueyo	5898		
Slipher	5910	Lower limit of spectrum	
Slipher	5950	Narrow band, edge following one	
Pueyo	5960		

Slipher	5975	Fairly conspicuous band; irregular and composite in Neptune, diffuse in Saturn	
Tobal	6002	Broad and faint. Lines suspected	
Slipher	6087	A band	
Slipher	6140	In Neptune, Saturn also	
Lowell	6180	Absent from de Moon, present in Jupiter, and darker an darker in Saturn, Uranus, Neptune	
Pueyo	6190		
Slipher	6195	Middle of very strong intense band, the most conspicuous in the spectrum, more diffuse on upper edge. Conspicuous all four planets. This band not identical with the one in red stars and different character.	
Tobal	6196	Very broad and strong band. The darker band in the spectra. Medium intensity in blue edge. Faint in red edge. Lines suspected	
Slipher	6260	Red edge of foregoing band. Keeler's visual chart did not extend to the wavelengths below	
Slipher	6405	Region seems covered by broad weak band	
Tobal	6443	Broad and faint band	
Pueyo	6404		
Slipher	6503	Absorptions too strong for solar lines alone	
Slipher	6564	C line of H. Stronger than in solar spectrum, narrow	U 10, H
Pueyo	6562		
Slipher	6600	Weak absorption	
Tobal	6641	Very broad band. Medium intensity. Blue edge definite, red edge faint. One central dark line and a second line (medium intensity) to red edge.	
Lowell	6720	First appeared in Saturn and were wider in Uranus and Neptune; others more numerous began in Uranus and darkened in Neptune	
Pueyo	6658		
Slipher	6678	Intense and composite band, the densest part of a very strong and broad band: broad and weak in Jupiter, Saturn	U 4, ?He
Tobal	6688	Faint band	
Slipher	6780	Bright place due to absence of absorption	
Slipher	6802	Weaker component of narrow double band. Doubtful if present in Jupiter, Saturn	

Tobal	6817	Faint line	
Pueyo	6824		
Slipher	6832	Stronger component. Doubtful if present in Jupiter, Saturn	U 7
Pueyo	6861		
Slipher	6870	Oxygen group B in terrestrial spectrum; not reinforced in Uranus but region absorbed	
Tobal	6886	Broad faint band	
Tobal	7001	Broad band. Medium intensity. One dark line to blue edge.	
Pueyo	7011		
Slipher	7025	Strong broad band, spectrum faint in this region; fairly definite band in Jupiter, Saturn, but doubtful in Neptune	U3 ?H_2O
Tobal	7051	Dark line, continuous to 7001.	
Slipher	7130:	Bright place in spectrum: continuous spectrum suddenly fades out below this point suggesting: (see 725:)	
Pueyo	7175		
Tobal	7216	Very dark and strongest band with various dark lines. One of the three brighter in the spectra	
Slipher	7250:	A possible strong band here. No part of the spectrum below 6780 free from absorption	
Pueyo	7271		
Tobal	7270	This a central point of a broad and very dark band. From 7200 to 7500.	
Tobal	7282		
Tobal	7339		
Tobal	7546		
Pueyo	7347		

TABLE IV: ADEL-SLIPHER METHANE ABSORTION BANDS PREDICTED (1934-1935)*

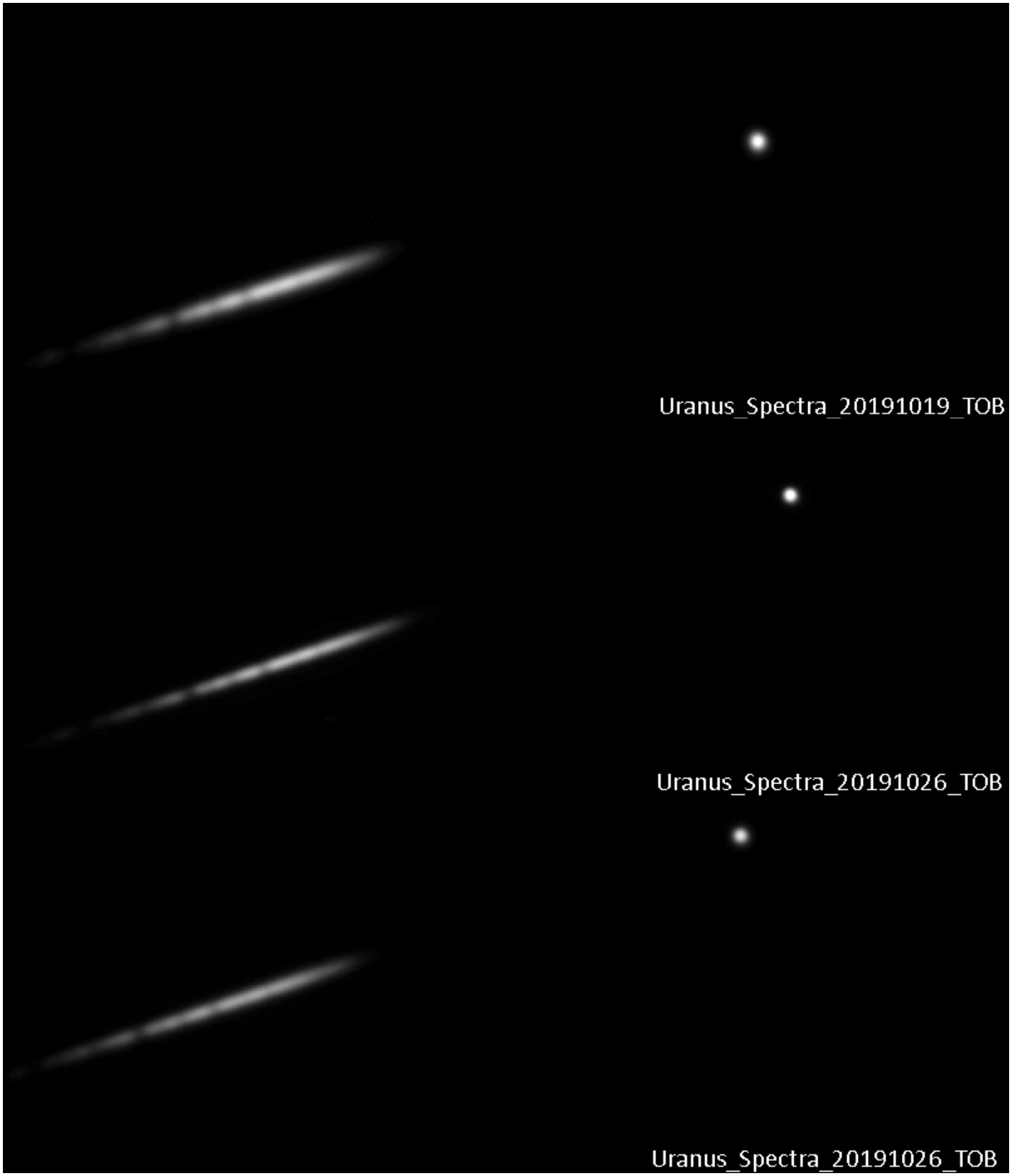
441	459	**486**	**509**	521	**534**	543	**568**	**576 blue edge**	**576**	**595**	**614**
619	**656**	**662**	**668**	**702**	720	**725**	782	788	861	874	886

*Light grey: confirmed by observations (λ in nm)

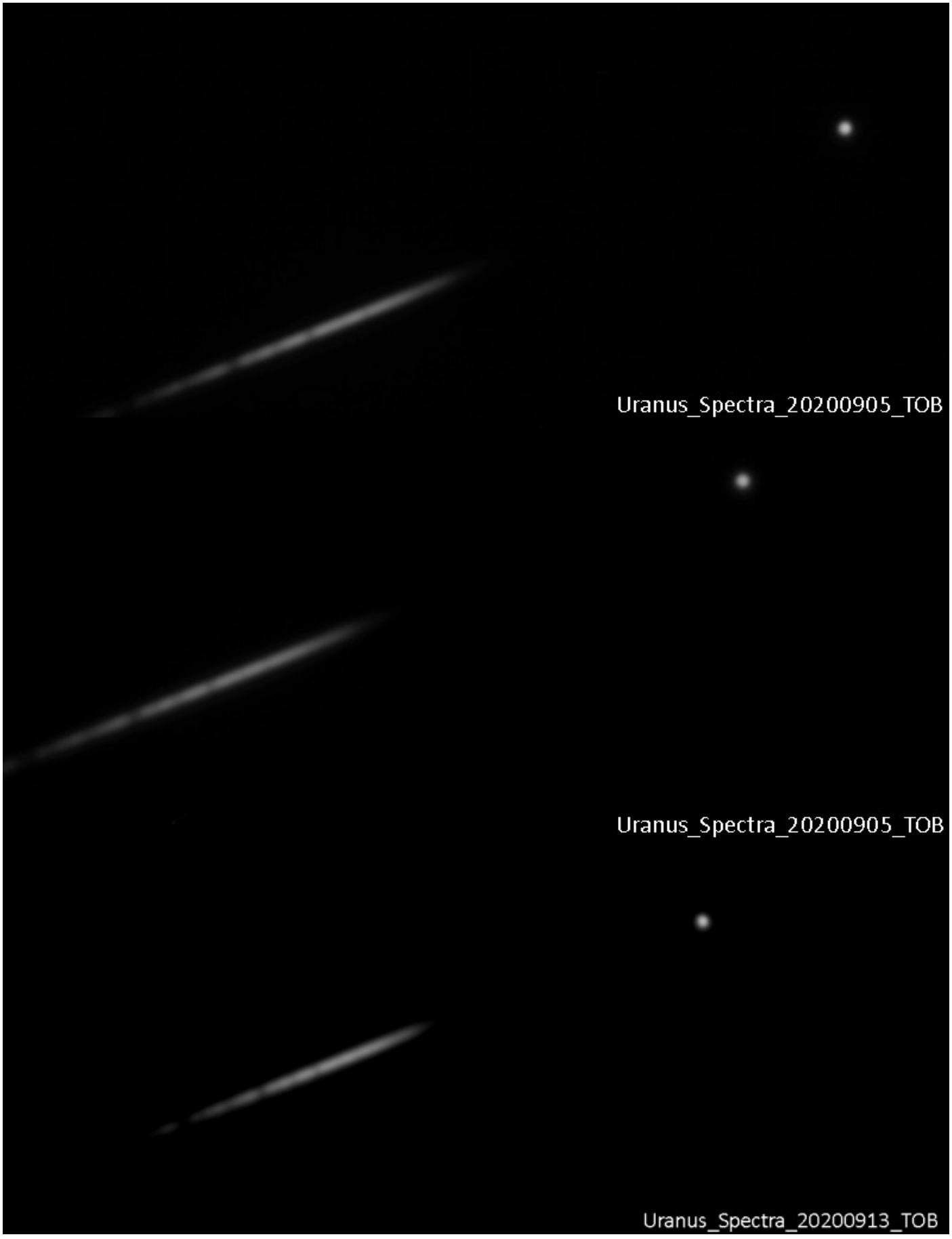
TABLE V: WILDT - MECKE (1933) METHANE BANDS CALCULATION & LABORATORY

Author	λ	Description	Nº
Mecke	8900	With absorption increasing to c.8790, where practically all light cut out	**1**
Mecke	8890	Clear-cut line	
Mecke	8870	Clear	
Mecke	8820	Clear	
Mecke	8670	Line	
Mecke	8640	Line	
Mecke	8610	Line	
Mecke	8600	Band	**2**
Mecke	8440	Line	
Mecke	8400	Line	
Mecke	8390	Line	
Mecke	8400	Band. Intensity as great as band 7250, and certainly greater than band 6200	**3**
Mecke	8000	Very dark absorption	
Mecke	7855	Very dark absorption	
Mecke	7840	Band	**4**
Mecke	7835	Very dark absorption	
Mecke	7350	Line	
Mecke	7255	Specially strong intense line	
Mecke	7255	Specially strong intense line	
Mecke	7250	Fairly broad with lines	**5**
Mecke	7235	Specially strong intense line	
Mecke	7190	Line	
Mecke	6200	The next band of major intensity but considerably less intense than band 7250	**6**

OBSERVATIONS OF URANUS by T.Tobal & J.Pueyo (2019-2020)



Uranus Spectra 20191124 TOB
Uranus Spectra 20191124 TOB
Uranus_Spectra_20200905_TOB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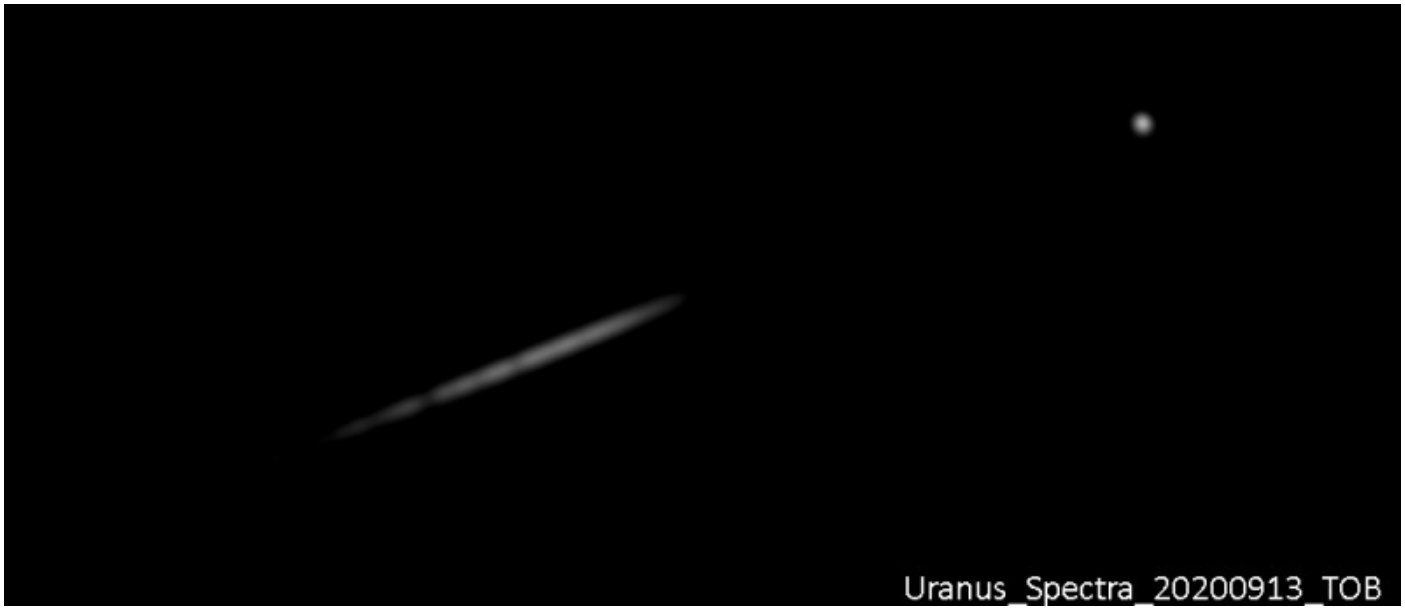
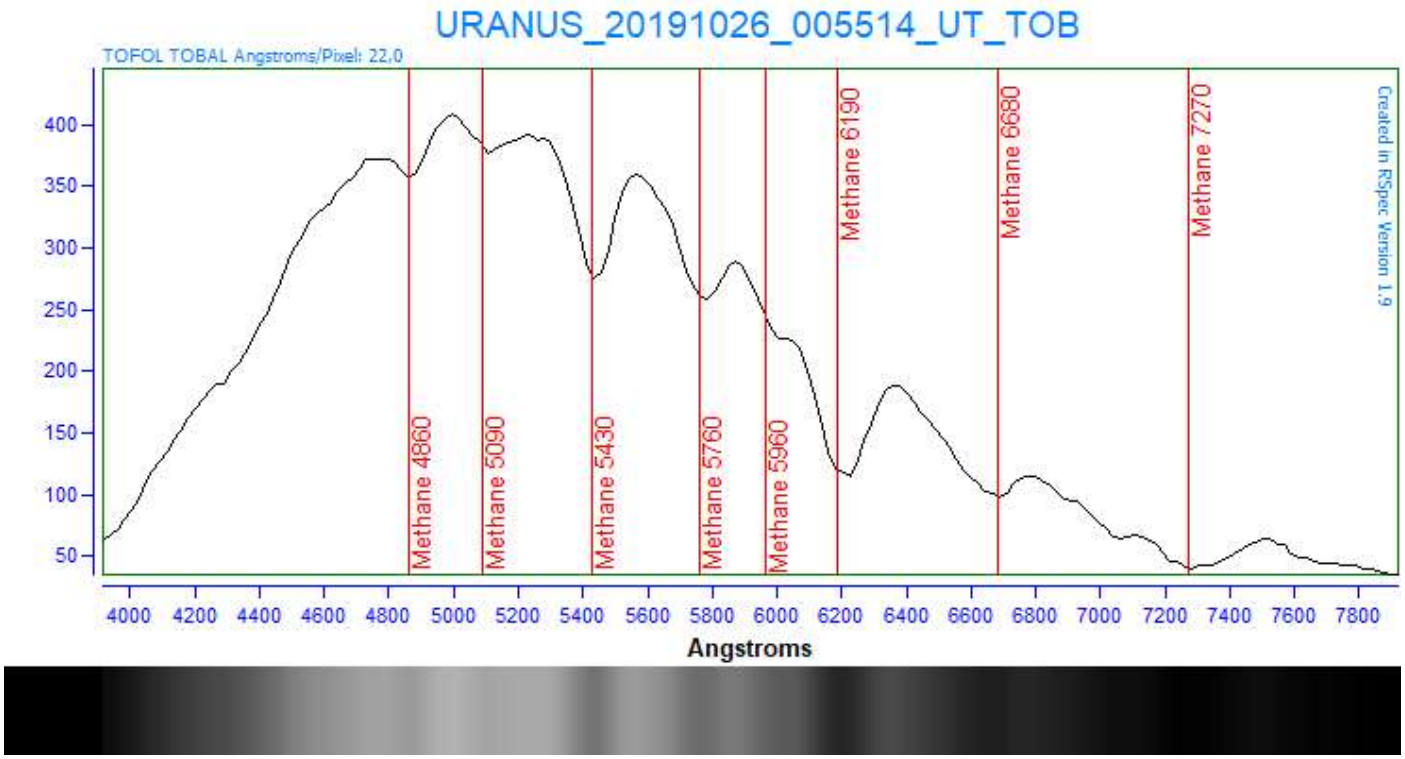
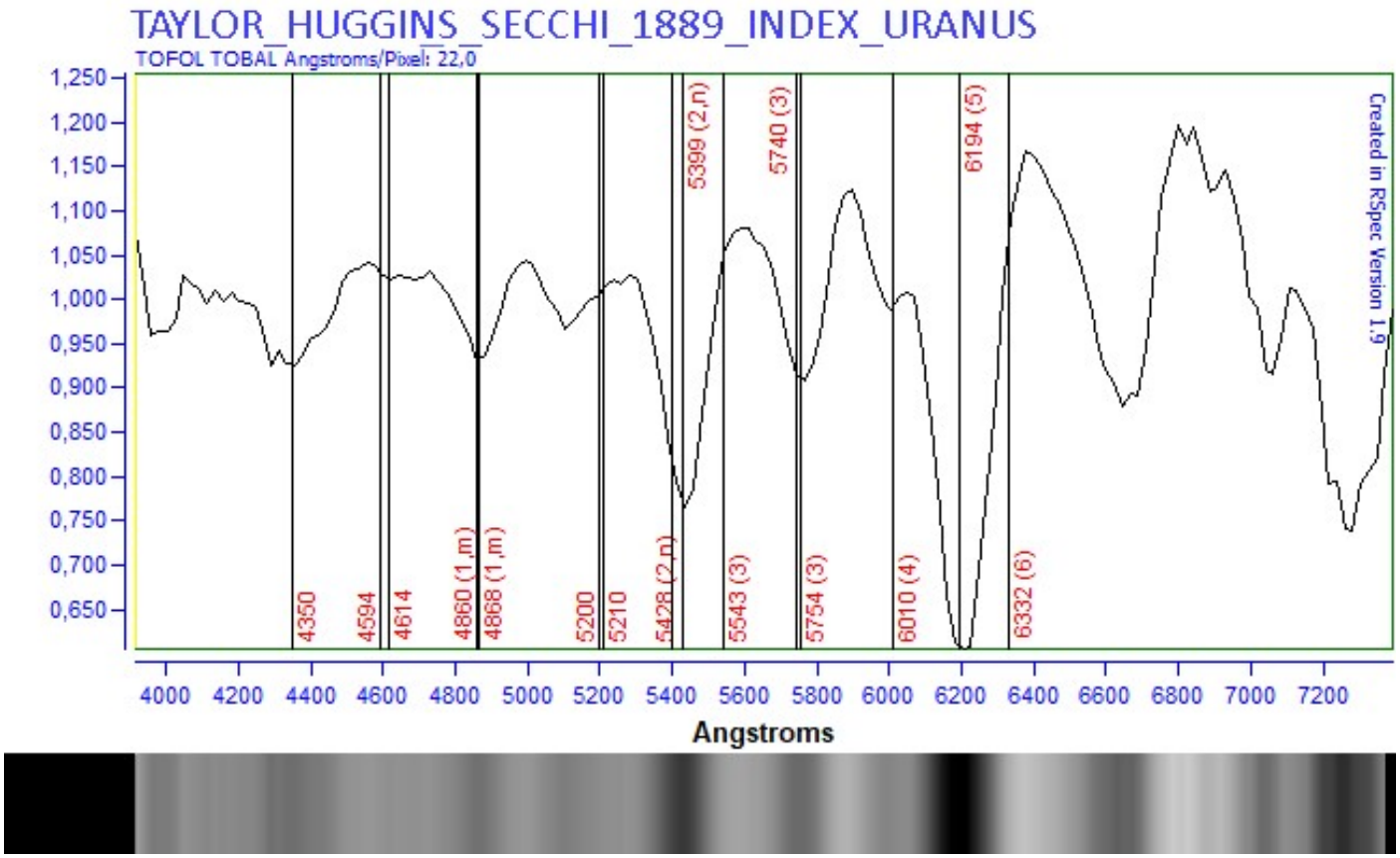


Spectroscopic observations of Uranus by T.Tobal (2019-2020)
Telescope SC-11” f/10 + SA-100+ASI-174MM.




TAYLOR_HUGGINS_SECCHI_1889_INDEX_URANUS
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1,250
1,200
1,150
1,100
1,050
1,000
0,950
0,900
0,850
0,800
0,750
0,700
0,650
4350
4594
4614
4860 (1,m)
4868 (1,m)
5200
5210
5428 (2,n)
5399 (2,n)
5543 (3)
5740 (3)
5754 (3)
6010 (4)
6194 (5)
6332 (6)
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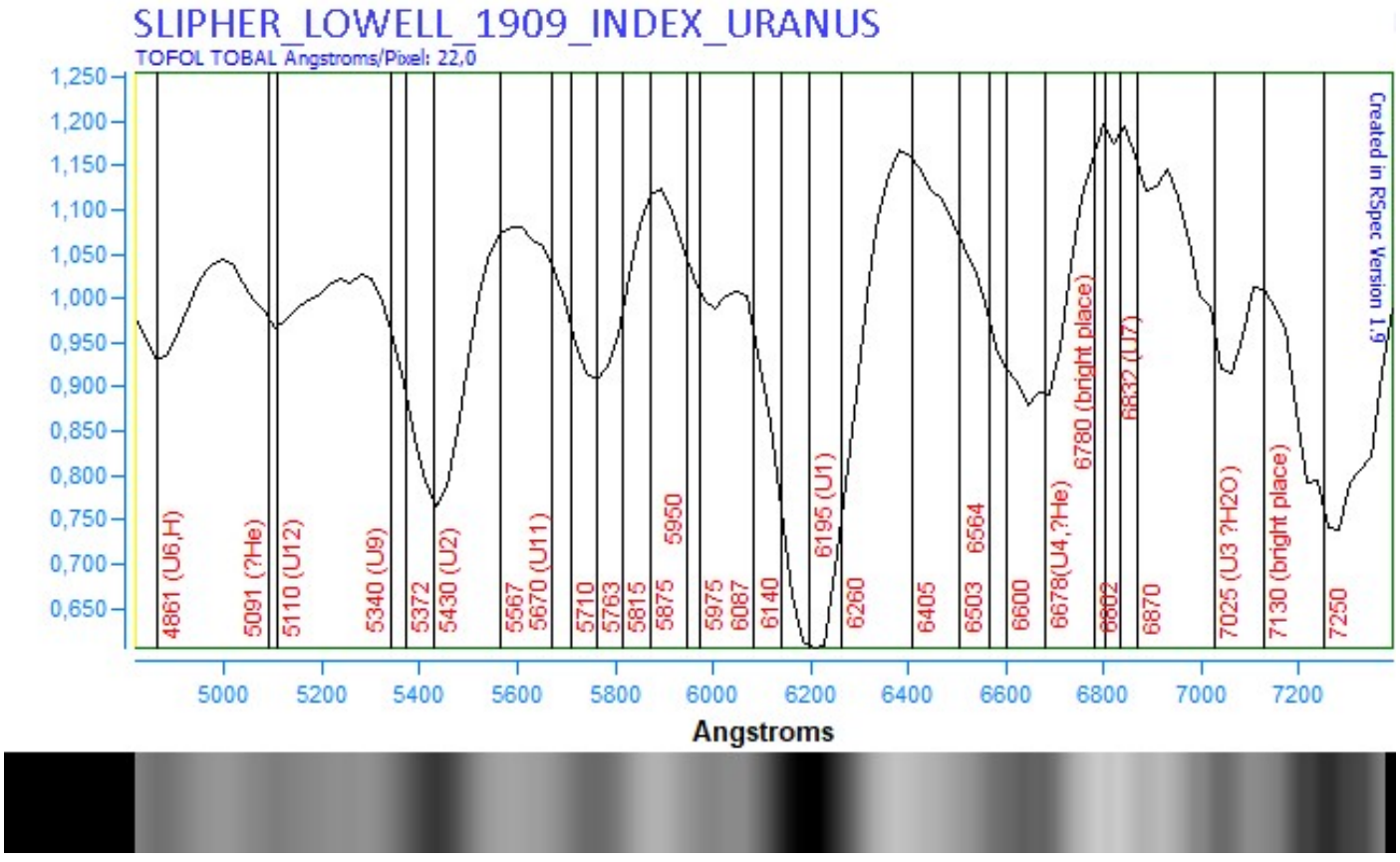
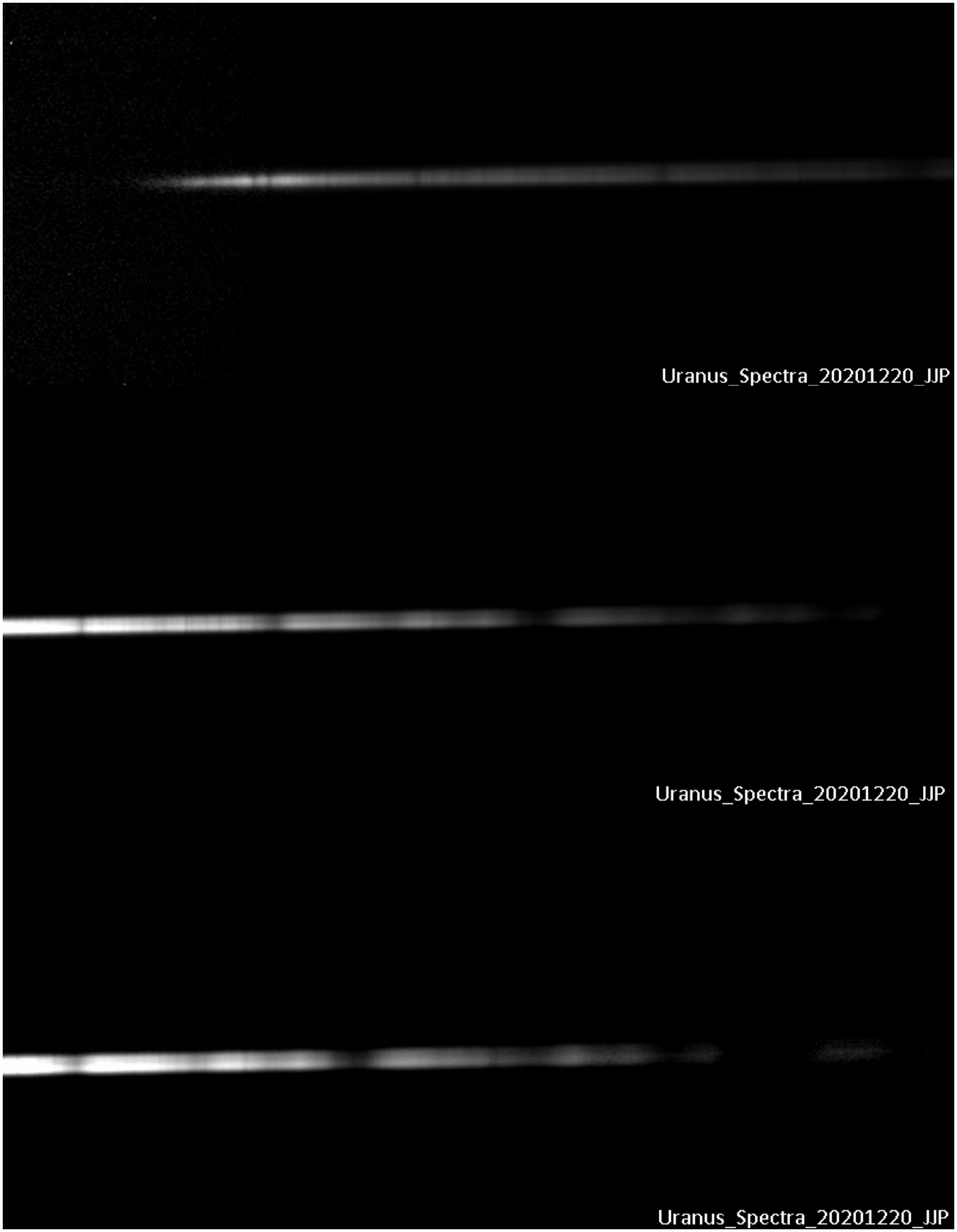
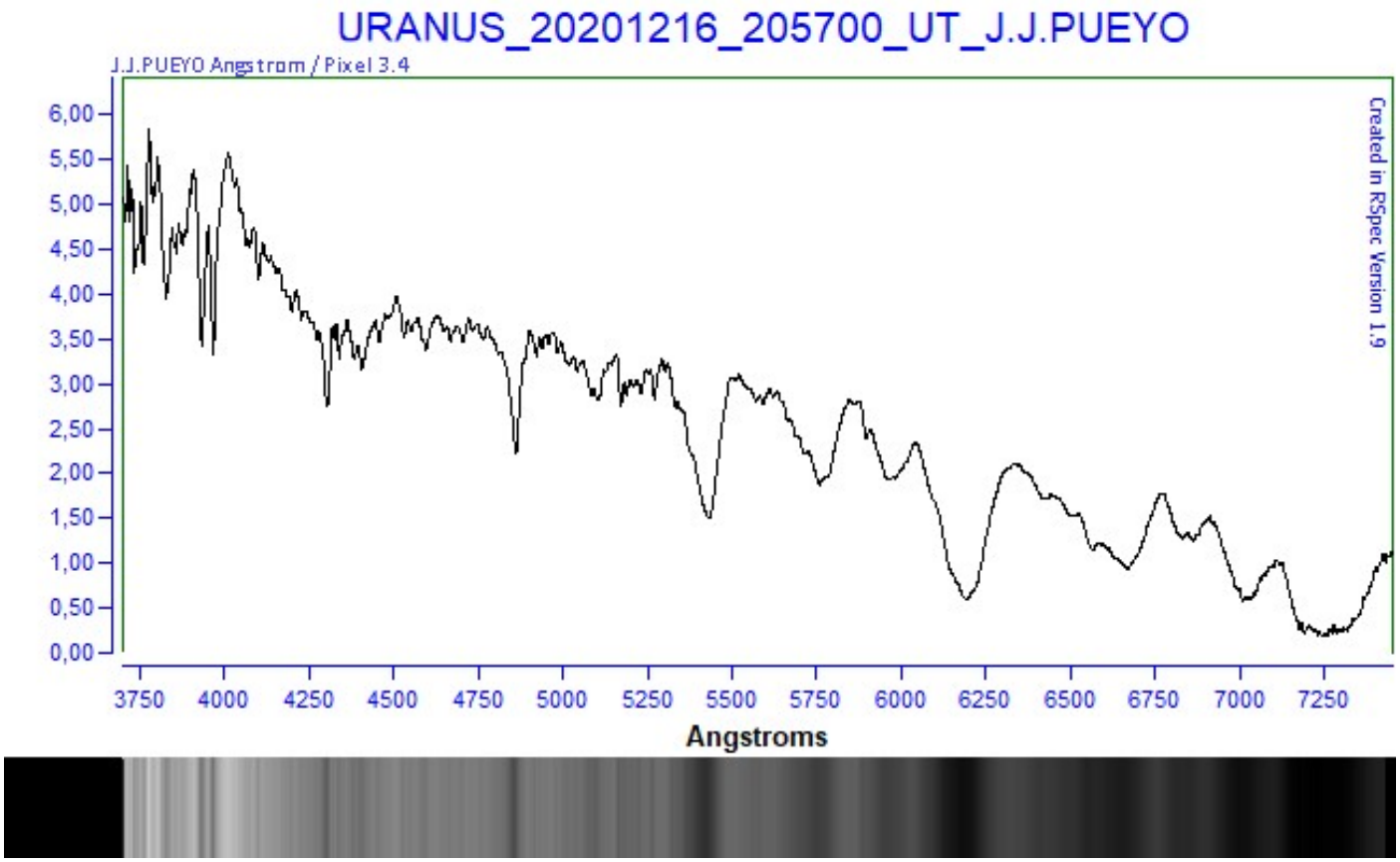
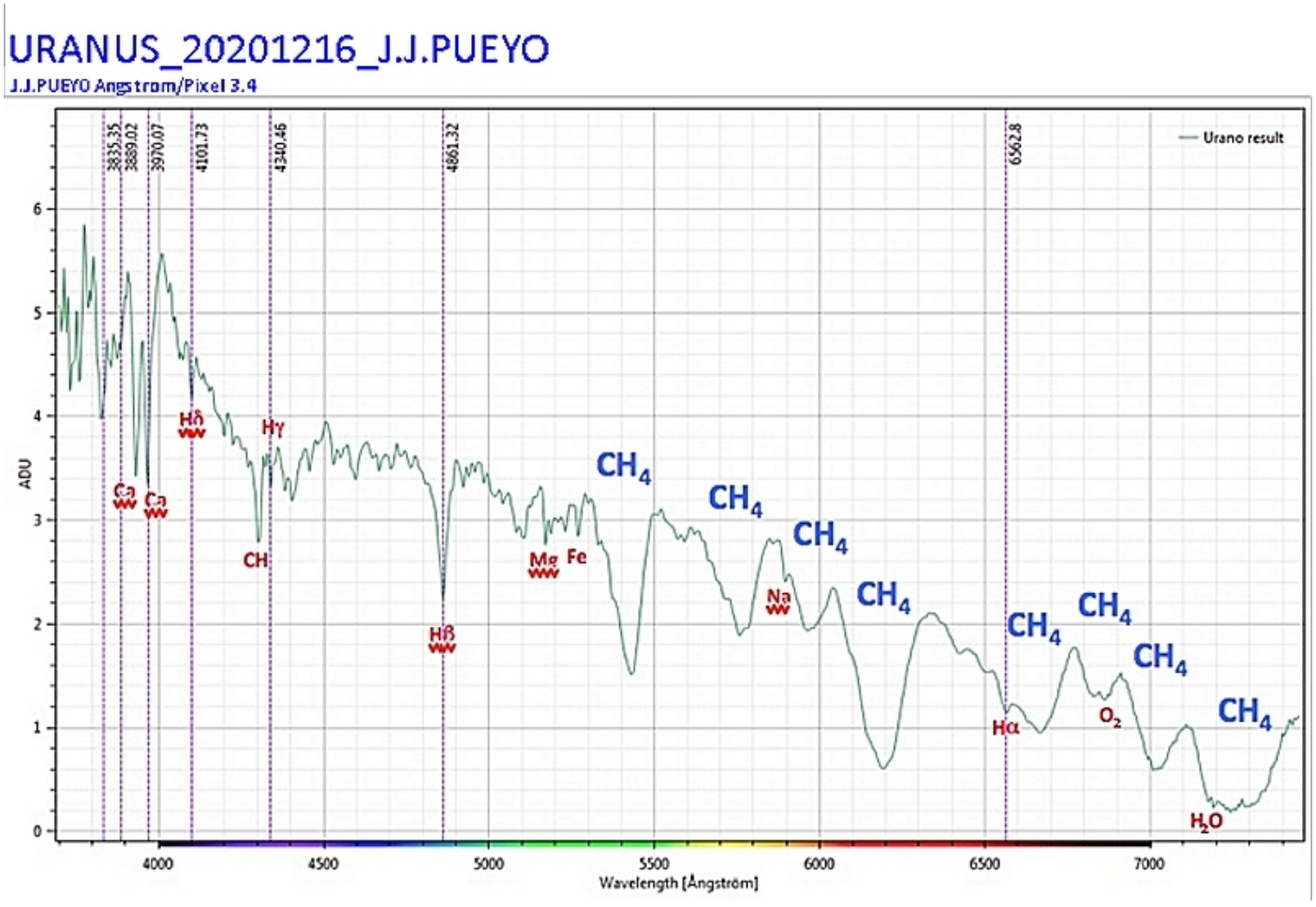
4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200
Angstroms


SLIPHER_LOWELL_1909_INDEX_URANUS
TOFOL TOBAL Angstroms/Pixel: 22,0
1,250
1,200
1,150
1,100
1,050
1,000
0,950
0,900
0,850
0,800
0,750
0,700
0,650
4861 (U6,H)
5091 (?He)
5110 (U12)
5340 (U9)
5372
5430 (U2)
5567
5670 (U11)
5710
5763
5815
5875
5950
5975
6087
6140
6195 (U1)
6260
6405
6503
6564
6600
6678(U4,?He)
6780 (bright place)
6802
6832 (U7)
6870
7025 (U3 ?H2O)
7130 (bright place)
7250
Created in RSpec Version 1,9
5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200
Angstroms

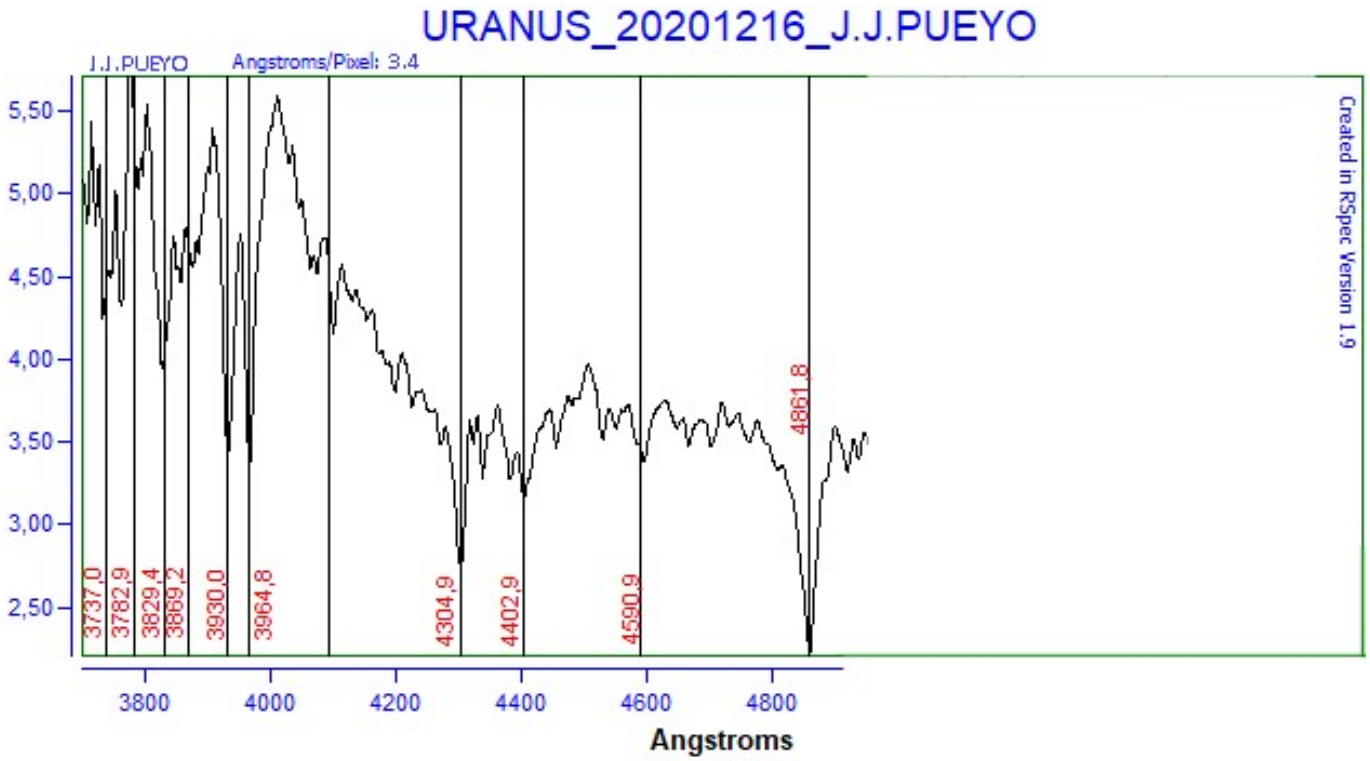


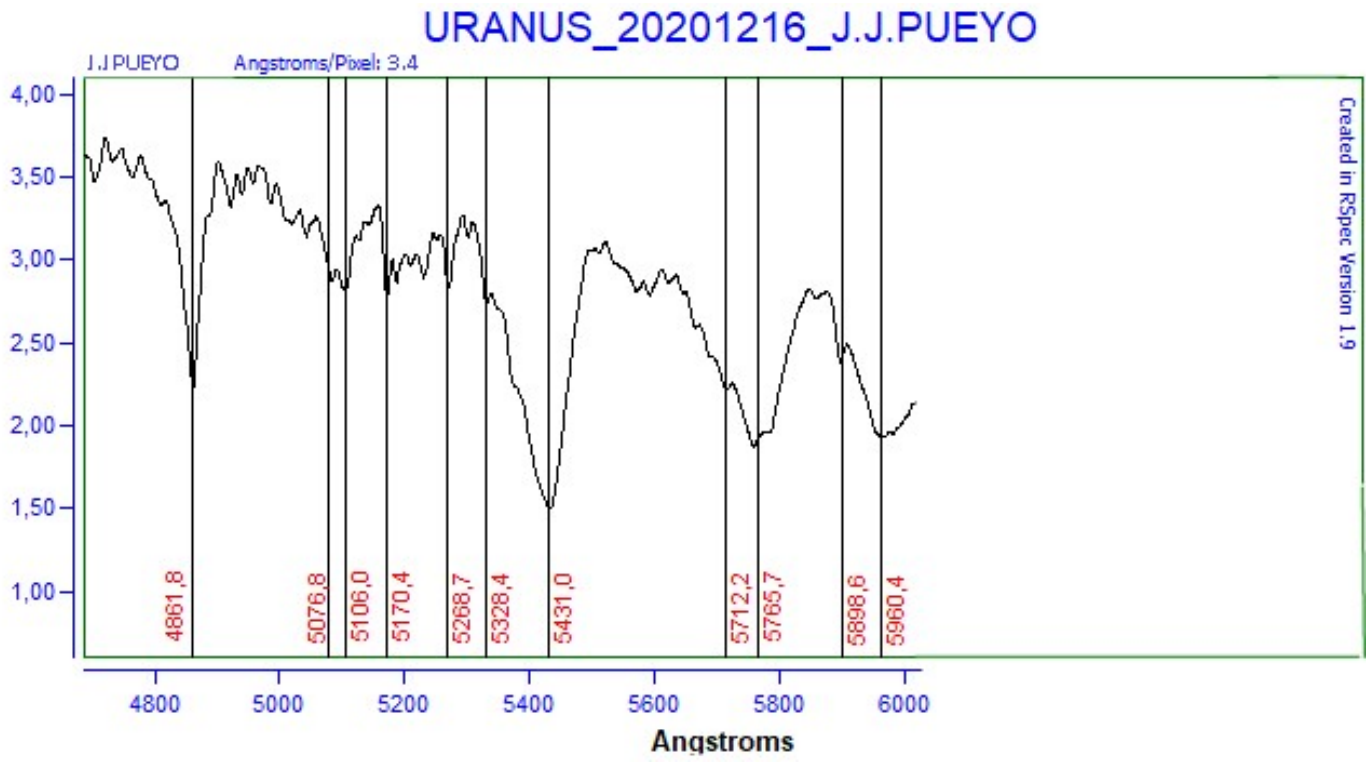
Spectroscopic observations of Uranus by J.J.Pueyo (2020)
Telescope SC-8” f/6.3 + Alpy600+ATIK -314L



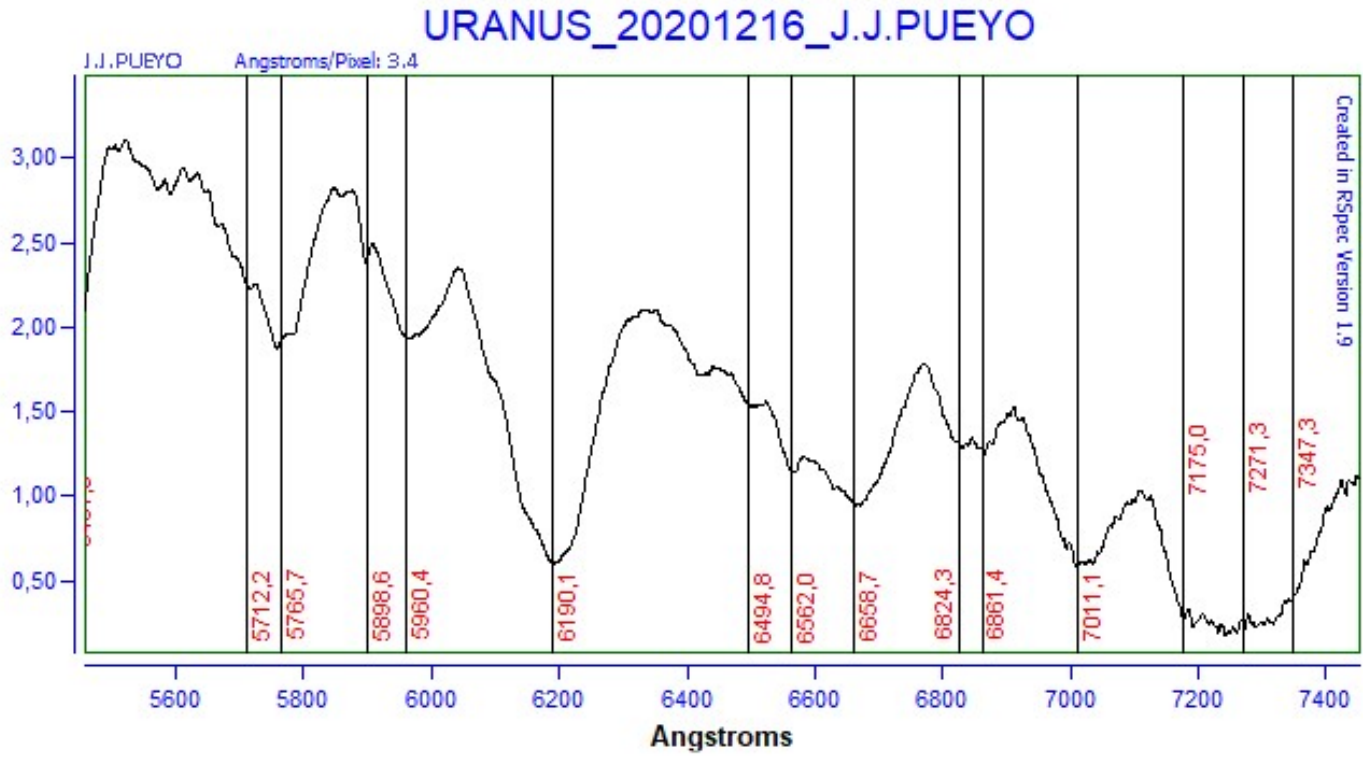


Analysis of Uranus spectra by J.J.Pueyo (2020)





Measurements of wavelengths (T.Tobal) on Uranus spectra (J.J.Pueyo)



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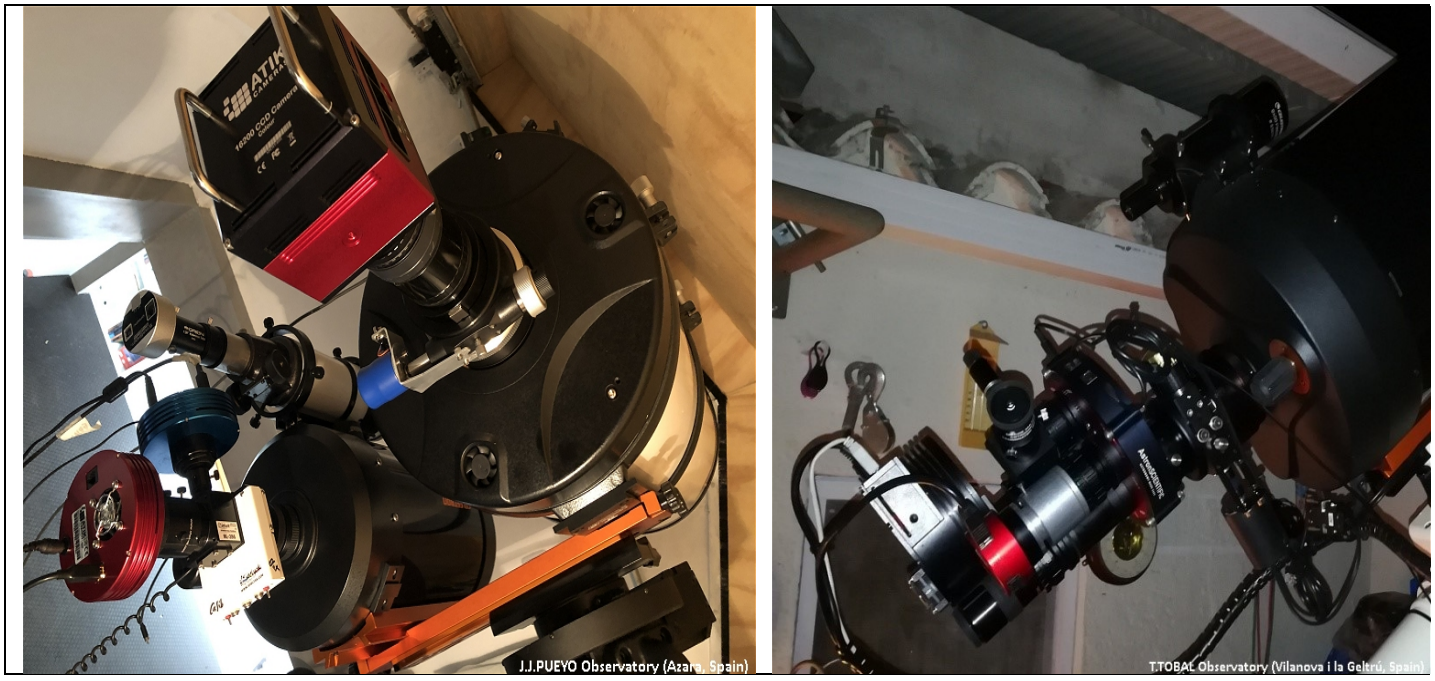


J.J.Pueyo (left) and T.Tobal (right) observatories

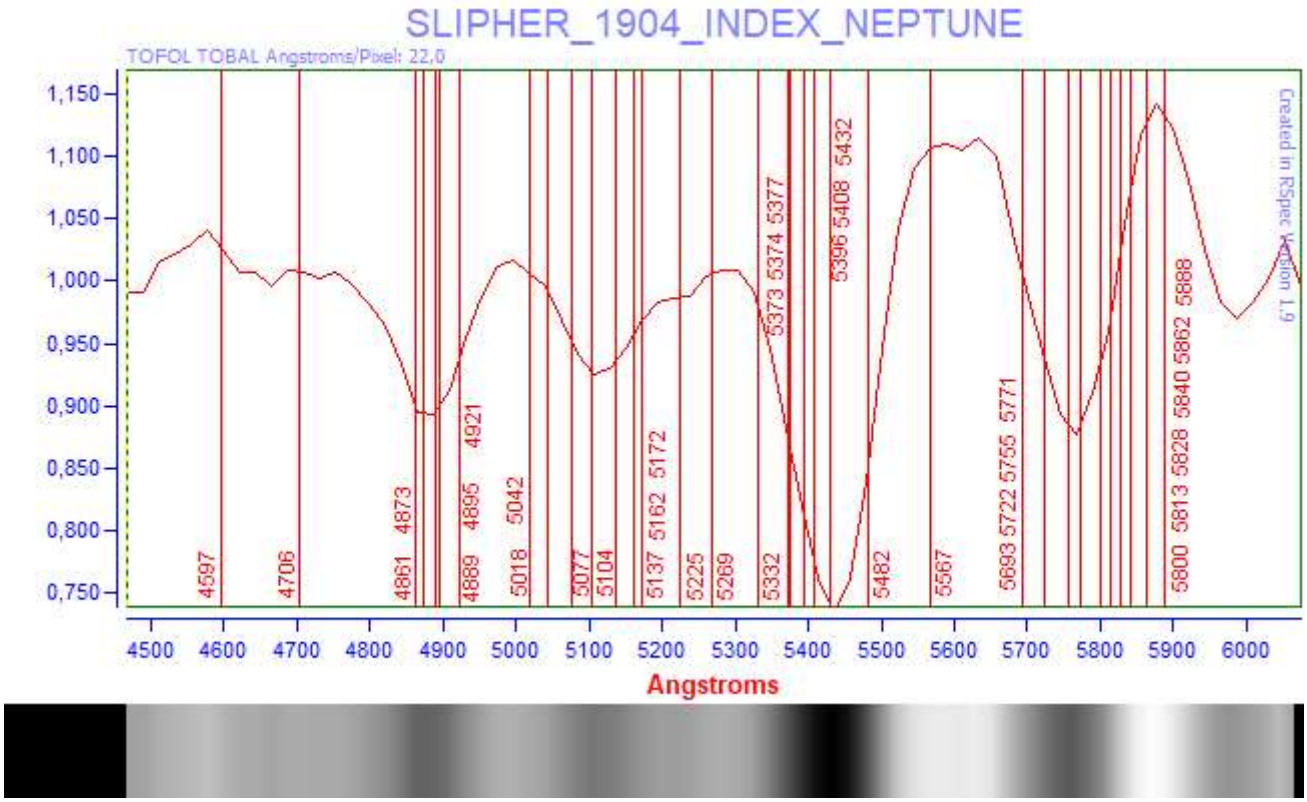
PART II
THE SPECTRA OF NEPTUNE

TABLE VI NEPTUNE: SLIPHER (1904) DESCRIPTIONS

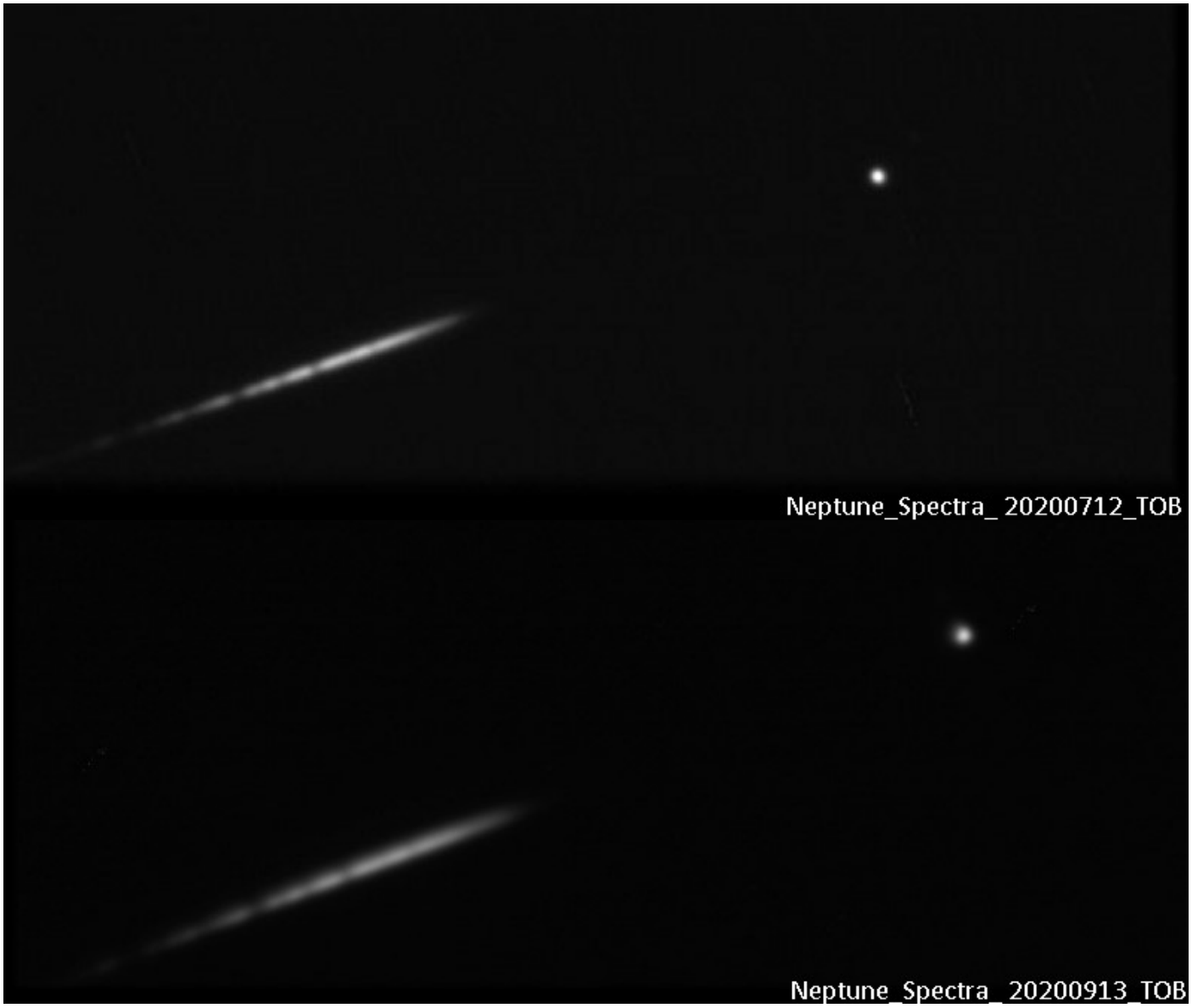
Author	λ	Description
Pueyo	3737	
Pueyo	3782	
Pueyo	3829	
Pueyo	3930	
Pueyo	3964	
Tobal	4102	Slight fall in intensity from de continuous
Pueyo	4304	
Tobal	4340	Slight fall in intensity from de continuous
Slipher	4400	Upper limit of spectrum
Pueyo	4402	
Slipher	4413	Band, possibly due to the solar lines 4405, 4408 and 4415 thought it seems too far to the red
Slipher	4458	Band, due to the group of solar lines 4455-4462
Slipher	4526	Narrow ban, probably due to the group of solar lines at his place
Pueyo	4590	
Slipher	4597	Middle of a weak band, which may or may not be due to solar lines
Slipher	4706	A weak ban, du, no doubt, to the strong solar lines 4703 and 4709
Tobal	4860	Dark and strong band. Medium intensity, blue and red edge are the same intensity.
Pueyo	4861	
Slipher	4861	A rather narrow, strong band, one of the three strongest in the spectrum. It is well defined and its position determined with considerable accuracy. Its position coincides with that of the F line of the solar spectrum.
Slipher	4873	Line
Slipher	4889	Narrow band, due to strong solar lines.
Slipher	4895	A bright place in the spectrum which decrease toward F
Slipher	4921	A darkening, due to solar lines at 4920. From this point to 4992 the spectrum is of about uniform intensity. At 4992 the intensity begins to increase, reaching a maximum at 5027.
Slipher	5018	A weak ban
Slipher	5042	Slight increase in absorption, probably due to solar lines
Pueyo	5076	
Slipher	5077	An increase in absorption, due possibly to solar line, or may be a violet component of the following band

Tobal	5090	Broad, low-medium intensity. More definite toward red edge
Slipher	5104	Point of maximum intensity of a rather strong band, which is somewhat less definite toward the violet.
Pueyo	5106	
Slipher	5137	A slightly increased absorption, possibly due to solar lines
Slipher	5104-5162	There is a rather rapid increase in density from 5104. This reaches its maximum at 6162, and again very rapidly decrease, due, no doubt, to the *b* group of solar lines
Slipher	5172	Dark place, violet members of *b* group of solar lines.
Pueyo	5200	
Slipher	5225	The middle of a broad, but weak absorption band, which begins not far below the *b* group and extends to 5245- It is equally intense for some distance.
Slipher	5269	A slight absorption, *E* of solar spectrum.
Slipher	5332	A slight absorption, possibly due to solar line
Slipher	5373	Increased absorption. There is a strong solar line at this point. This is the violet edge of the absorption band 5377 in the planet's spectrum.
Slipher	5374	A pair of lines.
Slipher	5377	Increased absorption which does not seem to be due to solar lines. Probably an atmospheric band.
Slipher	5396	Slight local absorption, probably due to a pair of solar lines
Slipher	5408	Slight local absorption, probably due to a pair of solar lines
Slipher	5425	A secondary maximum in the strongest absorption band in the spectrum
Tobal	5430	Broad and very dark band, more definite toward red edge, diffuse toward blue edge
Pueyo	5431	
Slipher	5432	The point of maximum intensity of this band
Slipher	5482	The lower edge of the band
Slipher	5567:	The middle of a weak band. Te great density of the plate at this point makes this observations very uncertain
Slipher	5693:	About the violet limit of the second strongest band in the spectrum. Its appears to be double.
Slipher	5722	A line
Slipher	5755	A line
Tobal	5760	Very broad, dark central band with two bands toward the blue and red edges
Pueyo	5765	
Slipher	5771	Point of maximum intensity of the violet component of this band
Slipher	5800	Maximum of red and weaker component.

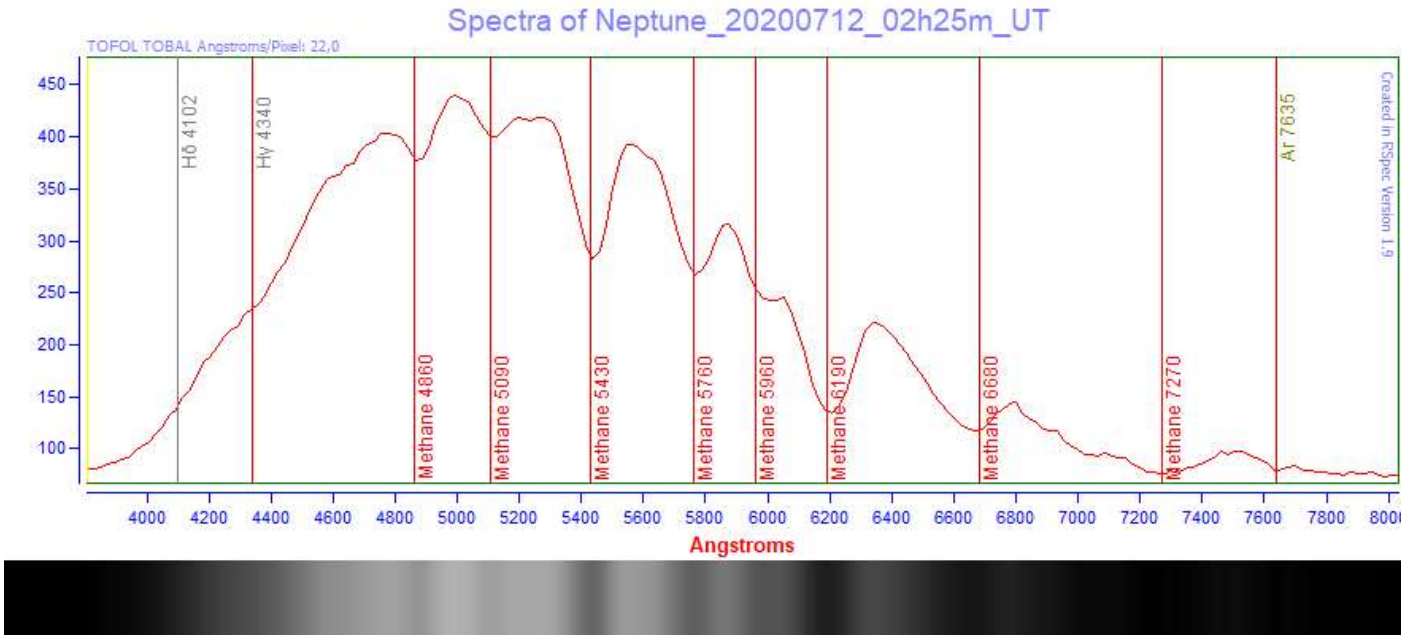
Slipher	5813	Red edge of band
Slipher	5828	Perhaps a line
Slipher	5840	A slight absorption. The spectrum is very weak at his point
Slipher	5862	Perhaps a line
Slipher	5888	Lower limit of spectrum. Line D.
Pueyo	5958	
Tobal	5960	Broad band, low-medium intensity. Diffuse toward edges.
Tobal	6190	The strongest dark band in the spectra. Diffuse towards edges
Pueyo	6195	
Tobal	6680	Very broad and dark band
Pueyo	6854	
Pueyo	7011	
Tobal	7270	Very broad and dark band
Tobal	7635	Dark band

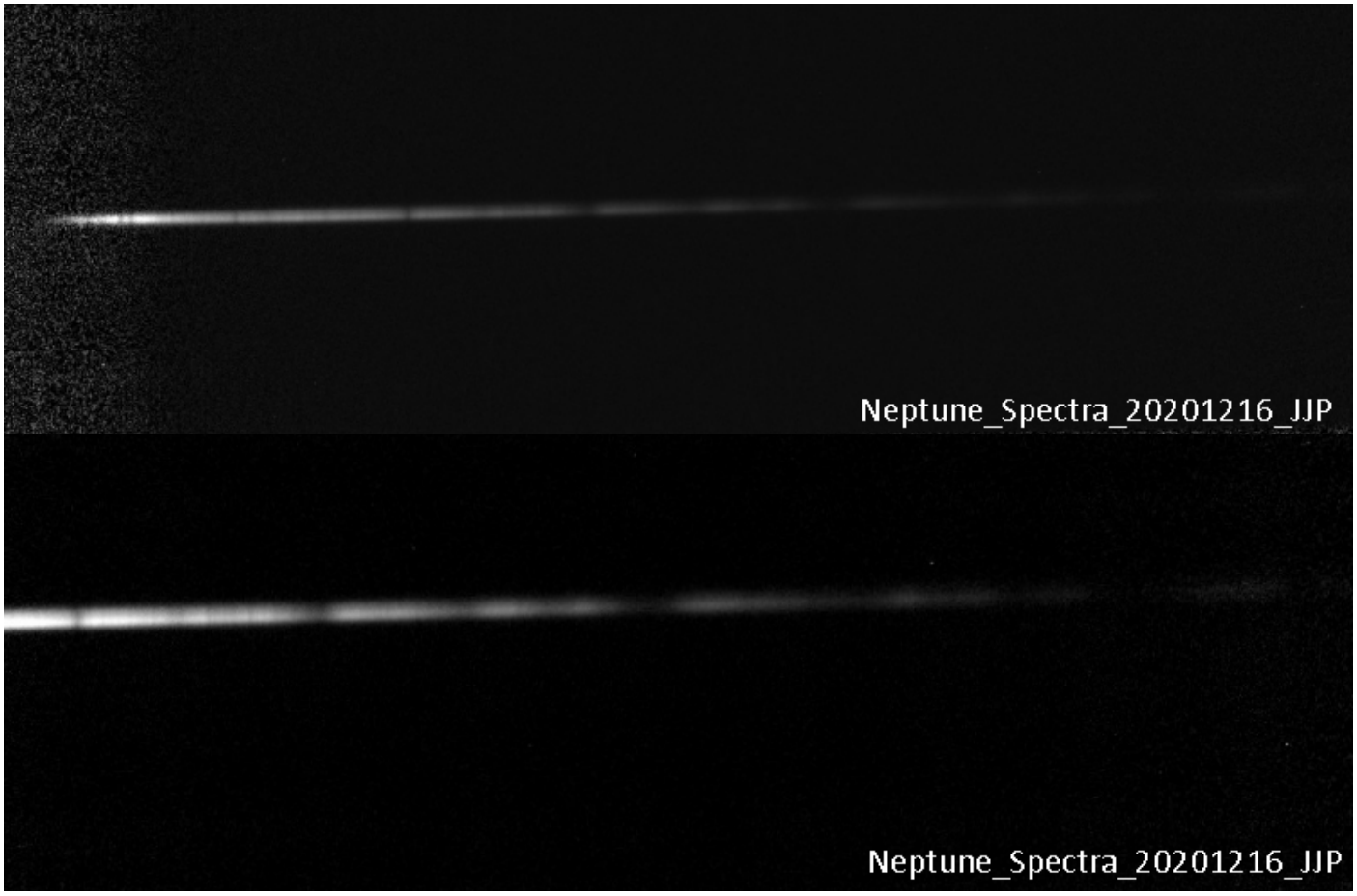


OBSERVATIONS OF NEPTUNE by T.Tobal & J.Pueyo (2019-2020)

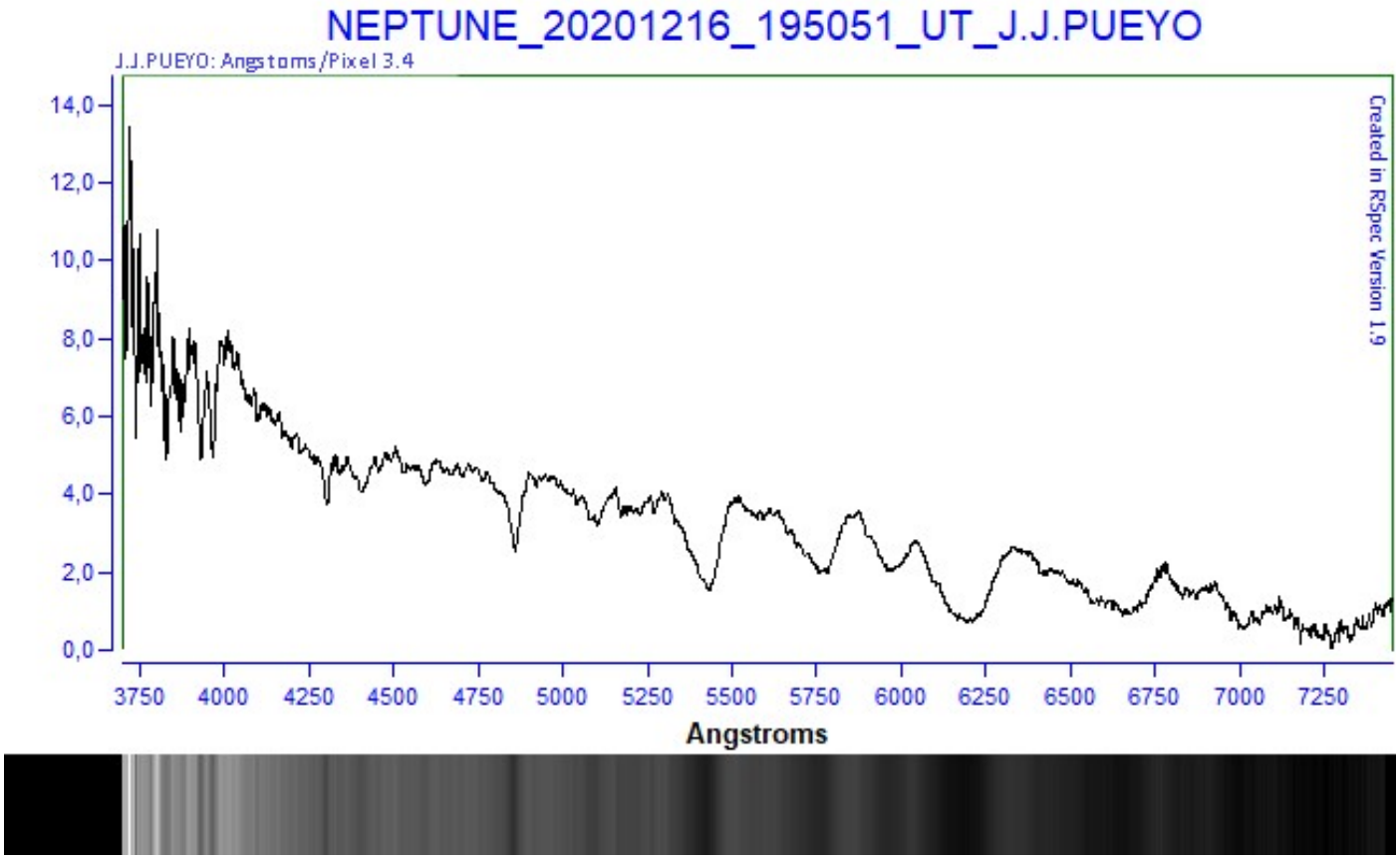


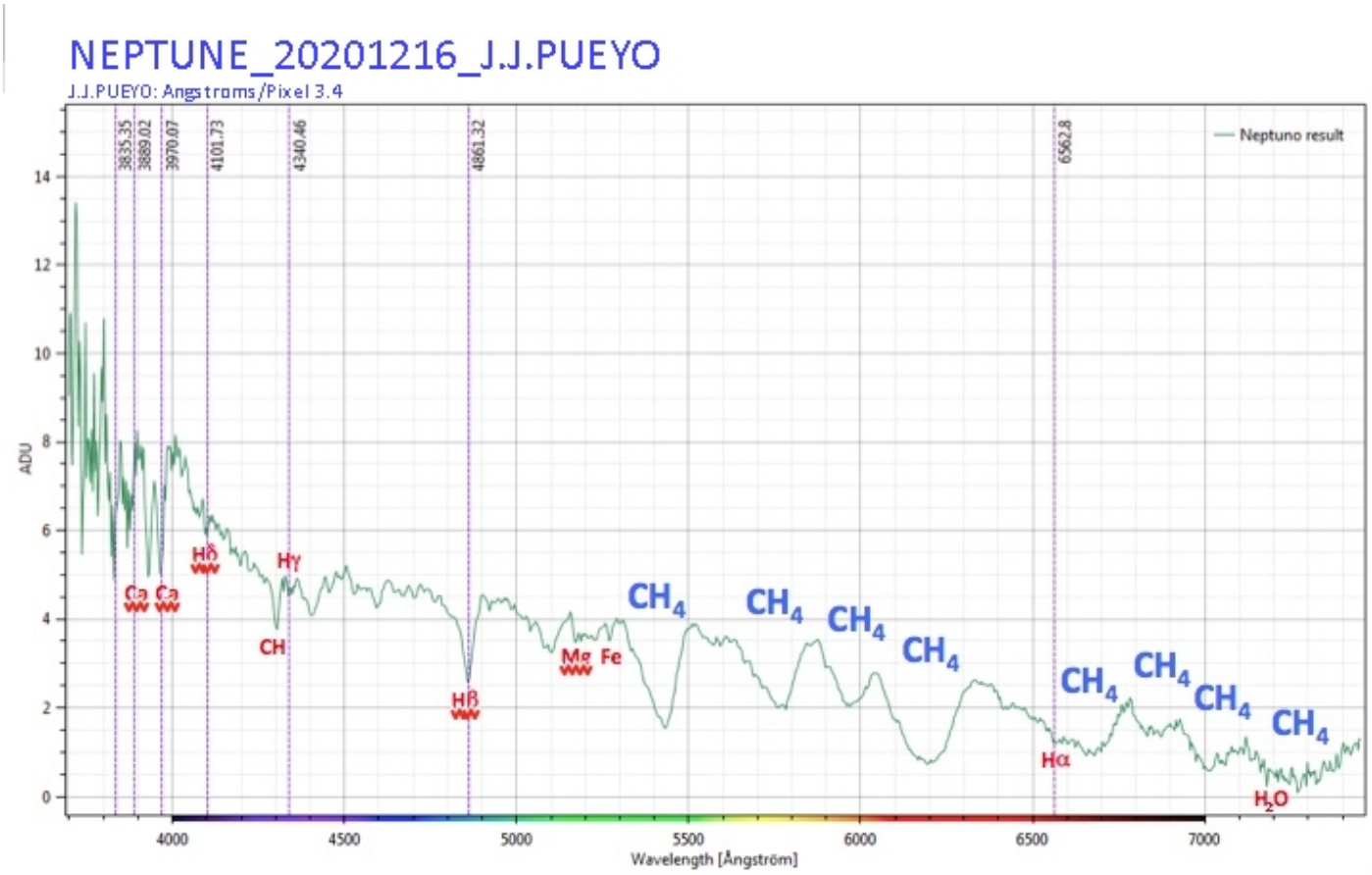
Spectroscopic observations of Neptune by T.Tobal (2019-2020).
Telescope SC-11” f/10 + SA-100+ASI-174MM.



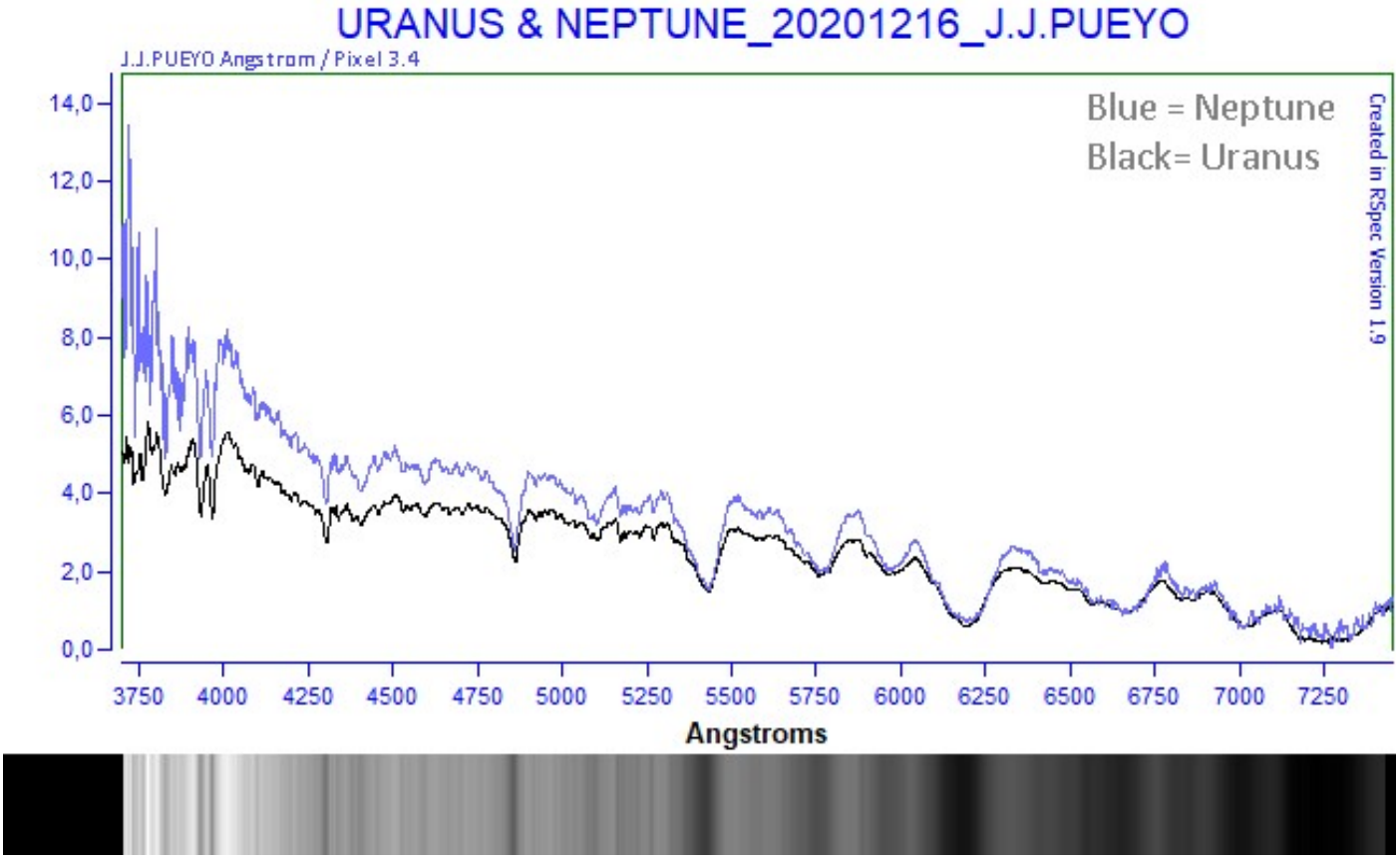


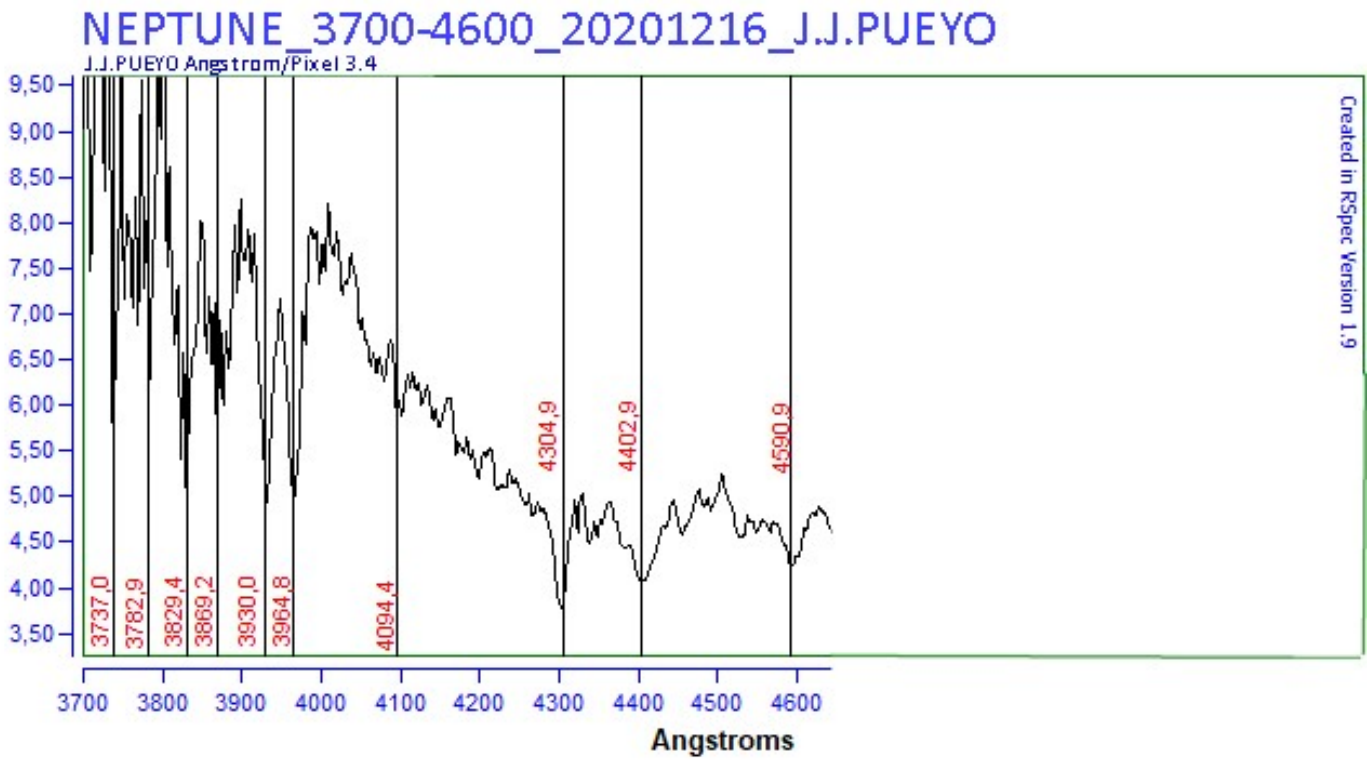
Spectroscopic observations of Neptune by J.J.Pueyo (2020)
Telescope SC-8” f/6.3 + Alpy600+Atik_314L.

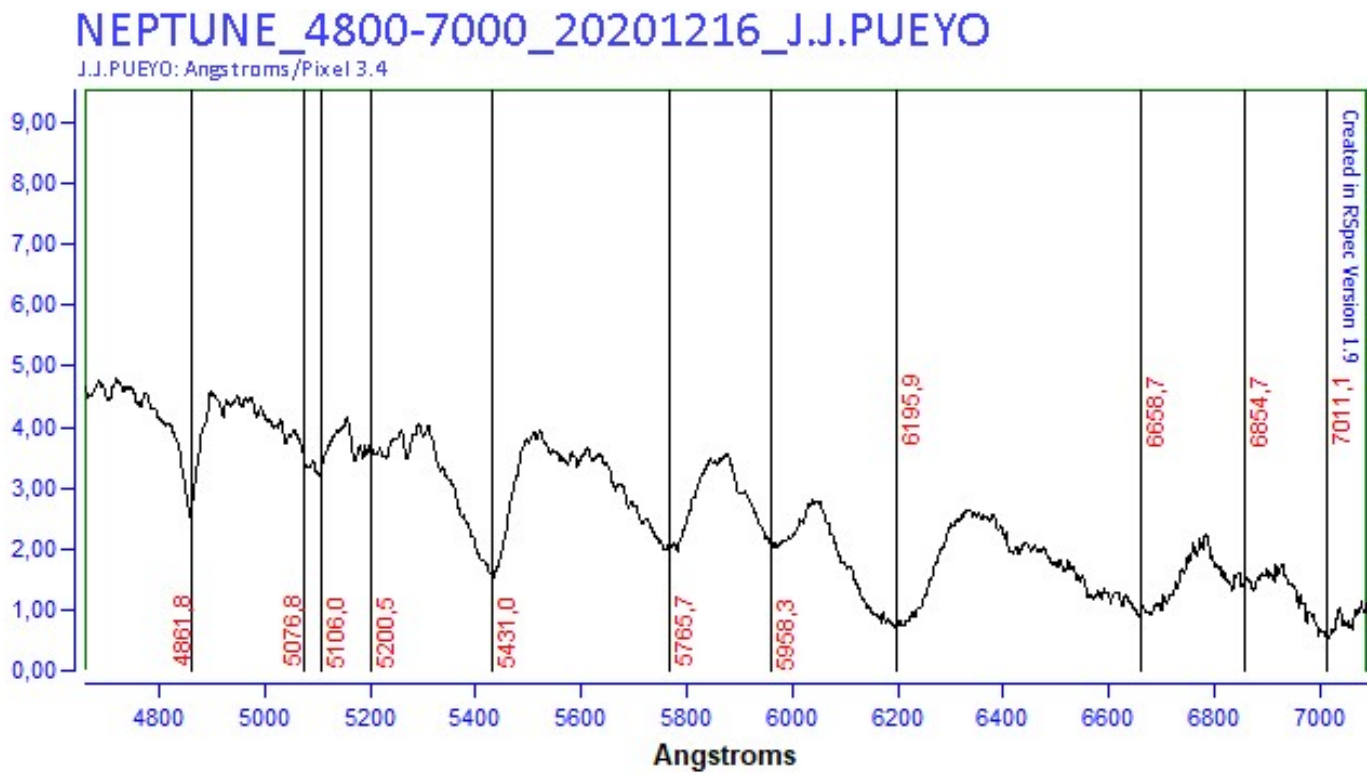




Analysis of Neptune spectra by J.J.Pueyo







Measurements of wavelengths (T.Tobal) on Neptune spectra (J.J.Pueyo)

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