

Be Türü 20 Vul Yıldızının Fotometrik ve Tayfsal Değişkenliği

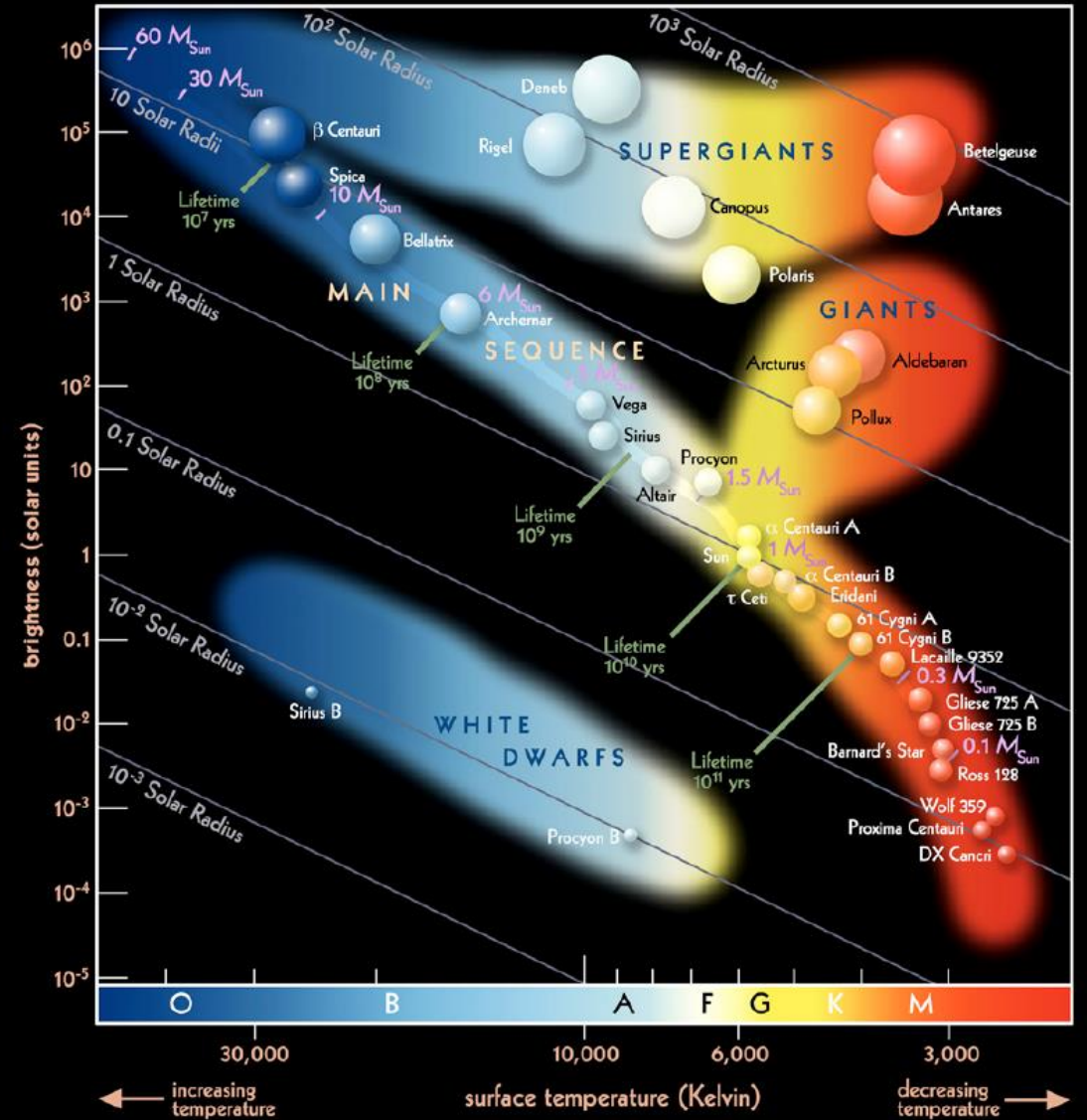
Hande OKURLAR, Esin ÇATAL, Göktuğ SAVUR, Metin ALTAN

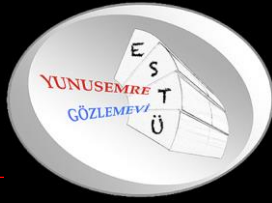
Eskişehir Teknik Üniversitesi Astrofizik Eğitim ve Araştırma Birimi



B Yıldızlarının Astrofiziksel Özellikleri

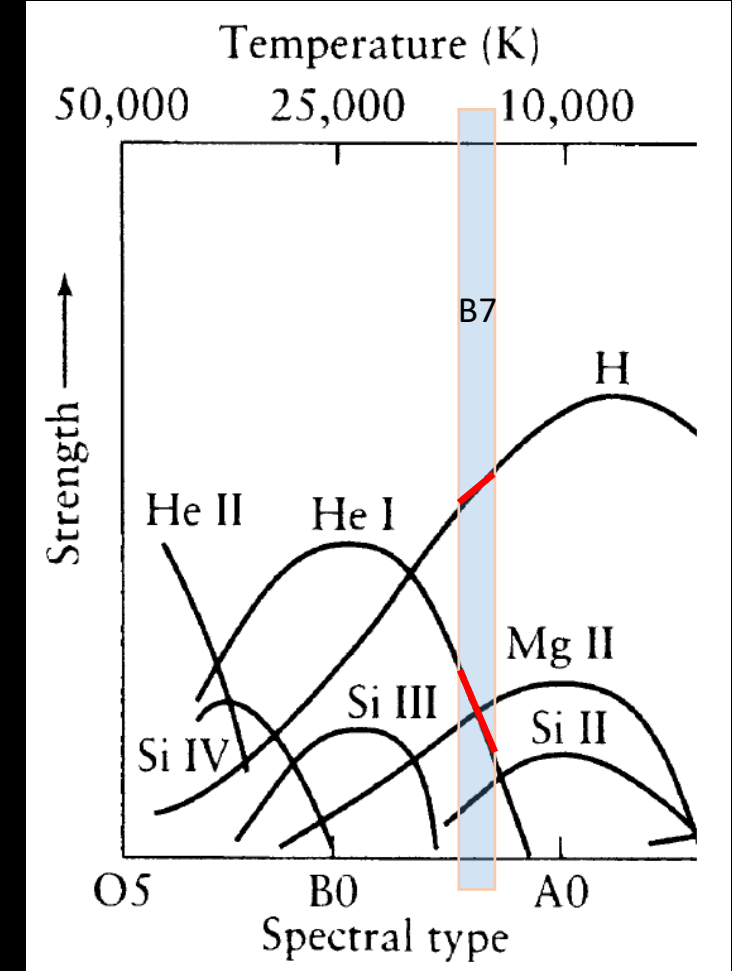
- B yıldızları, optik tayfında hidrojen (H) ve nötr helyum (HeI) bulunan sıcak yıldızlardır.
- Çok hızlı dönen, aktivitelerinin mavi ve UV bölgede daha verimli algılanabildiği B yıldızlarının tayfları H γ ve HeI absorpsiyon çizgilerine sahipken, tayflarında disklerinden kaynaklı emisyon çizgileri de oluştururlar.
- Bu yıldızların, kütleleri Güneş'in kütlelerinin 2 ila 16 katı ve yüzey sıcaklıkları 10.000 ile 30.000 K arasındadır.
- B tipi yıldızlar son derece parlak ve mavidir.





B0 - B9 tayfsal sınıf aralığında, B0-B3 aralığındakiler erken, B3-B9 aralığındakilere geç yıldızlar denir.

- **Erken B yıldızları** – genellikle Helyum kuvvetli
 - **Geç B yıldızları** – genellikle Helyum zayıf
- Sıcaklığı belirlemek için Si IV veya Si III çizgi kuvvetleri kullanılır.
- Parlaklığı belirlemek için Fe III, Al III veya N II çizgi kuvvetleri kullanılır.





Be Yıldızları

- Emisyonda hidrojen Balmer çizgilerinden en az birine sahip olan B yıldızları, Be yıldızları olarak tanımlanır.
- Be yıldızları, tayfında belirgin bir hidrojen emisyon gösterir.
- Merkezi B yıldızı + Dağılma diski
- Yıldız disk üzerine kütle kaybediyor.
- Diferansiyel olarak dönüyor.
- Optik, UV ve IR'de yayılım yapıyor.



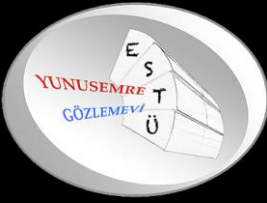
Klasik Be Yıldızı



Çalışmamızda, B7V tayf tipindeki B türü
20 Vulpeculae yıldızının eş zamanlı alınan
fotometrik ve tayfsal verilerin analizini
yaptık ve farklı nitelikteki değişkenlikleri
inceledik.

20 Vul

Spectral Type	Radius R_{\odot}	Mass M_{\odot}	T_{eff} (K)	log g
B0V	10	17	30,000	4
B1V	6.42	13.21	25,400	3.9
B2V	5.33	9.11	20,800	3.9
B3V	4.8	7.6	18,800	4
B5V	3.9	5.9	15,200	4
B6V	3.56	5.17	13,800	4
B7V	3.28	4.45	12,400	4.1
B8V	3	3.8	11,400	4.1
B9V	2.7	3.29	10,600	4.1



20 Vul - HIP 99531

Type: **star**
Magnitude: **5.90** (extincted to: **6.18** B-V: **-0.09**)
Absolute Magnitude: **-1.82**
RA/DE (J2000): 20h12m0.7s/+26°28'43.5"
RA/DE (of date): 20h12m58s/+26°32'51"
Galactic longitude/latitude (J2000): +65°31'45.4"/-4°04'23.1"
Hour angle/DE: 3h36m39s/+26°32'51" (geometric)
Hour angle/DE: 3h36m37s/+26°33'10" (apparent)
Az/Alt: +270°21'58"/+43°44'42" (geometric)
Az/Alt: +270°21'58"/+43°45'19" (apparent)
Spectral Type: B7Ve...
Distance: 1140.41 Light Years
Parallax: 0.00286"



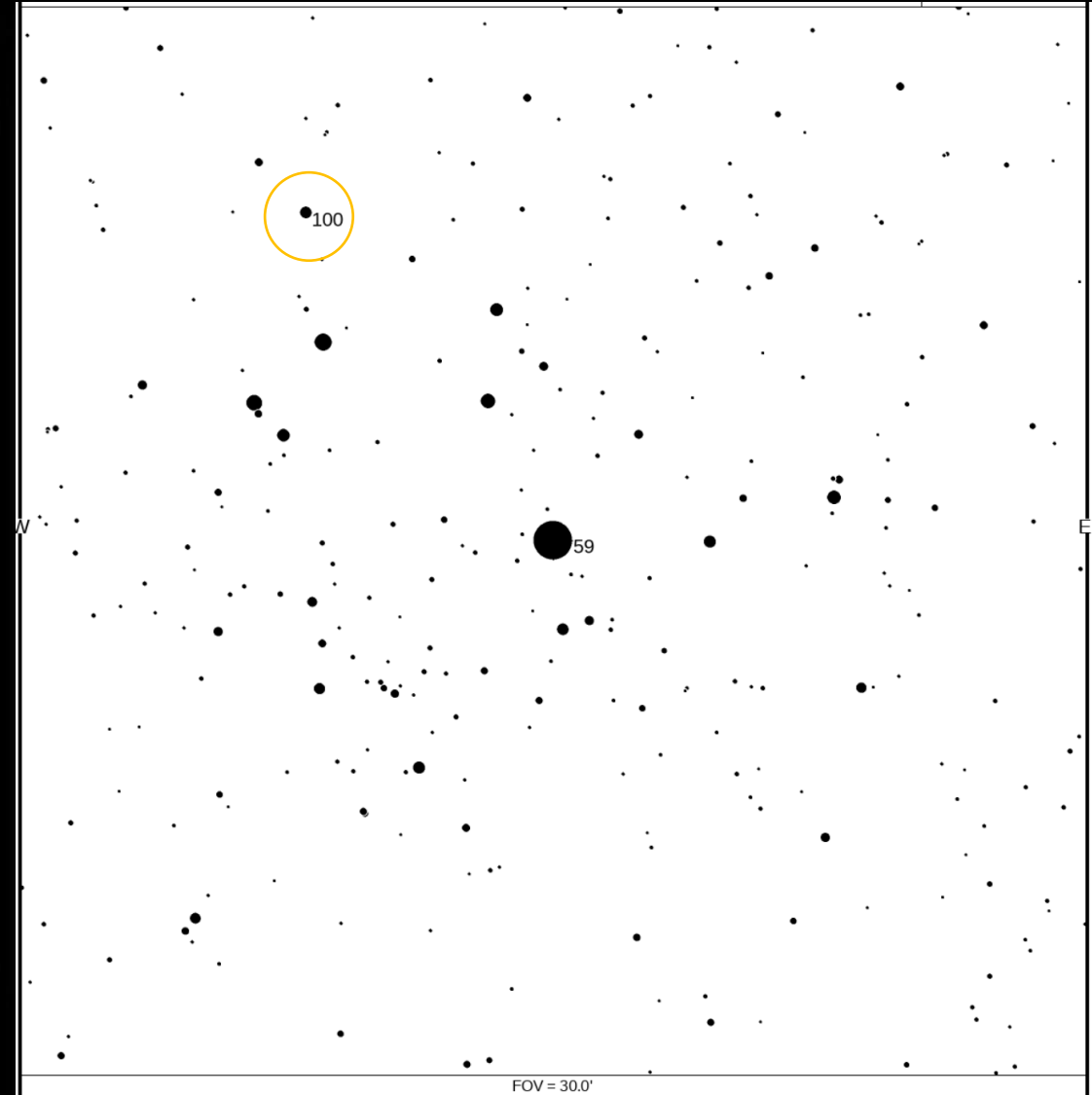
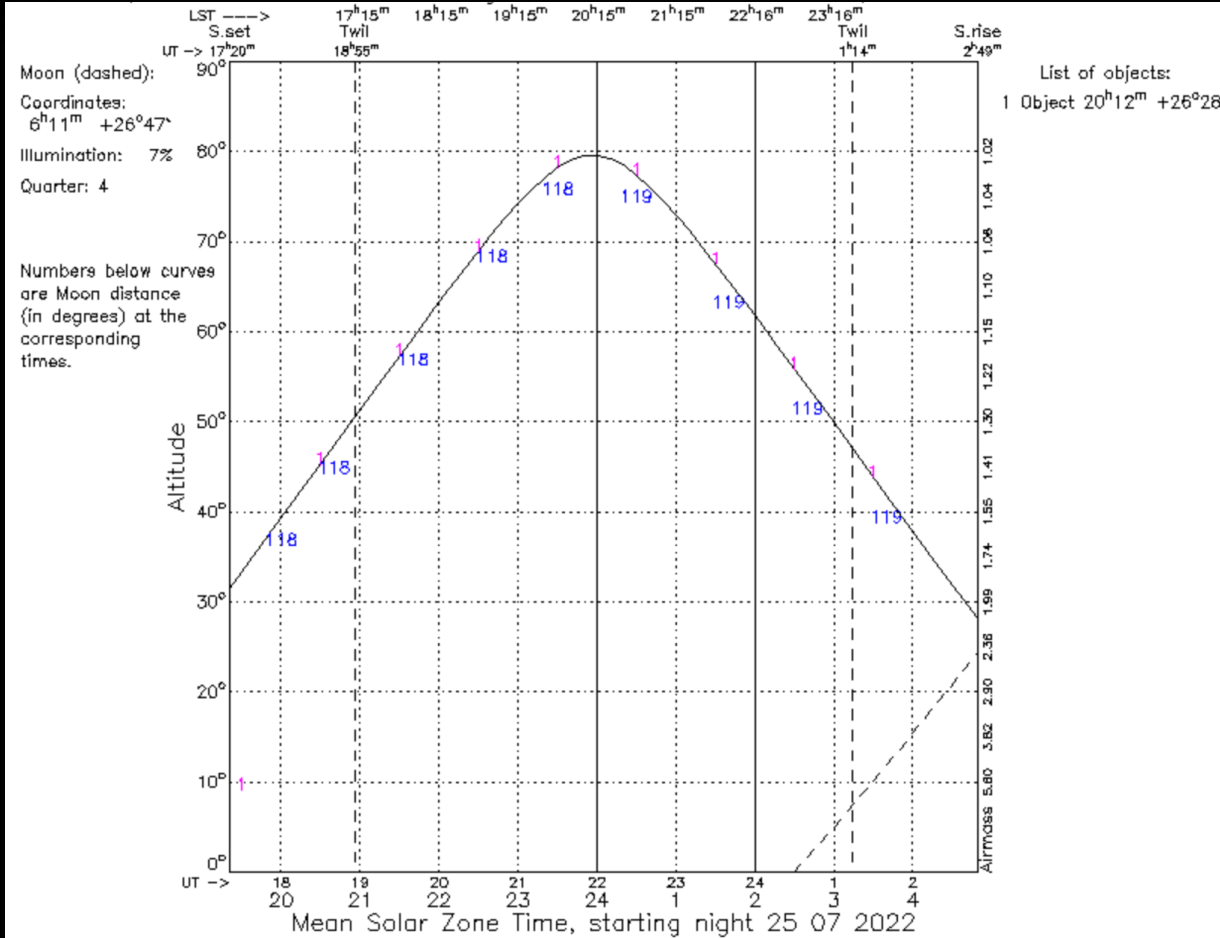
Date and Time

2022 / 9 / 6 1 : 46 : 29



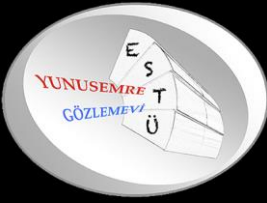


25.07.2022



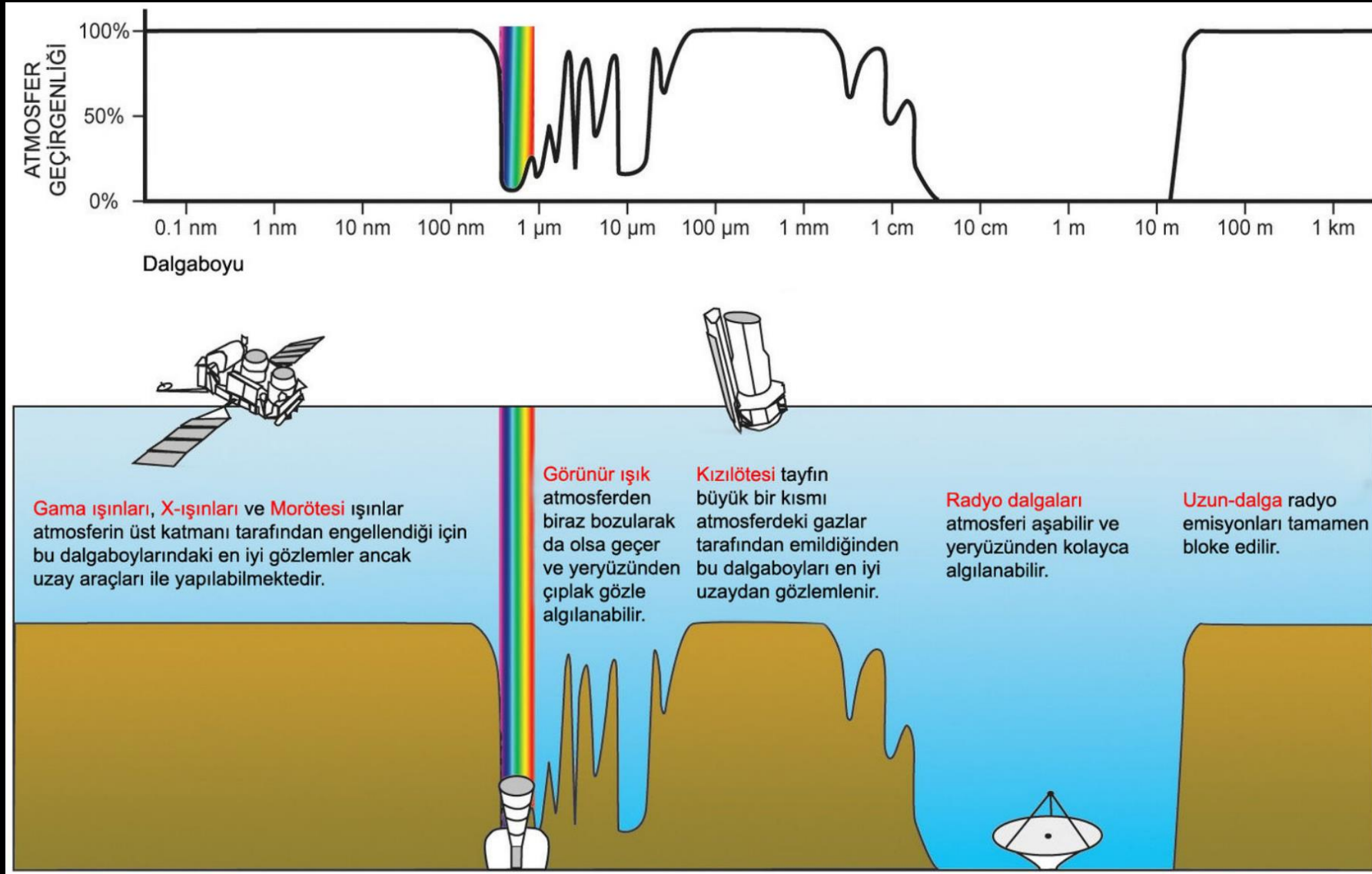
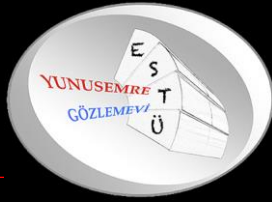
39.885700° N 30.460536° E

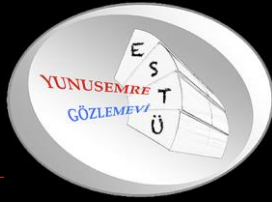




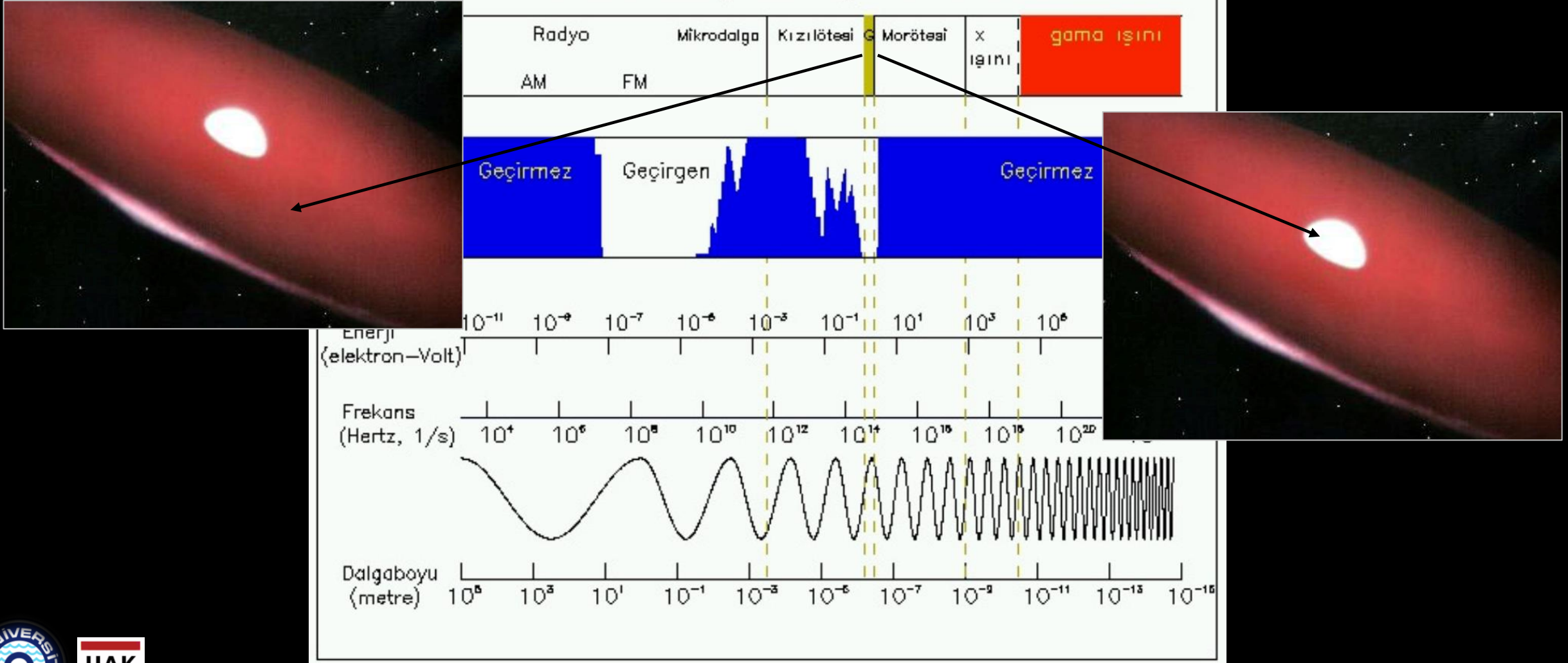
GÖZLEM

- *Fotometrik Gözlem Çalışmaları*
- *Tayfsal Gözlem Çalışmaları*





Elektromanyetik Tayf ve Özellikleri

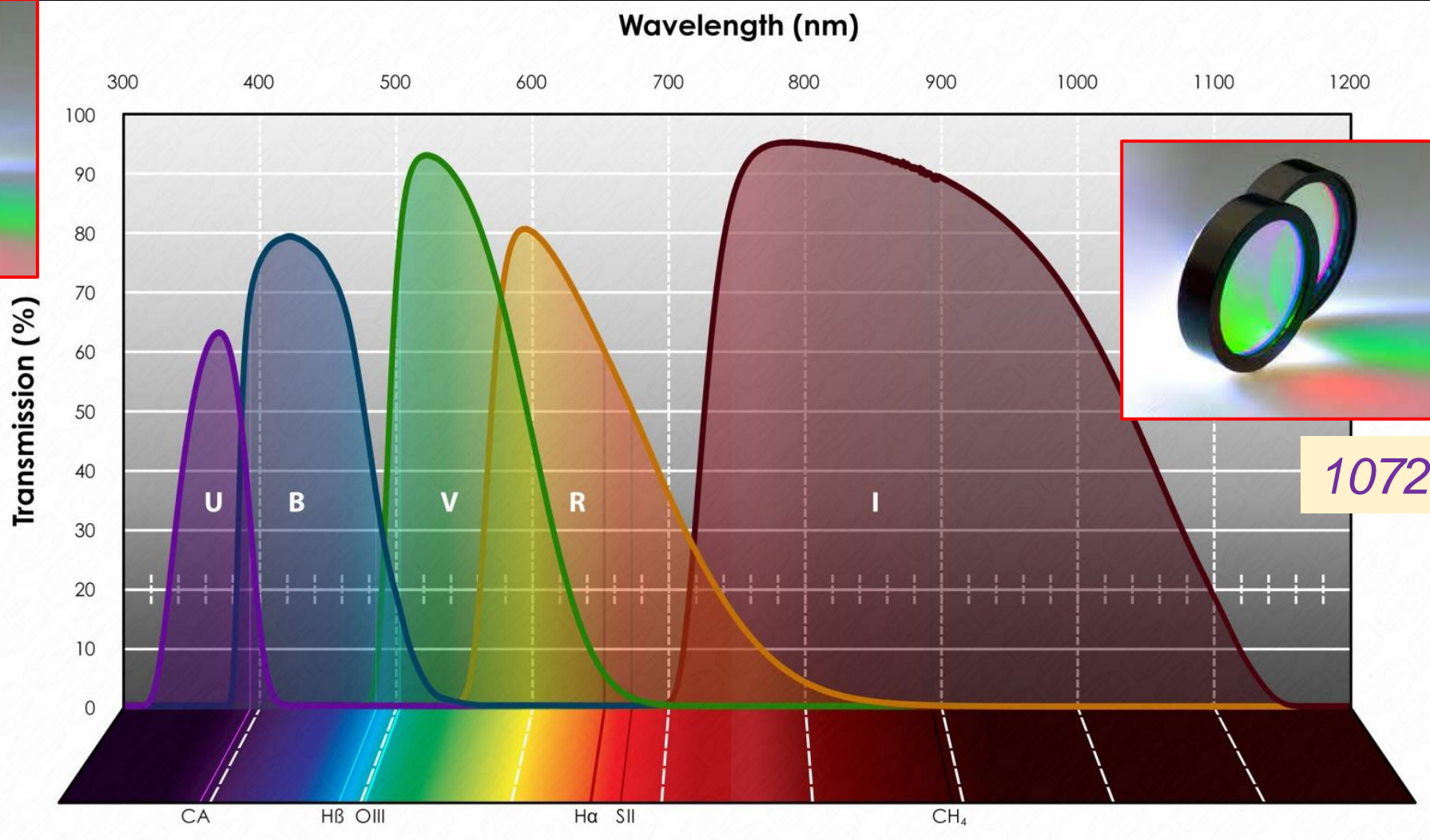




285 nm

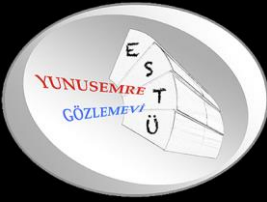


1072 nm



BAADER UBVRI Bessel Photometric Filters





1072 nm

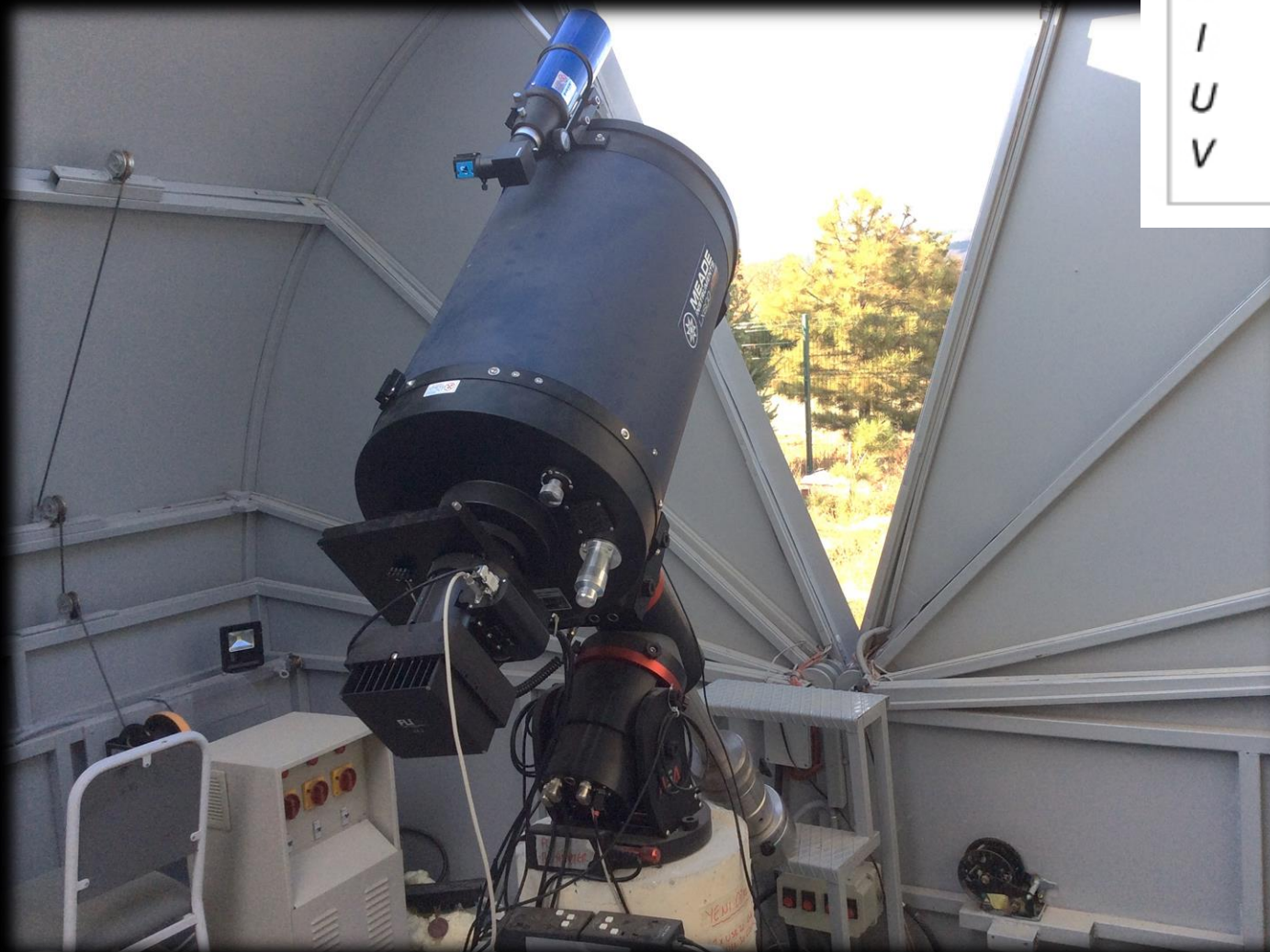
285 nm

C

I

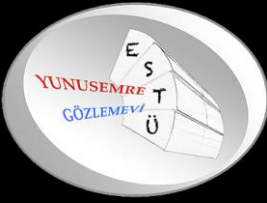
U

V





Tarih	Filtresiz		285nm		V Filtre		U Filtre		I Filtre		1072nm	
	Adet	Süre (sn)	Adet	Süre (sn)	Adet	Süre (sn)	Adet	Süre (sn)	Adet	Süre (sn)	Adet	Süre (sn)
02.07.2019	612	0.4	-	-	607	1.5	-	-	-	-	-	-
10.07.2020	-	-	55	10	55	2	-	-	-	-	55	40
18.07.2022	978	0.2	-	-	-	-	-	-	-	-	-	-
20.07.2022	20	0.1	21	20	21	0.8	-	-	-	-	19	220
21.07.2022	70	0.1	68	20	66	0.8	-	-	-	-	67	220
22.07.2022	28	0.1	28	20	27	0.8	-	-	-	-	29	220
24.07.2022	54	0.1	57	20	54	0.8	-	-	-	-	56	220
26.07.2022	24	0.1	24	20	24	0.8	-	-	-	-	24	220
19.08.2022	33	0.1	27	15	33	0.8	-	-	-	-	32	220
19.08.2022	-	-	5	20	-	-	-	-	-	-	-	-
22.08.2022	-	-	9	3	-	-	-	-	-	-	-	-
22.08.2022	-	-	14	30	-	-	-	-	-	-	21	220
23.08.2022	-	-	37	30	-	-	26	20	36	30	31	250



BESS Veri Tabanı

28.07.2016

24.06.2018

14.08.2019

07.09.2019

20.09.2019

10.04.2020

05.08.2020

28.06.2021

09.07.2021

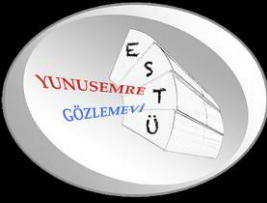
ESTÜ – Gözlemevi

02.07.2019

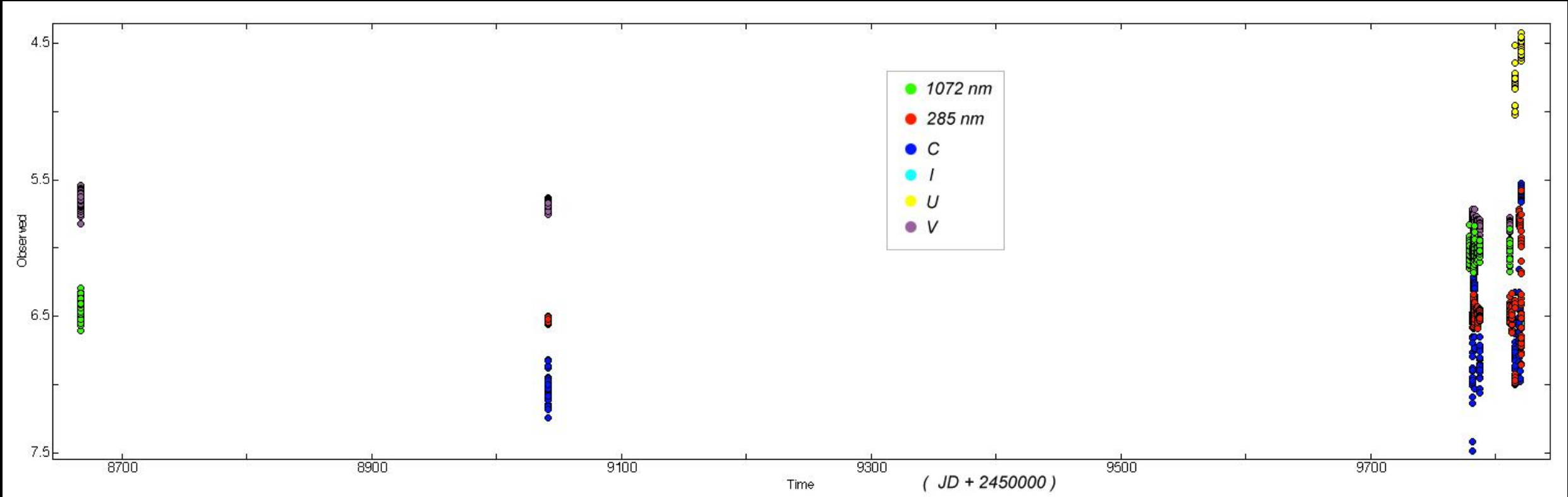
03.07.2019

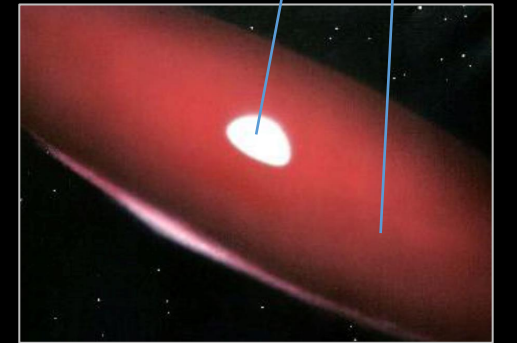
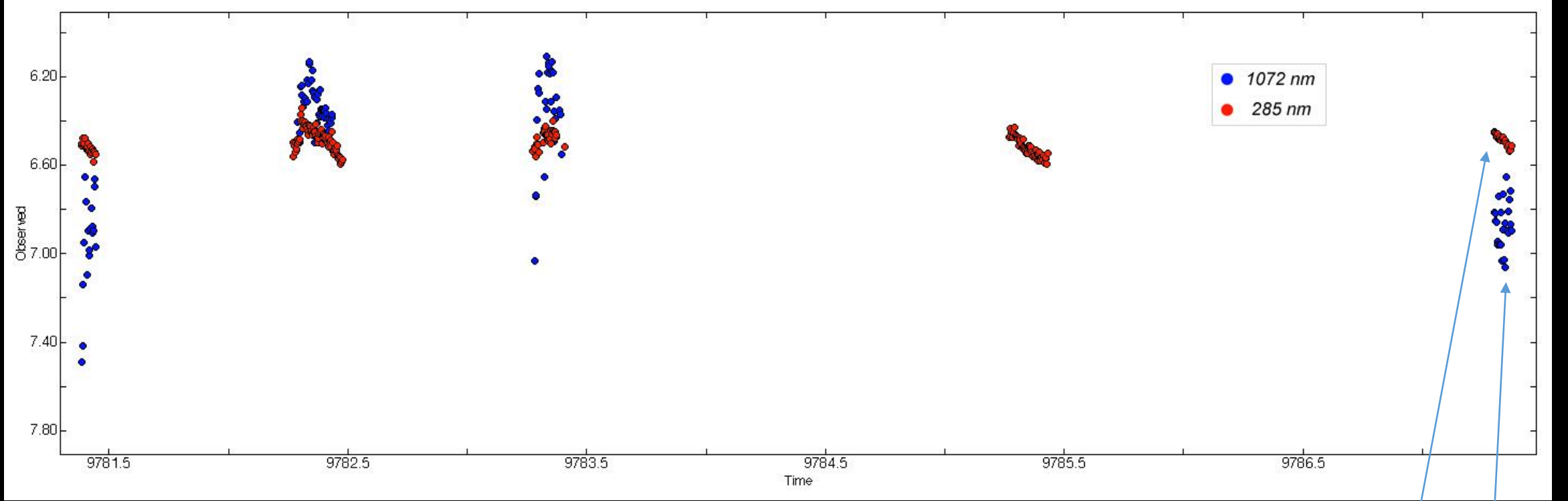
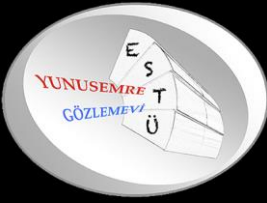
04.09.2021

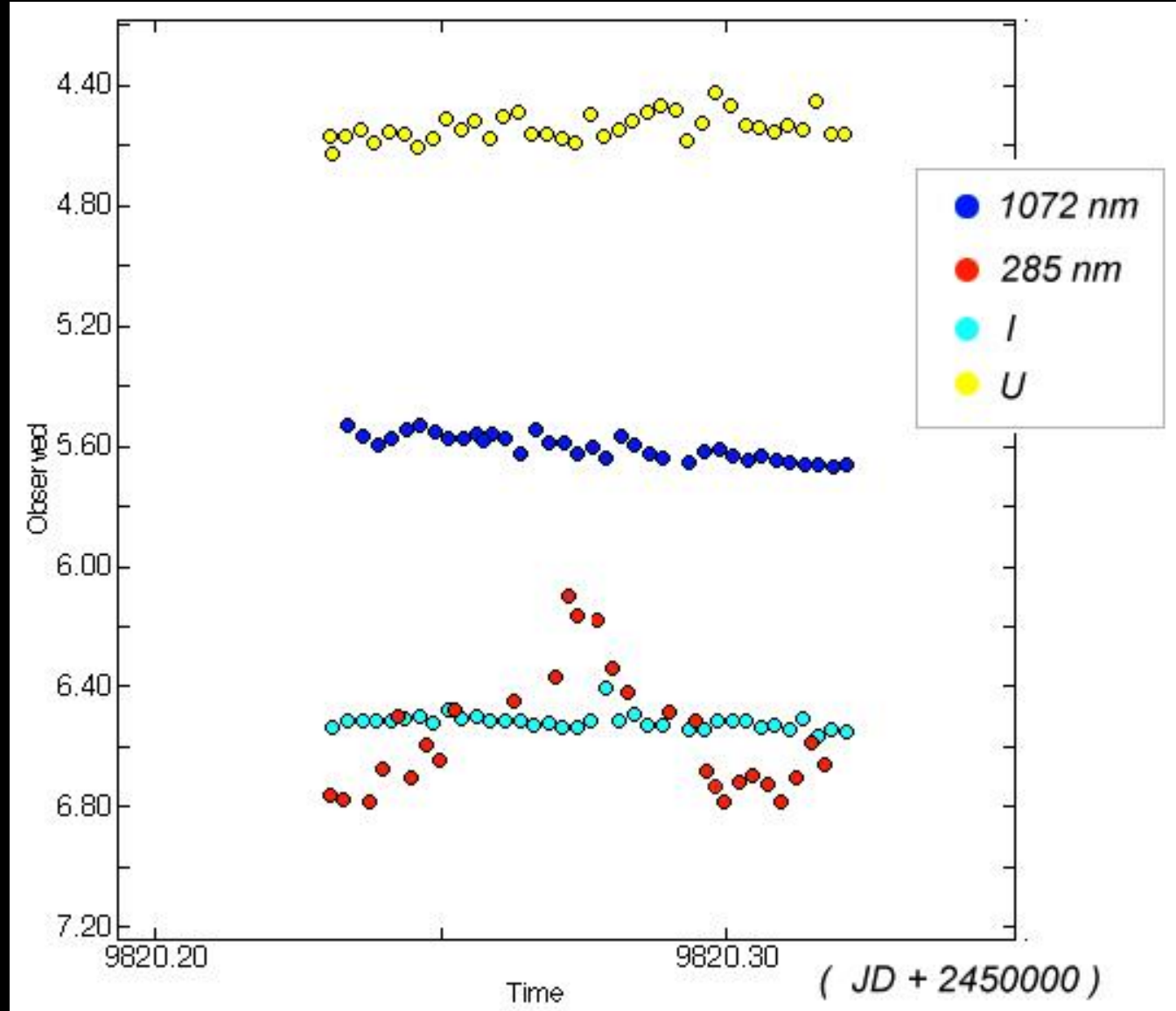
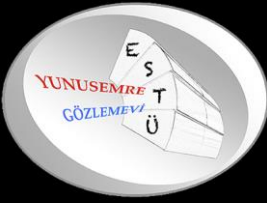
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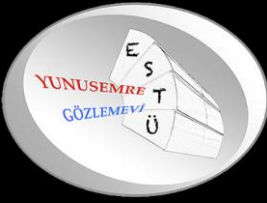


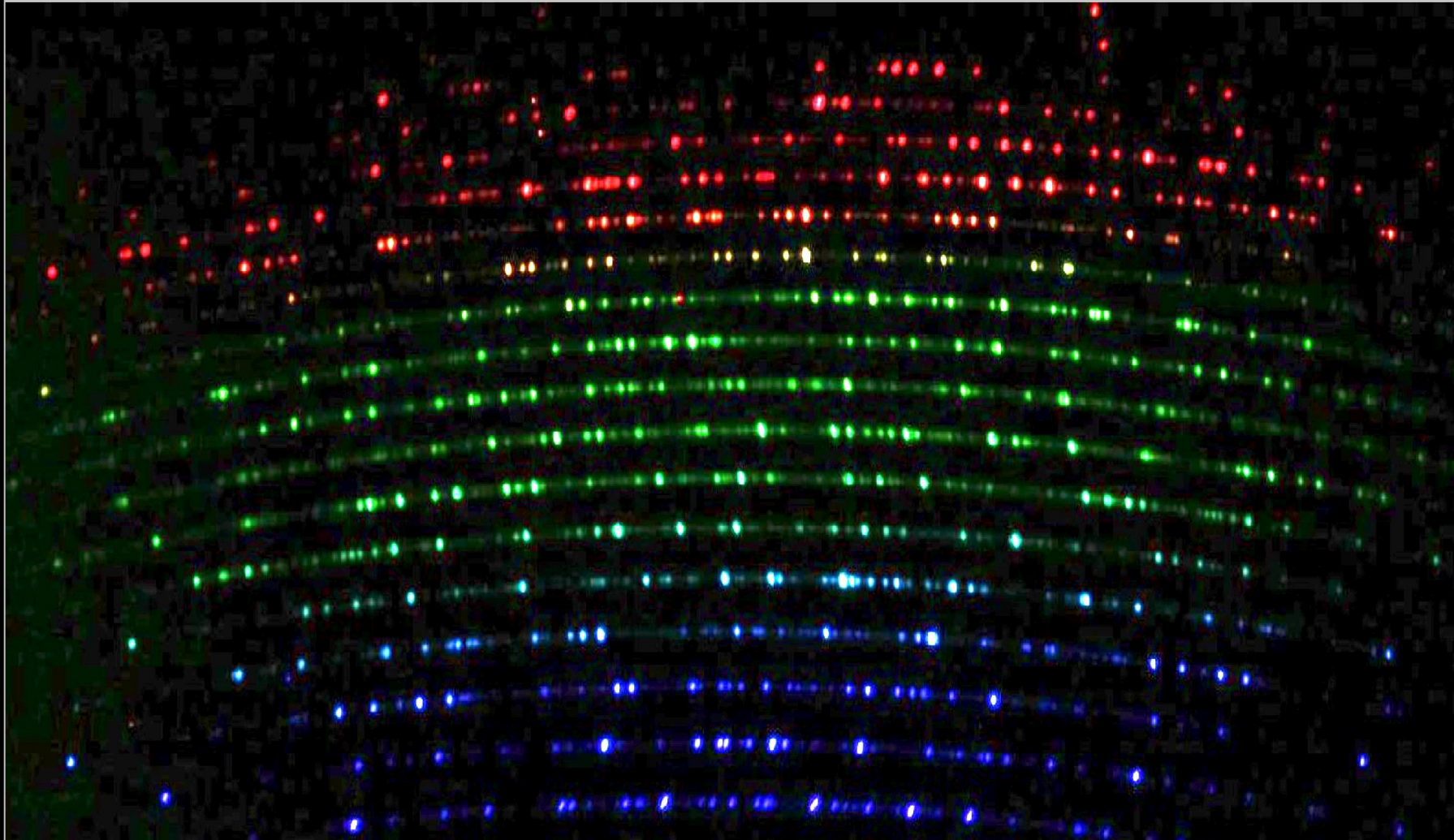
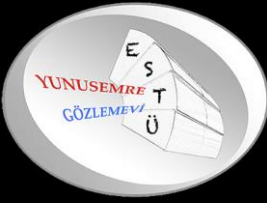
Fotometrik Gözlem Sonuçları

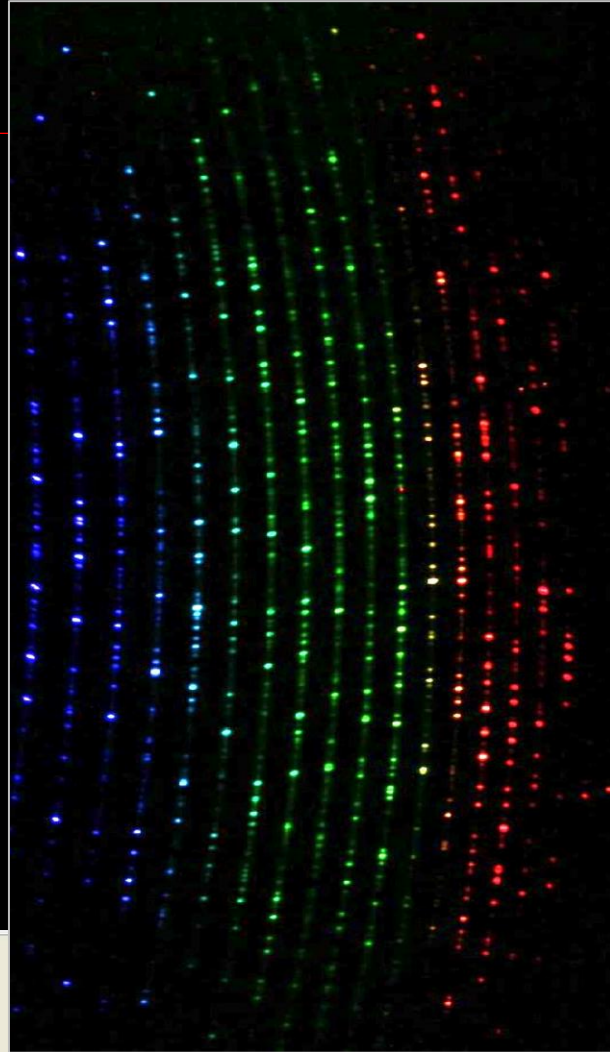
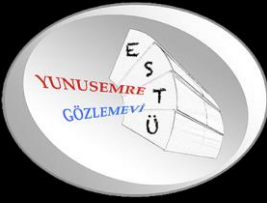








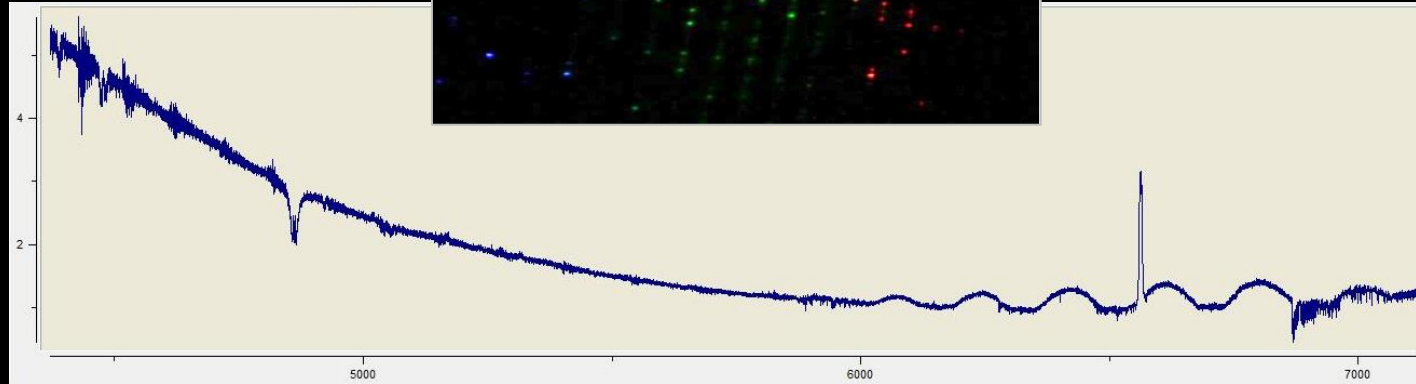




438 nm



715 nm





Configuration choice

New configuration: altan_1

Spectrograph | Camera | Telescope | Processing

Detect ordres

Minimum order N°: 31

Maximum order N°: 51

Binning area height (pixel): 20

Detection area width (pixel): 25

Reference order

Reference order N°: 34

Middle order Y coordinate (pixel): 1865

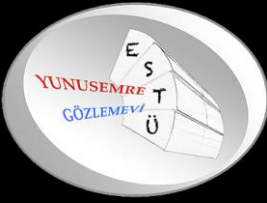
Reference line Lambda (Angstrom): 6583.906

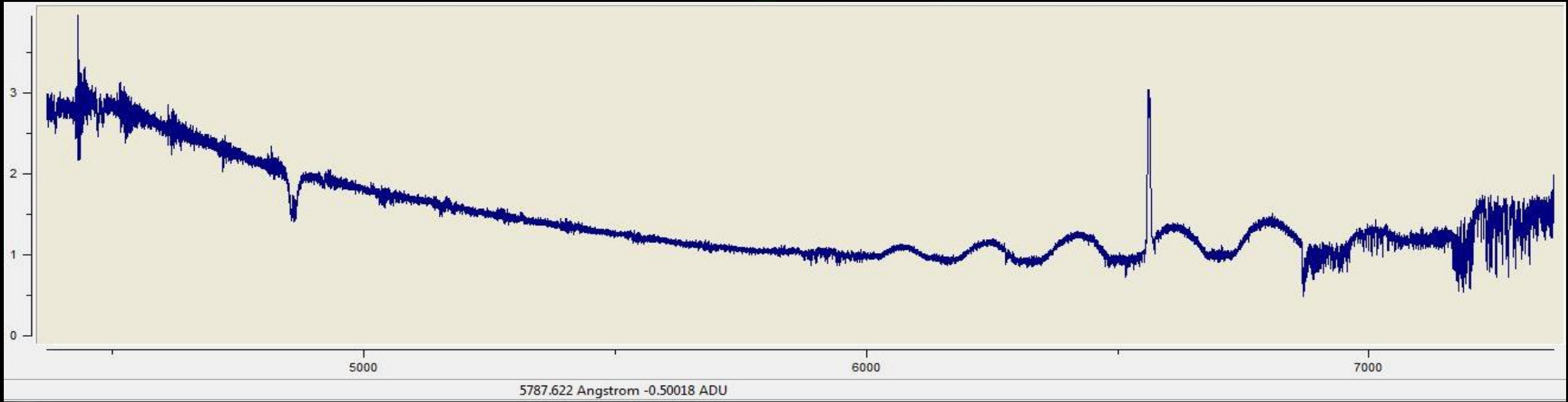
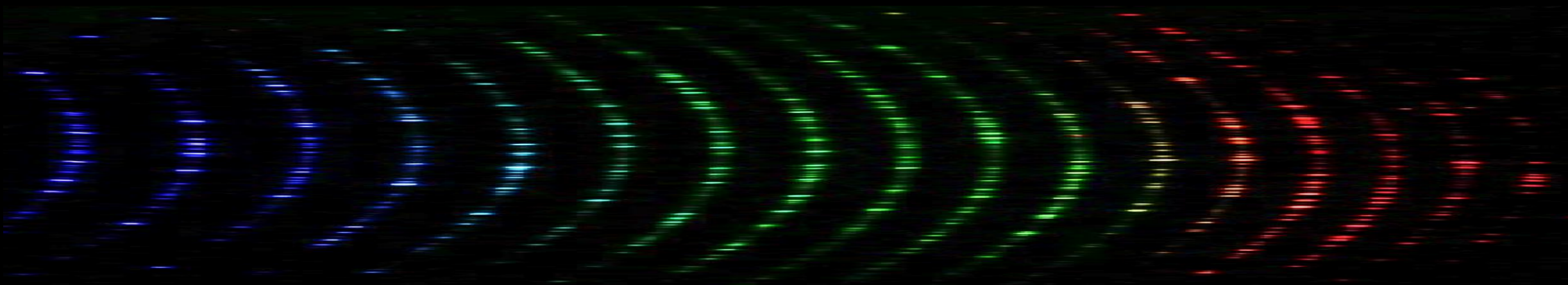
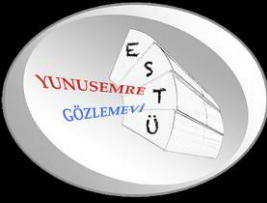
Reference line X abscisse (pixel): 1076

Detection threshold (ADU): 2000

ORDER	RMS	CENTRAL	RMS-CAL	RESOLUTION	NB LINE
31	0.0424	7251.517	0.0160	11316.5	26
32	0.0214	7024.907	0.0035	11504.0	10
33	0.0315	6812.032	0.0126	11820.0	12
34	0.0639	6611.678	0.0137	12118.4	14
35	0.1177	6422.773	0.0145	12288.8	14
36	0.1831	6244.362	0.0077	13572.5	14
37	0.2418	6075.596	0.0143	13322.2	14
38	0.2690	5915.712	0.0182	13311.8	14
39	0.2776	5764.027	0.0112	12961.4	16
40	0.2965	5619.926	0.0133	13871.7	13
41	0.3084	5482.855	0.0383	13317.3	16
42	0.3236	5352.310	0.0476	13395.9	16
43	0.3232	5227.838	0.0200	13166.4	16
44	0.3181	5109.024	0.0136	13554.6	13
45	0.2874	4995.490	0.0096	13691.9	13
46	0.2661	4886.892	0.0221	13027.2	13
47	0.4030	4782.916	0.0065	12675.7	10
48	0.2806	4683.272	0.0037	12629.8	13
49	0.0948	4587.695	0.0051	12376.5	11
50	0.0391	4495.941	0.0085	11220.7	9
51	0.0664	4407.785	0.0043	11466.1	10

eShell-process: Processing OBJECT-PROCESS : 20220827-184420-20Vul-1x1800s.fit
 eShell-process: with BIAS=20220830-172255-BIAS-10x0s.fit
 eShell-process: with DARK=20220830-172442-DARK-1x1800s.fit
 eShell-process: with CALIB=20220830-175751-CALIB-7x14s.fit
 eShell-process: with OBJECT=20220827-184420-20Vul-1x1800s.fit







Configuration choice

New configuration | altan_1 | Cop

Spectrograph | Camera | Telescope | Processing

Detect ordres

Minimum order N° | 33

Maximum order N° | 52

Binning area height (pixel) | 20

Detection area width (pixel) | 25

Reference order

Reference order N° | 34

Middle order Y coordinate (pixel) | 1865

Reference line Lambda (Angstrom) | 6583.906

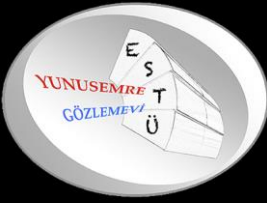
Reference line X abcisse (pixel) | 1078

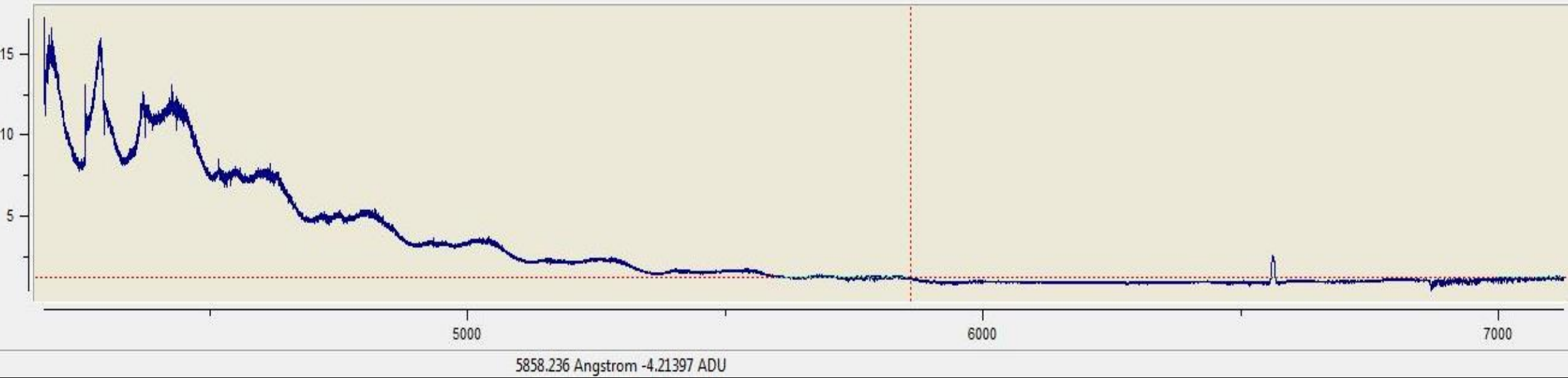
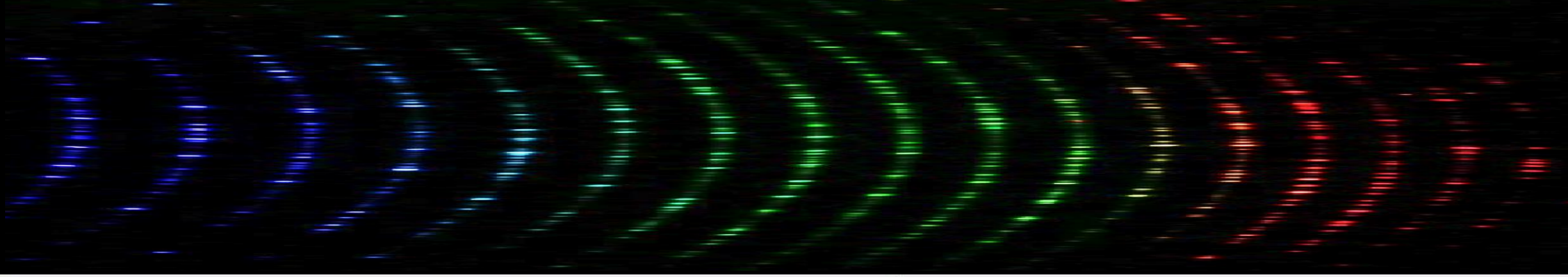
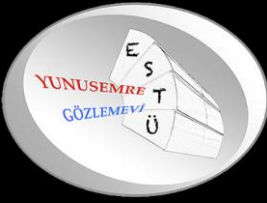
Detection threshold (ADU) | 2000

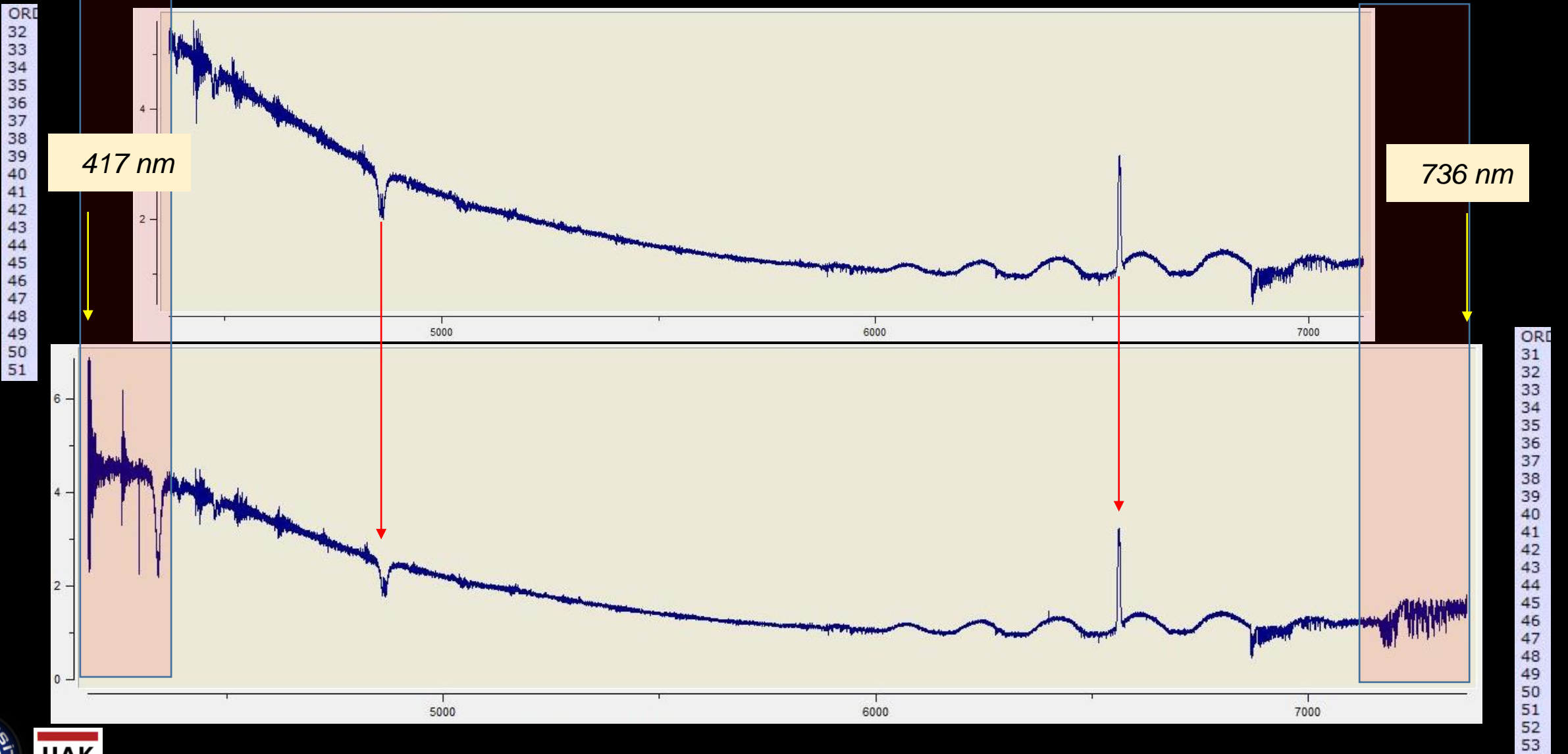
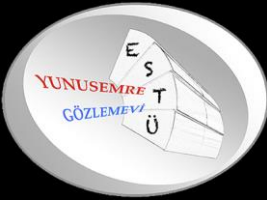
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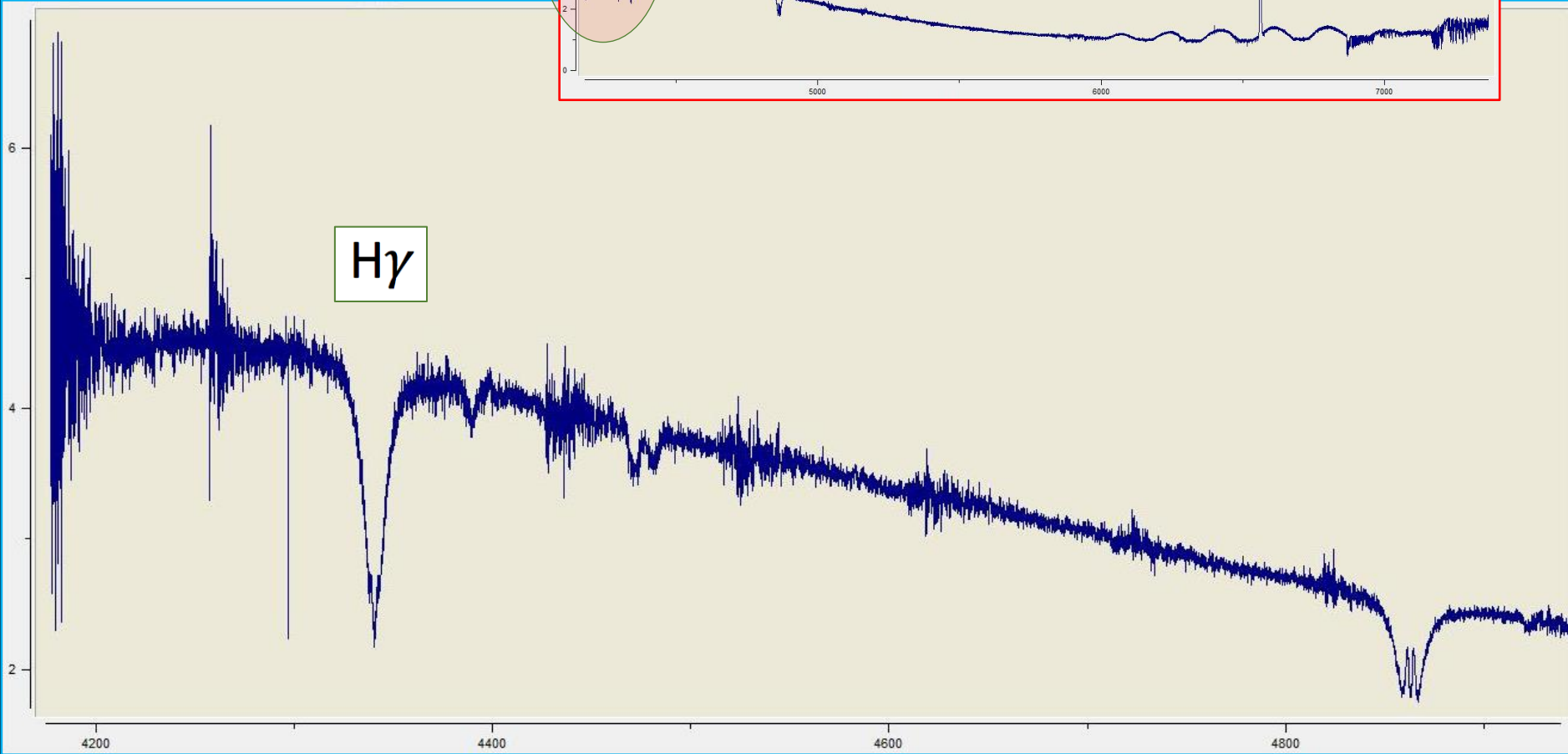
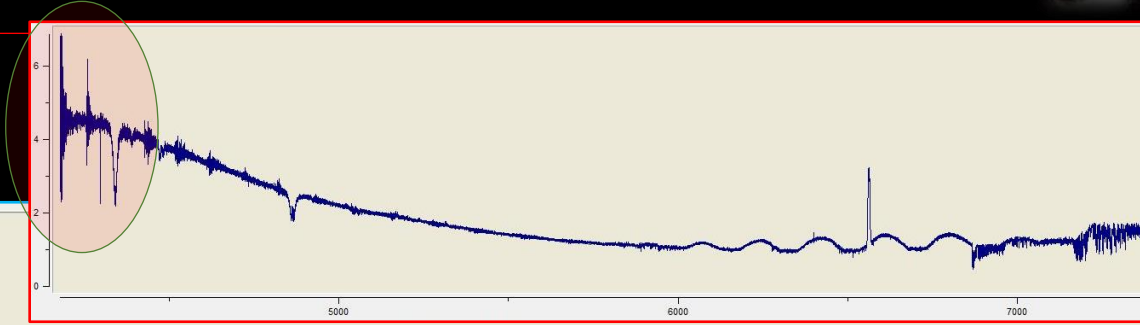
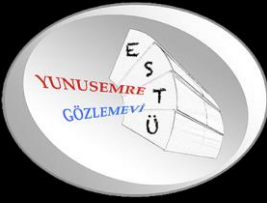
ORDER	RMS	CENTRAL	RMS-CAL	RESOLUTION	NB LINE
33	0.0569	6811.846	0.0087	11479.9	12
34	0.0305	6611.497	0.0144	11193.2	14
35	0.0429	6422.597	0.0133	12070.3	13
36	0.0603	6244.192	0.0056	12489.0	15
37	0.0898	6075.430	0.0179	13066.5	16
38	0.1235	5915.550	0.0128	12756.6	16
39	0.1515	5763.869	0.0105	12664.5	16
40	0.1642	5619.773	0.0083	13405.8	12
41	0.1533	5482.705	0.0292	12976.7	16
42	0.1566	5352.164	0.0230	13298.8	14
43	0.1575	5227.695	0.0105	12644.6	16
44	0.1469	5108.884	0.0074	12858.0	13
45	0.1455	4995.353	0.0052	13283.3	13
46	0.1409	4886.759	0.0118	13097.4	12
47	0.1400	4782.785	0.0035	12190.4	10
48	0.0674	4683.144	0.0033	12379.8	12
49	0.0280	4587.569	0.0045	11906.1	10
50	0.0613	4495.818	0.0072	11450.4	9
51	0.1322	4407.665	0.0061	12227.5	10
52	0.2494	4322.902	0.0227	13260.1	18

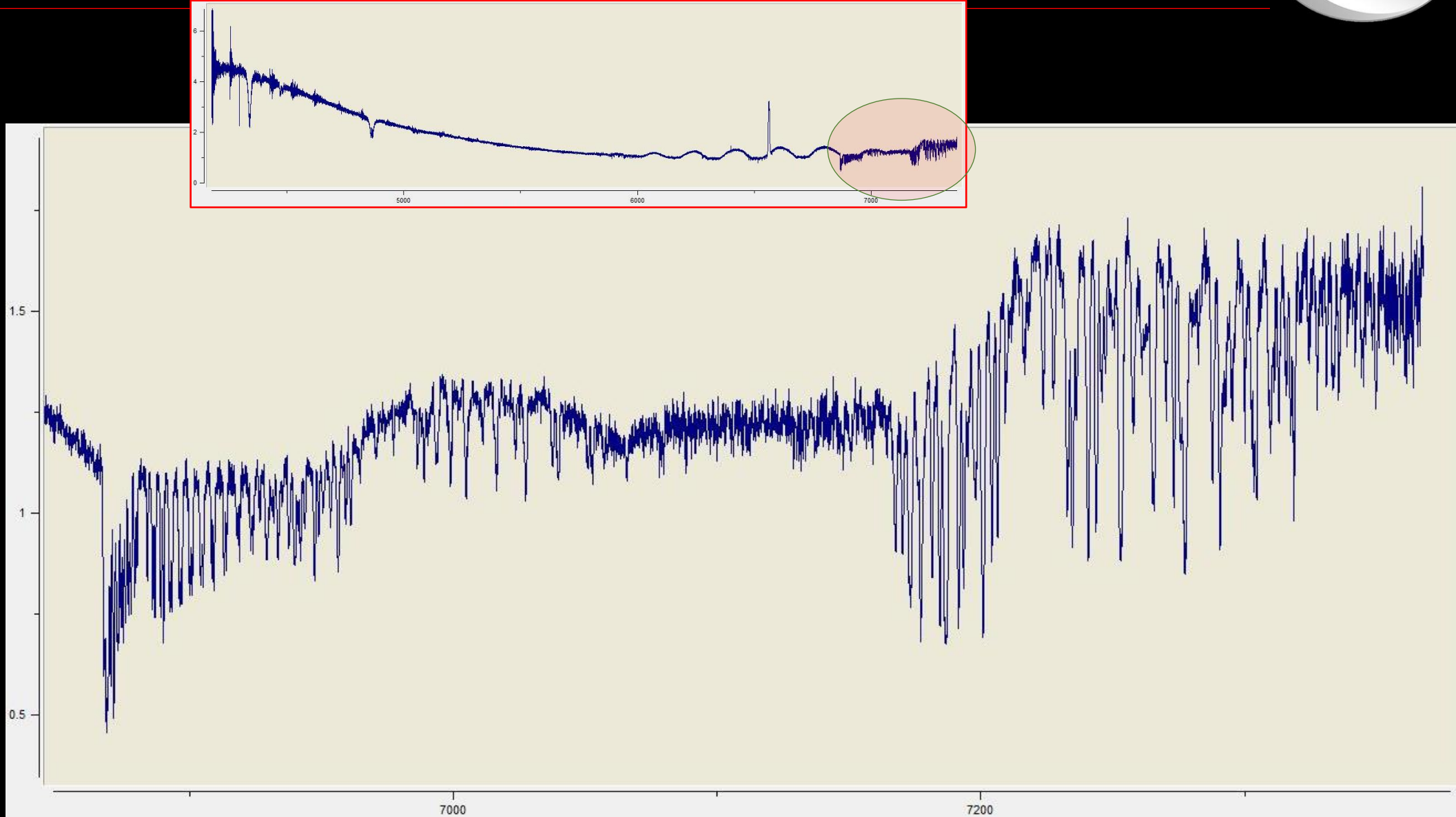
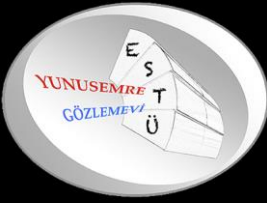
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Configuration choice

New configuration

Spectrograph | Camera | Telescope | Processing

Detect ordres

Minimum order N°

Maximum order N°

Binning area height (pixel)

Detection area width (pixel)

Reference order

Reference order N°

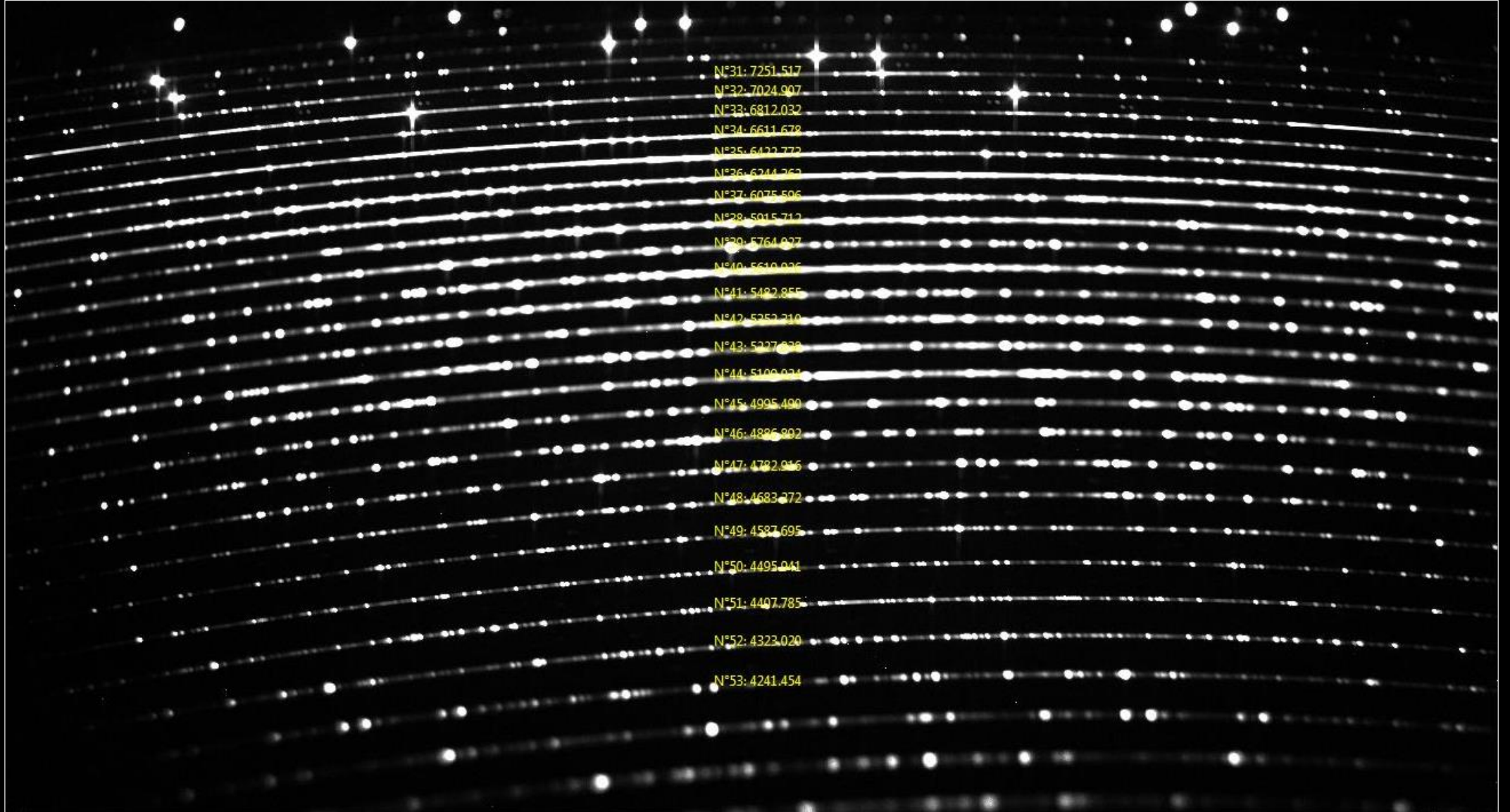
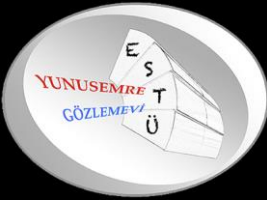
Middle order Y coordinate (pixel)

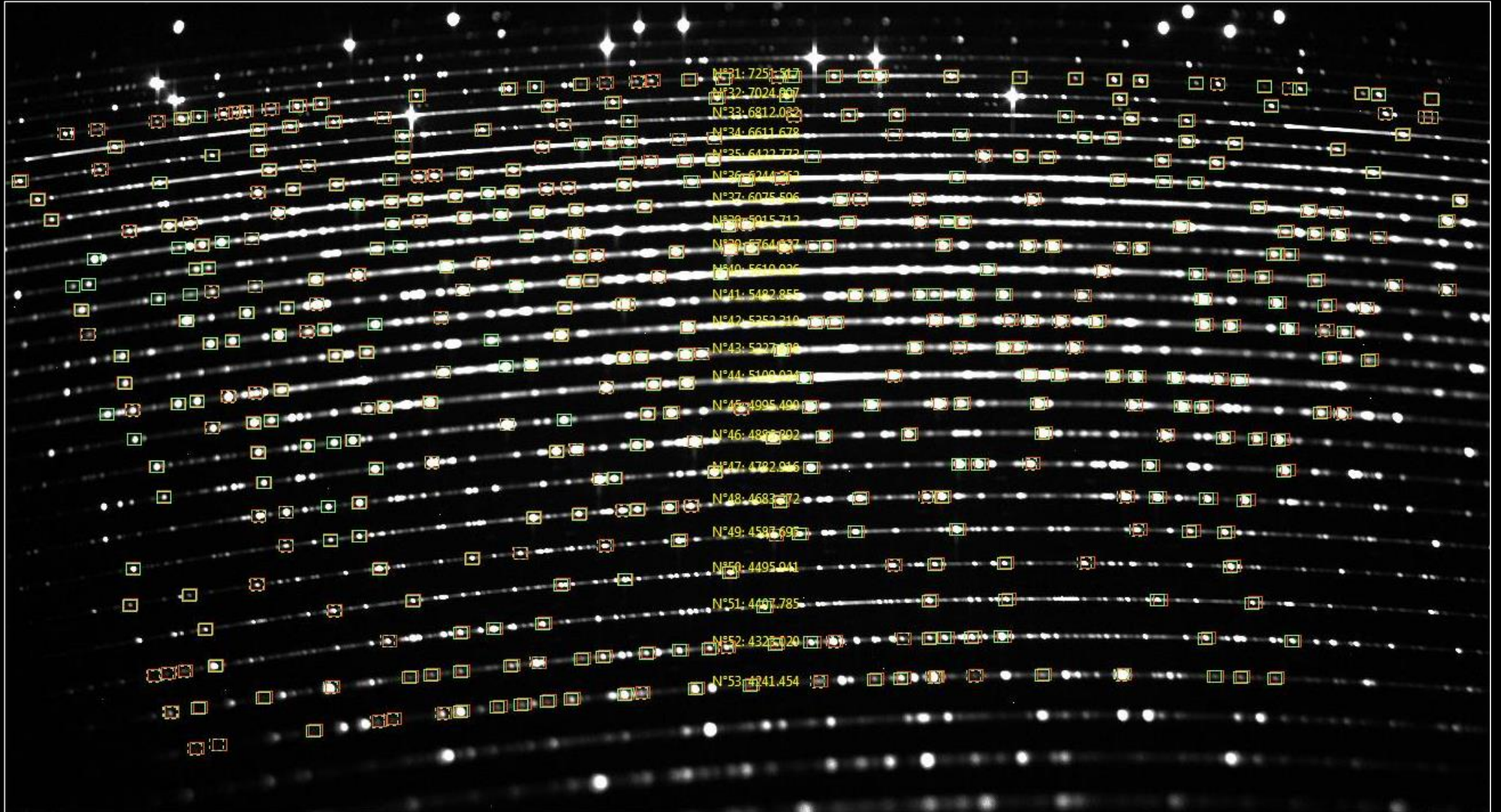
Reference line Lambda (Angstrom)

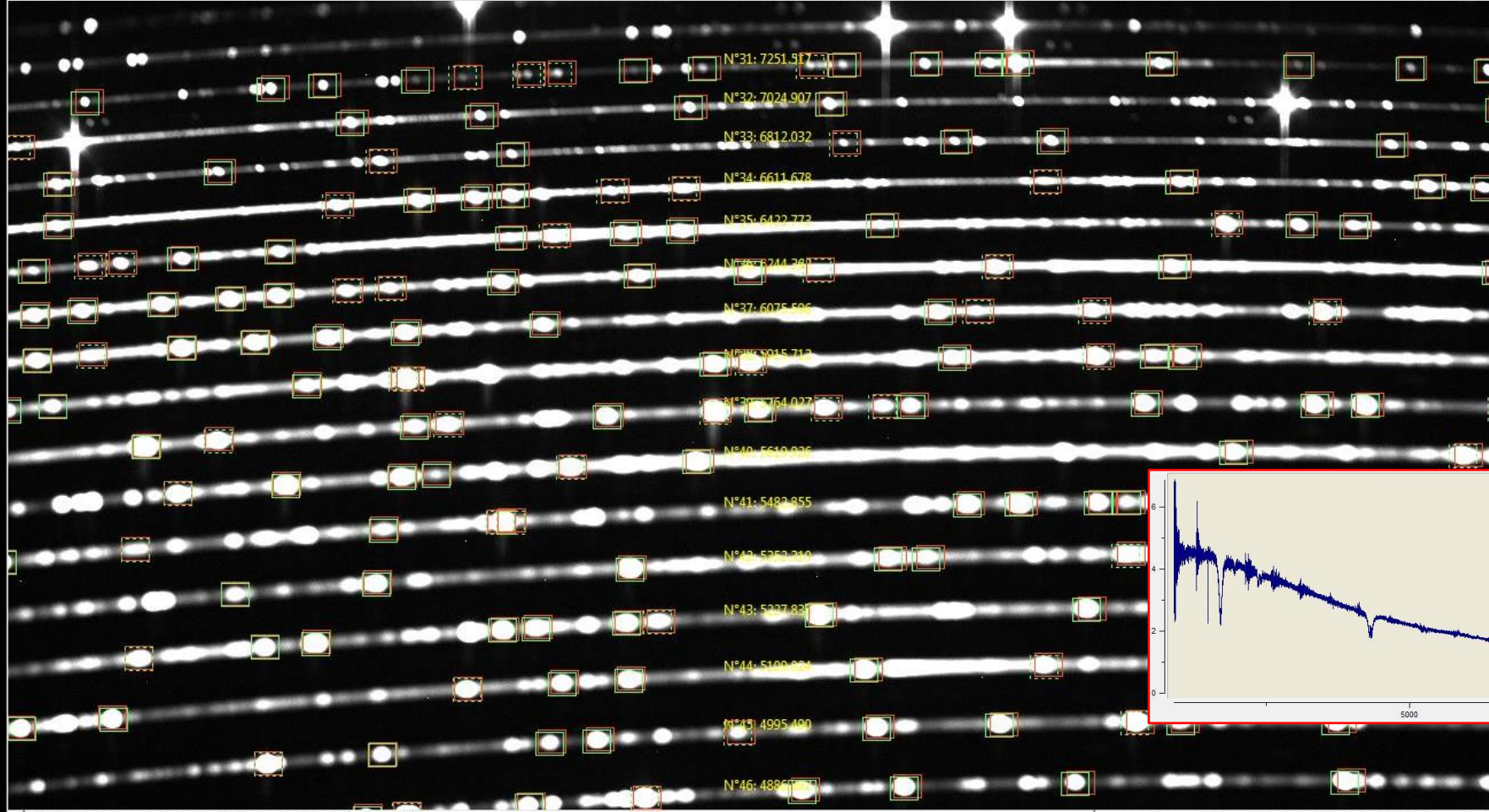
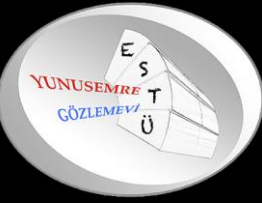
Reference line X abscisse (pixel)

Detection threshold (ADU)

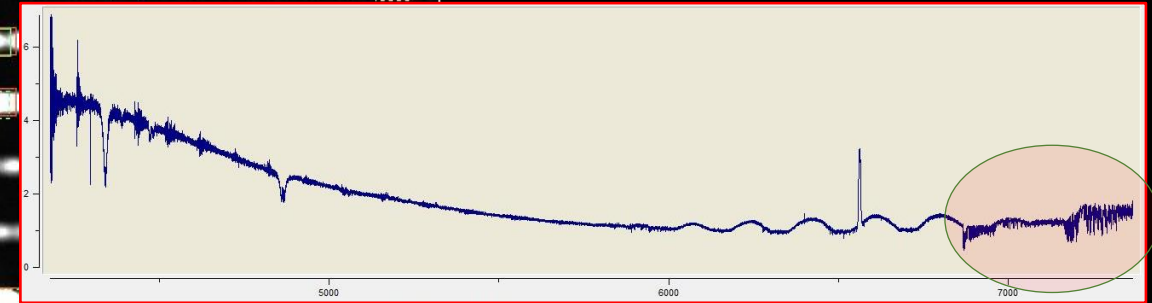
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eShel-process: with FLAT=20220901-094345-FLAT-9x18s.fit
eShel-process: with THAR=20220901-094048-CALIB-7x14s.fit
eShel-process: Calibration result 20220901-094048-CALIB-7x14s.fit
ORDER RMS CENTRAL RMS-CAL RESOLUTION NB LINE
31 0.0595 7251.517 0.0159 11531.7 25
32 0.0254 7024.907 0.0048 11655.3 10
33 0.0231 6812.032 0.0083 11447.1 12
34 0.0465 6611.678 0.0096 11647.4 13
35 0.0842 6422.773 0.0152 12748.5 15
36 0.1393 6244.362 0.0097 12910.4 15
37 0.1999 6075.596 0.0134 13359.9 14
38 0.2325 5915.712 0.0160 12985.9 15
39 0.2460 5764.027 0.0081 12611.2 15
40 0.2493 5619.926 0.0093 13832.9 12
41 0.2588 5482.855 0.0371 13088.4 16
42 0.2854 5352.310 0.0337 12240.3 14
43 0.2868 5227.838 0.0145 12297.7 15
44 0.2673 5109.024 0.0168 12539.2 14
45 0.2631 4995.490 0.0101 13163.1 15
46 0.2359 4886.892 0.0184 12855.9 12
47 0.3076 4782.916 0.0049 12347.0 9
48 0.2123 4683.272 0.0041 12051.1 13
49 0.0643 4587.695 0.0035 11517.4 10
50 0.0347 4495.941 0.0055 11349.2 8
51 0.0788 4407.785 0.0038 11354.1 9
52 0.1669 4323.020 0.0205 13005.8 10
53 0.3288 4241.454 0.0221 13200.3 15
eShel-process: Processing OBJECT-PROCESS : 20210904-211858-20vul-1x4000s.fit
eShel-process: with BIAS=20220901-082916-BIAS-10x0s.fit
eShel-process: with DARK=20220901-083100-DARK-1x4000s.fit
eShel-process: with CALIB=20220901-094048-CALIB-7x14s.fit
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eShel-process: End processing 2022-09-01T09:52:05 TU
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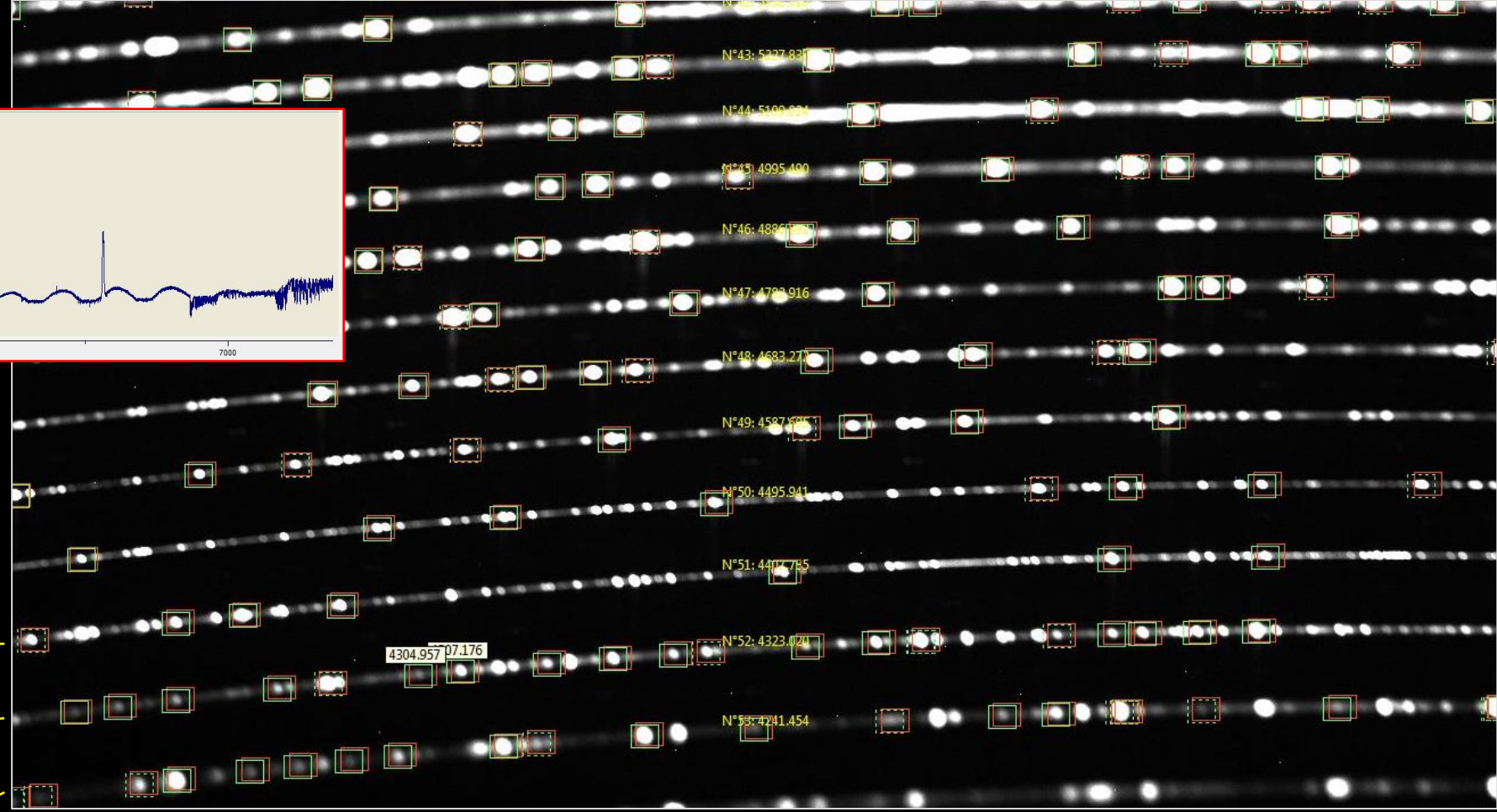
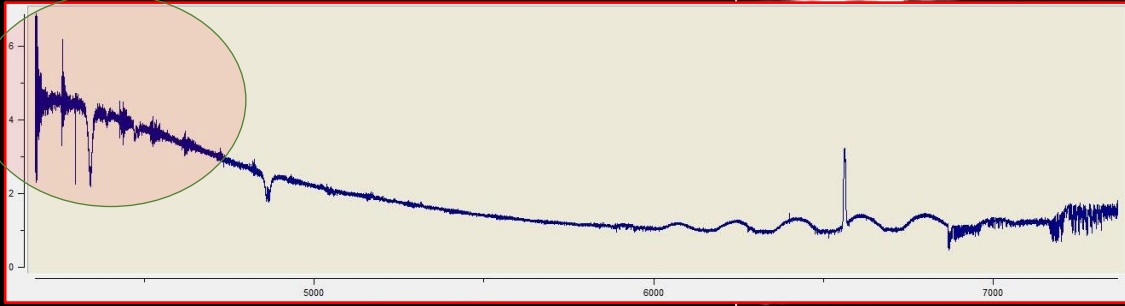
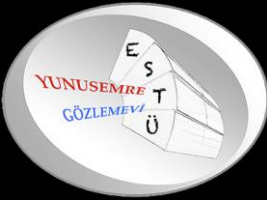






- 31 7251.517
- 32 7024.907
- 33 6812.032
- 34 6611.397





50 4495.941

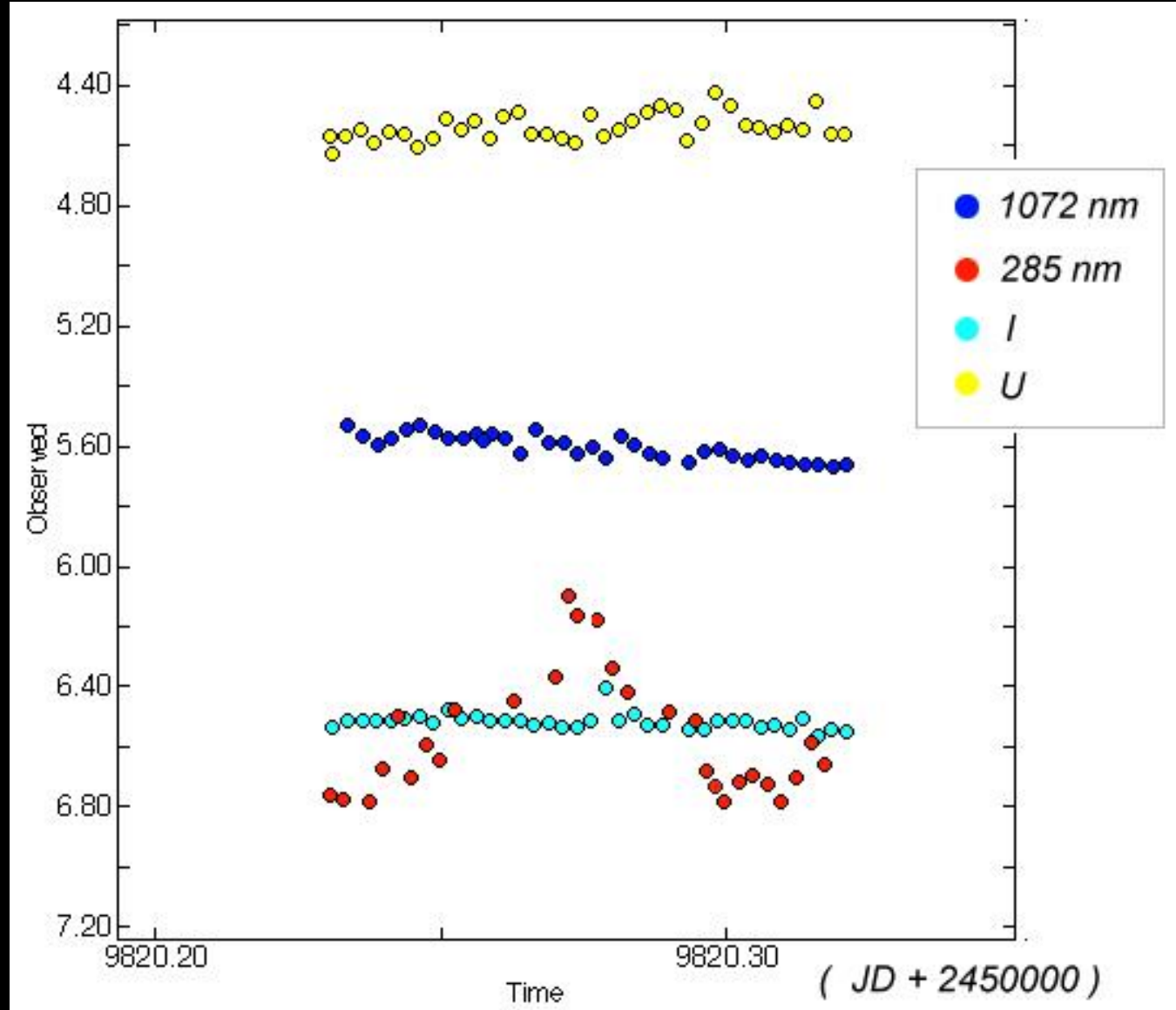
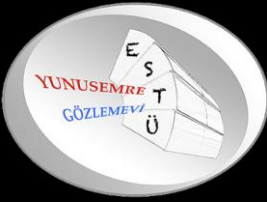
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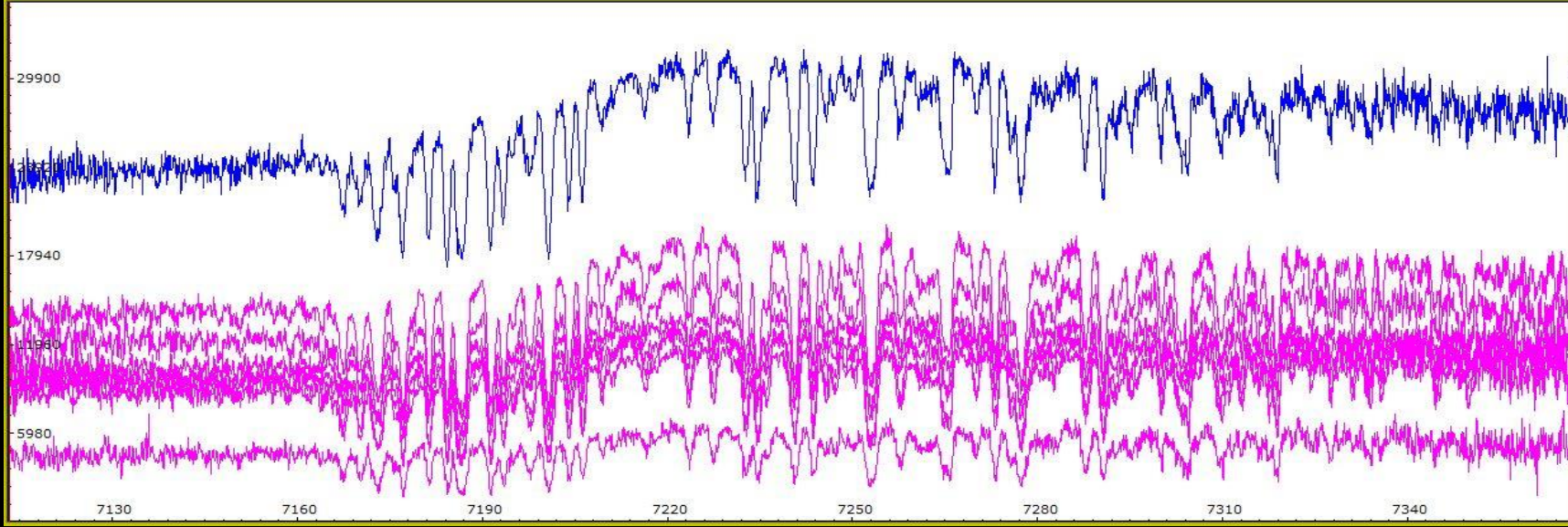
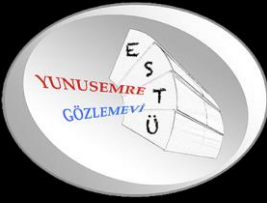
52 4323.020

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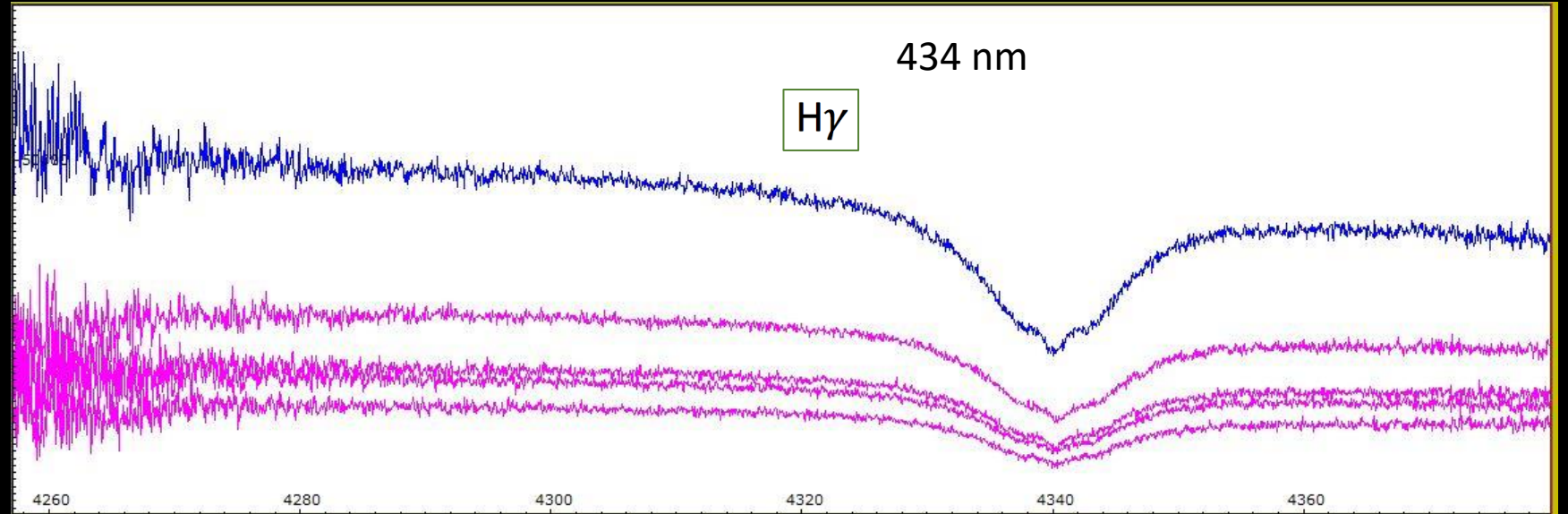
4304.957 407.176

N°42: 4495.941
N°43: 5227.827
N°44: 5100.924
N°45: 4995.490
N°46: 4886.100
N°47: 4789.916
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N°51: 4407.785
N°52: 4323.020
N°53: 4241.454



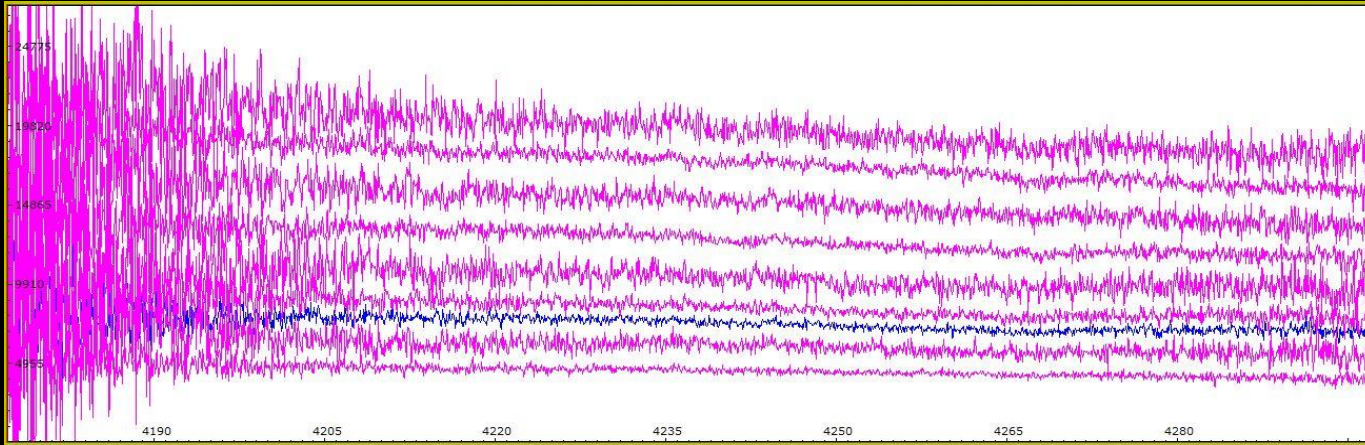
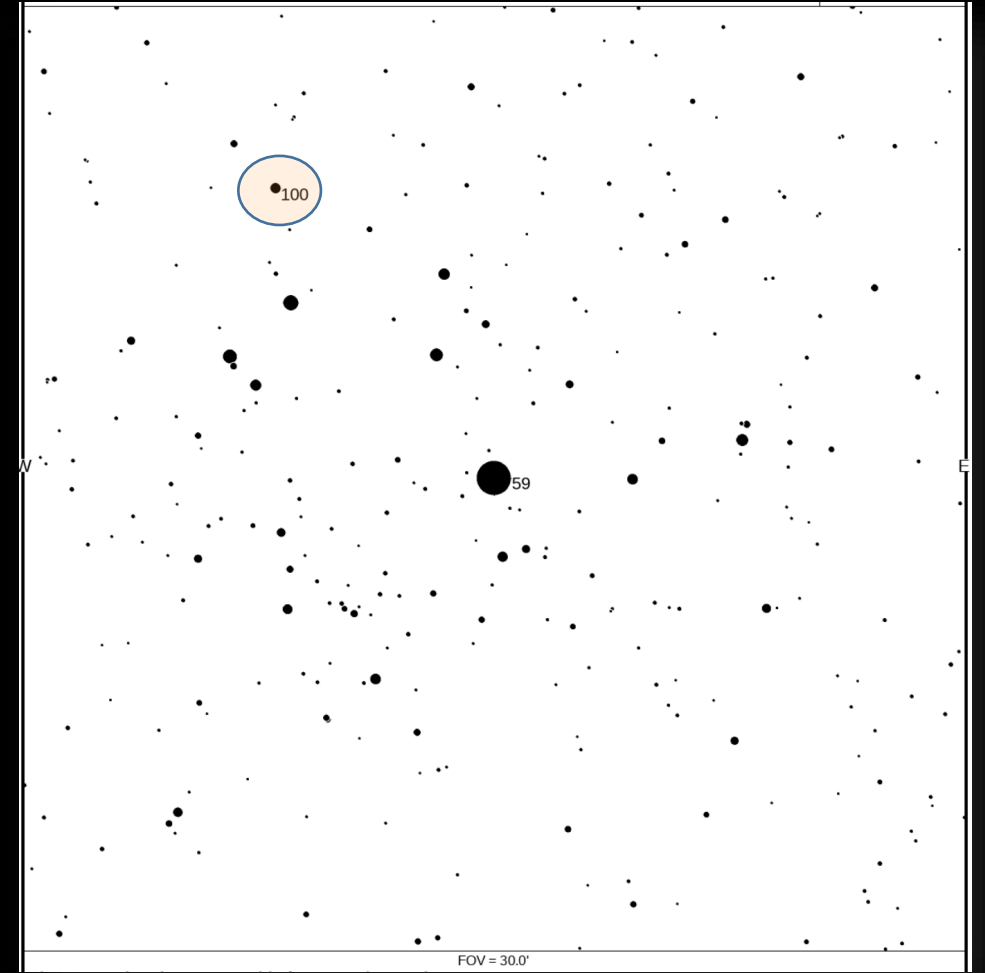
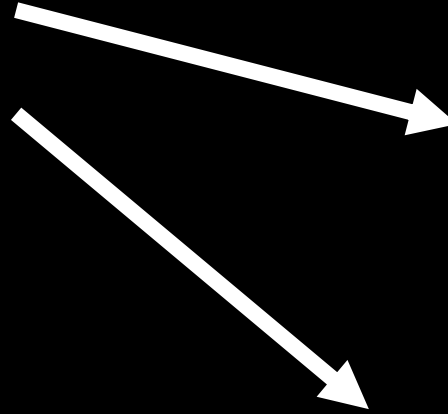
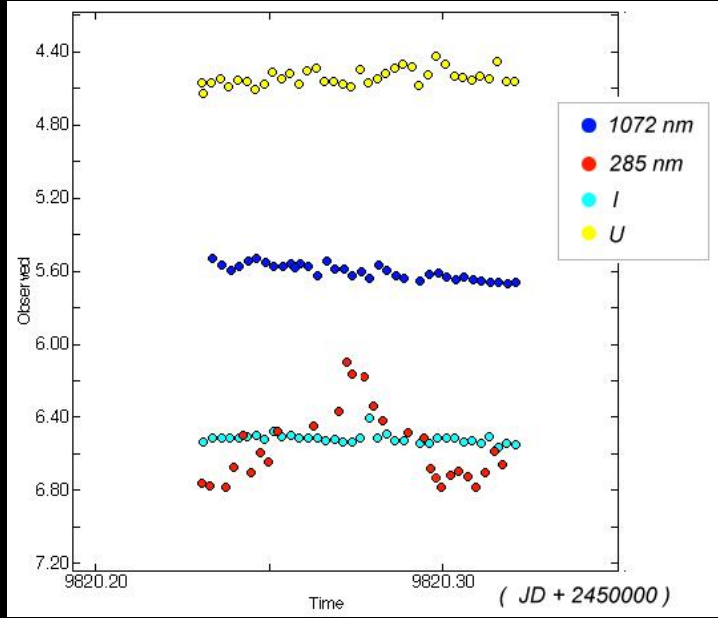


Order 31



Order 52





Order 53

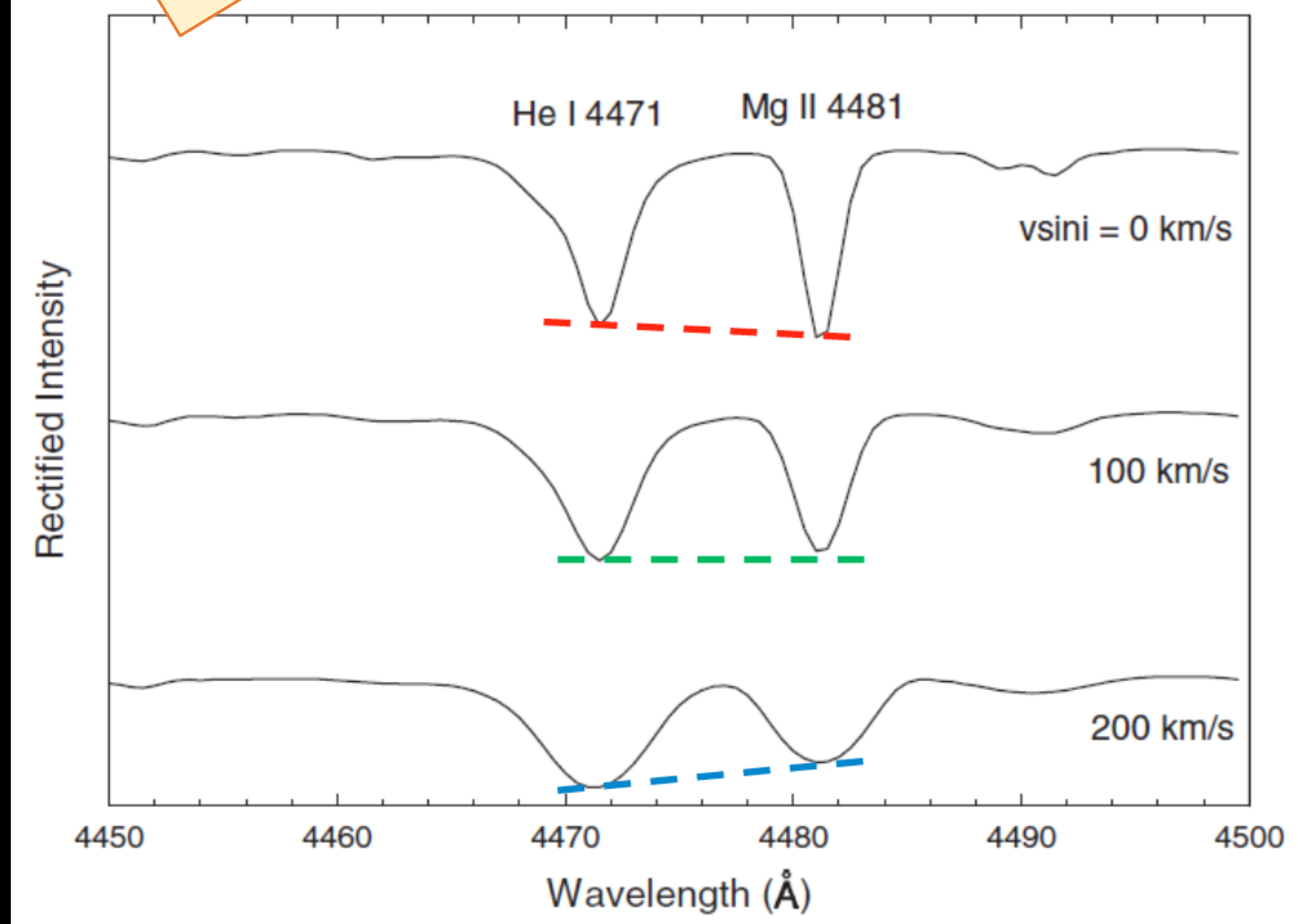


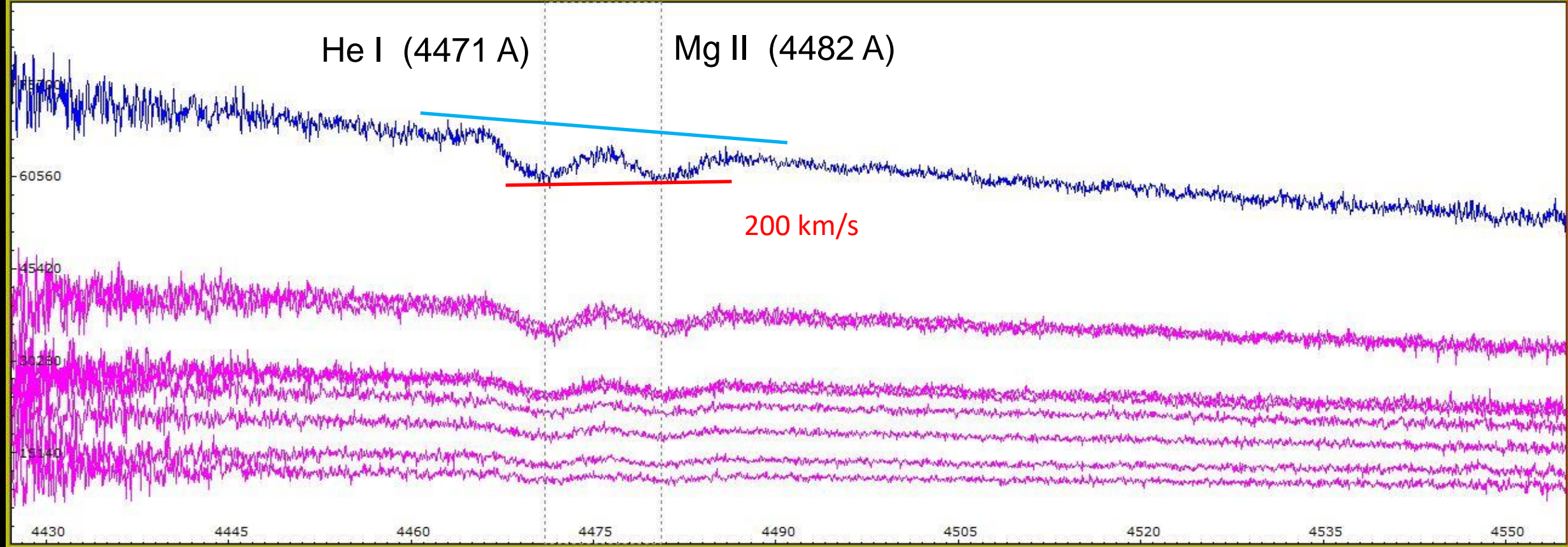
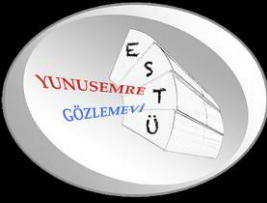


Order 50

Rotasyonel Genişleme

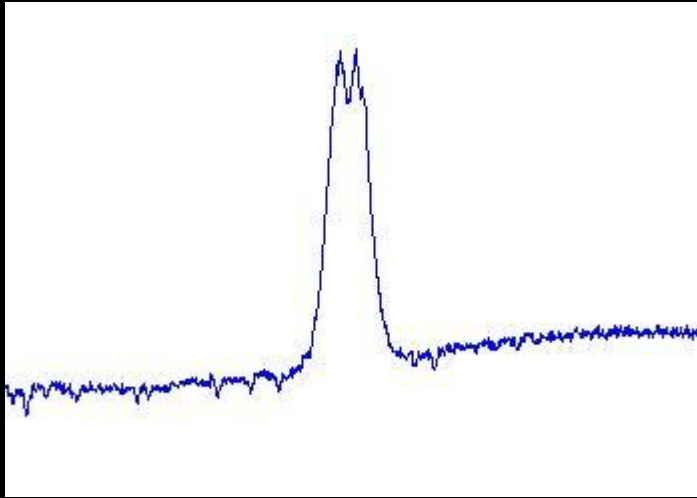
- Yıldızın sınırları Doppler kayması yaşar.
- Absorpsiyon çizgilerinin şeklini etkiler.



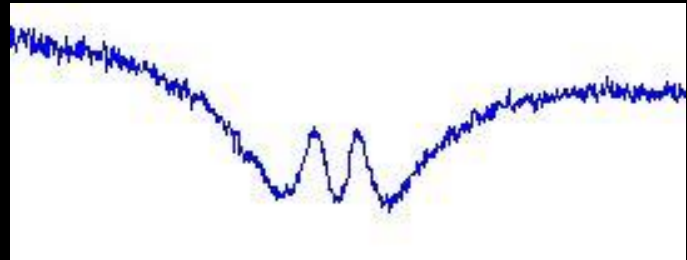




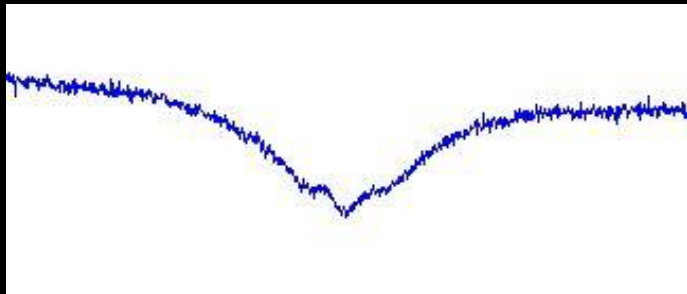
20 Vul



H α

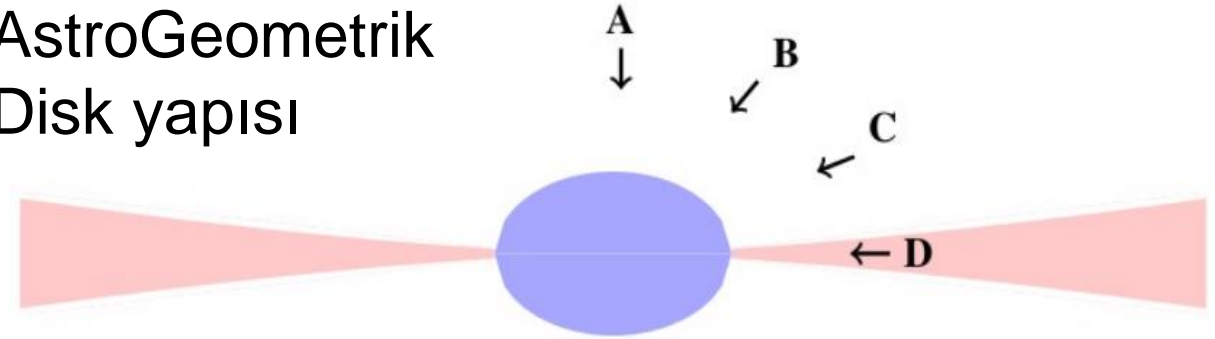


H β

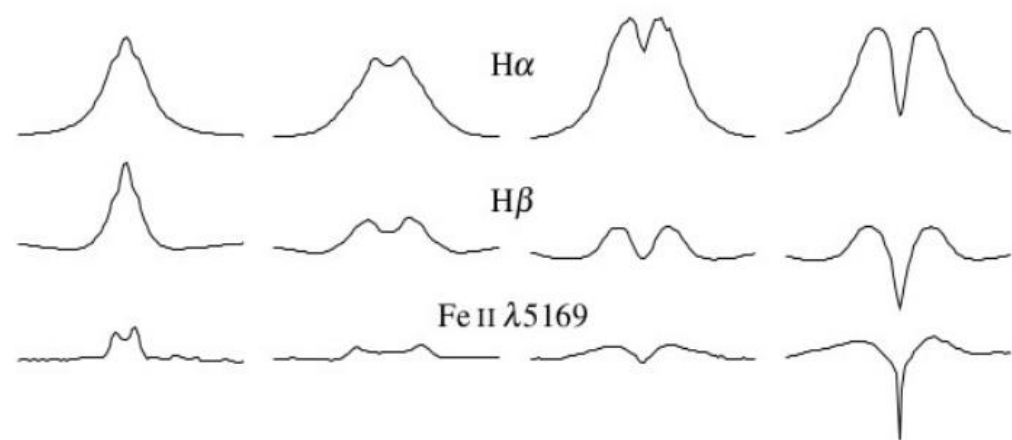


H γ

AstroGeometrik Disk yapısı



A	B	C	D
(HR 5223)	(μ Cen)	(HR 4823)	(<i>o</i> Aqr)





Sonuç ve Öneriler

- Bu çalışma kapsamında 20 Vul yıldızı üzerinden yapılan fotometrik ve tayfsal analizler ve yorumları ile B türü yıldızların genel özellikleri değerlendirilmiştir.
- Fotometrik gözlem çalışmalarında merkezdeki yıldızın parlaklık değişkenliğini incelemek için standart U filtresine ilaveten 285nm dalgaboyuna duyarlı filtre kullanılmıştır. I filtresine ilaveten de 1072nm dalgaboyuna duyarlı filtre kullanılarak yıldızın dağılma diskine ait parlaklık değişkenliği değerlendirilmiştir.
- Yapılan işlemin sonucunda yıldızın ve dağılma diskinin parlaklık değişkenliği birbirinden ayrılarak incelenebilmiştir.



Sonuç ve Öneriler

- Fotometrik gözlemlerle eş zamanlı yaptığımız tayfsal gözlemler sırasında yıldızın ve dağılma diskinin tayfsal değişkenliğini ayırt edebilmek için echelle tayf çekerin standart 32-51 orderlarına ilaveten 31-53 orderlarında değerlendirilmiştir.
- Yapılan odaklama uygulaması sonucunda 31. order odaklı çalışmalarda dağılma diskinin ait değişkenlik belirlenmesinde hassasiyet yakalandı.
- 53. order odaklı çalışmalarımızda ise yıldıza ait tayfsal değişkenlik daha detaylı incelenebilmiştir.
- Çalışmaların bundan sonraki aşamalarında elementlerin çizgi tanımlamaları ve sentez mekanizmaları incelenerek tayfsal değişkenlikler detaylandırılarak yıldızın evrim süreci takip edilecektir.



Kaynakça

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- Rivinius, Thomas, et al, Rapidly Rotating B Stars with Viscous Keplerian Decretion Disks, Astronomy & Astrophysics, 2013
- Klement, R., et al, Revealing the structure of the outer disks of Be stars, Astronomy & Astrophysics, 2017.