Spectroscopic Astronomy

David Aguado

OECE 2026

BeiHang University



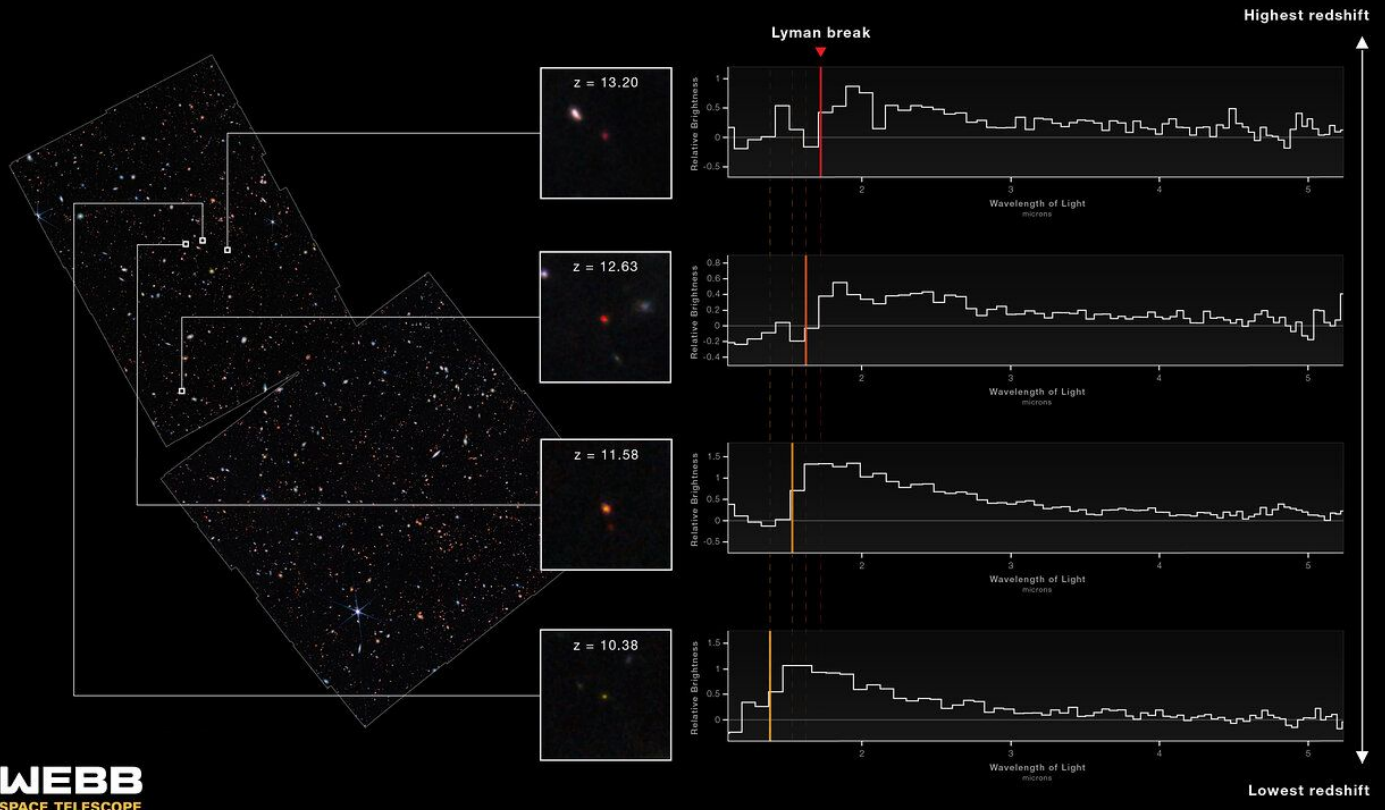
SESSION 1



ESA-JWST

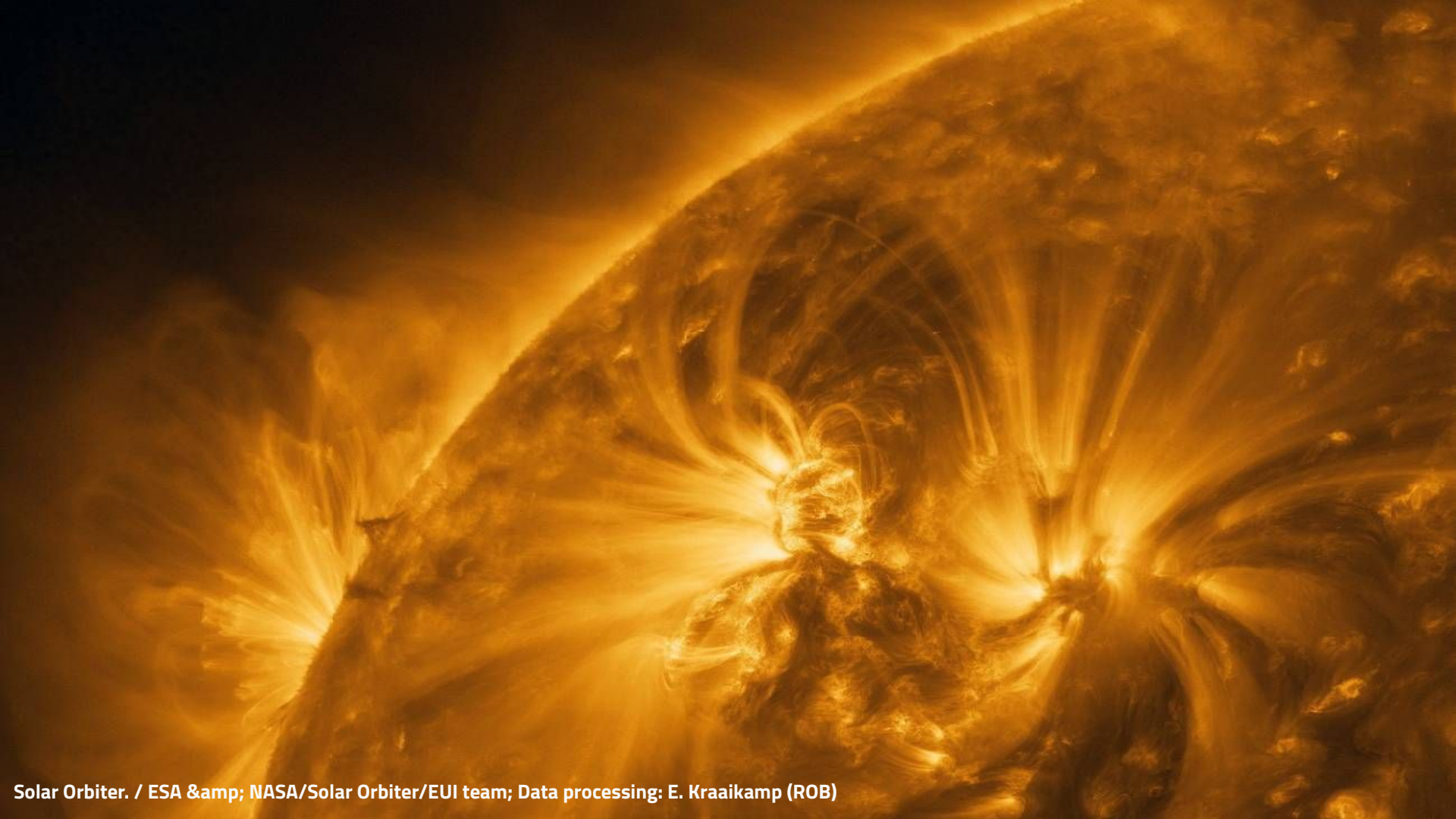
JWST ADVANCED DEEP EXTRAGALACTIC SURVEY (JADES)

WEBB SPECTRA REACH NEW MILESTONE IN REDSHIFT FRONTIER

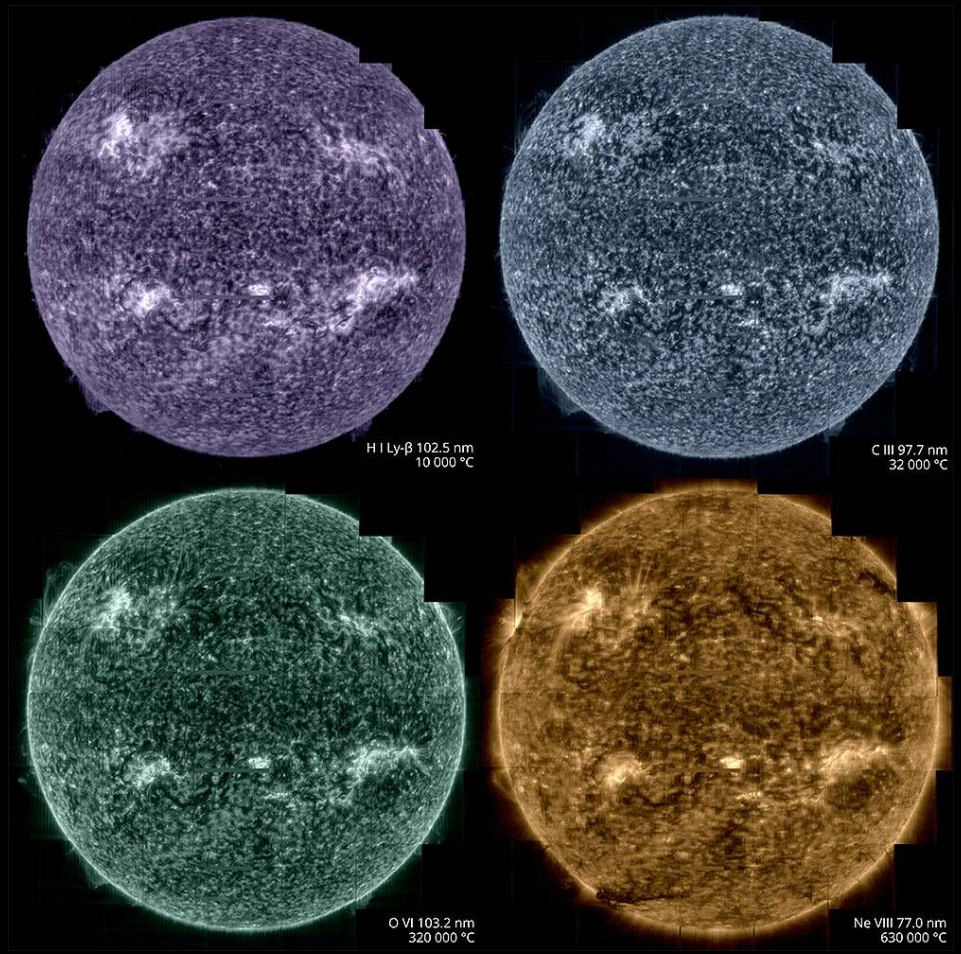


WEBB SPACE TELESCOPE

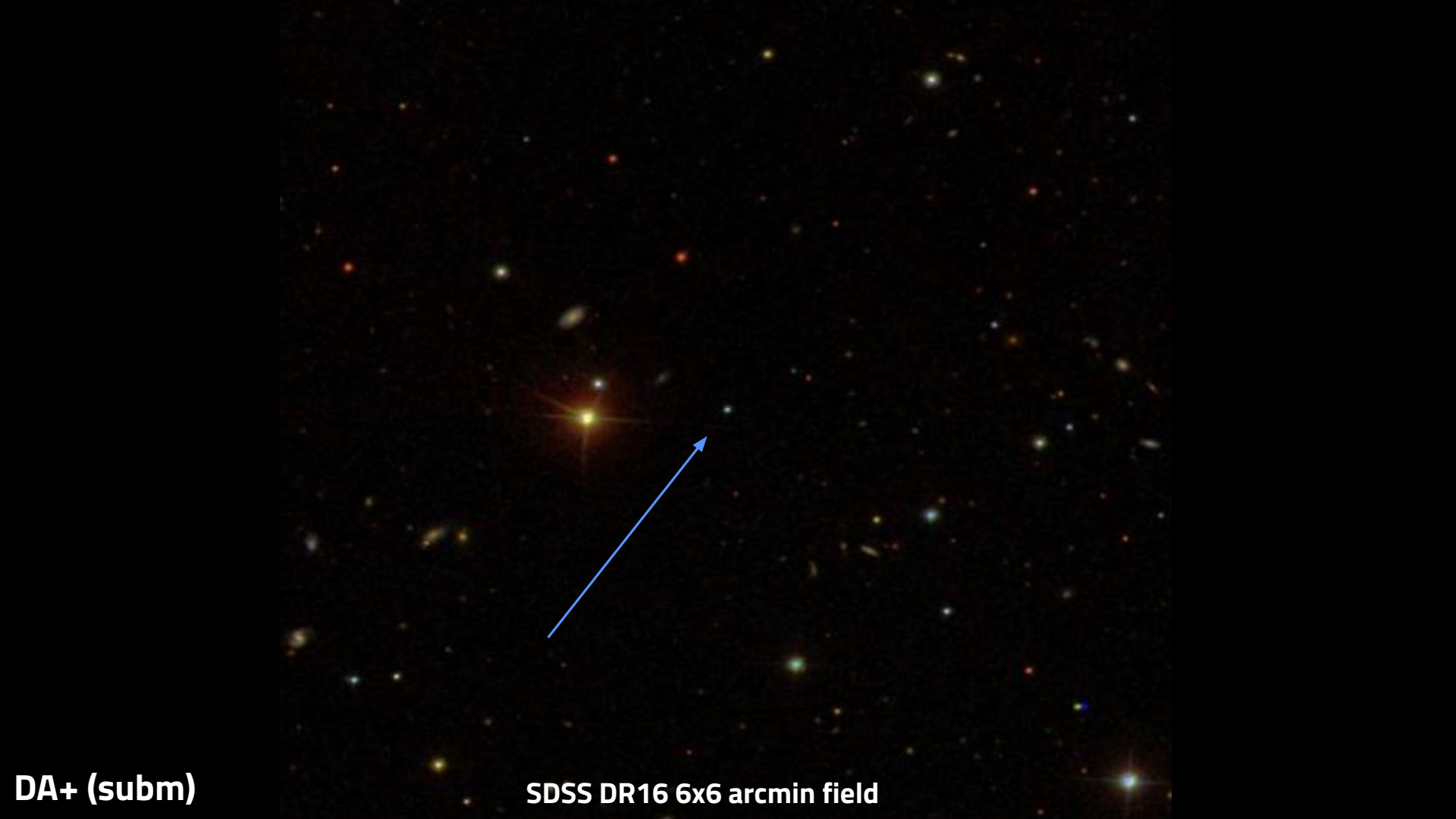
ESA-JWST

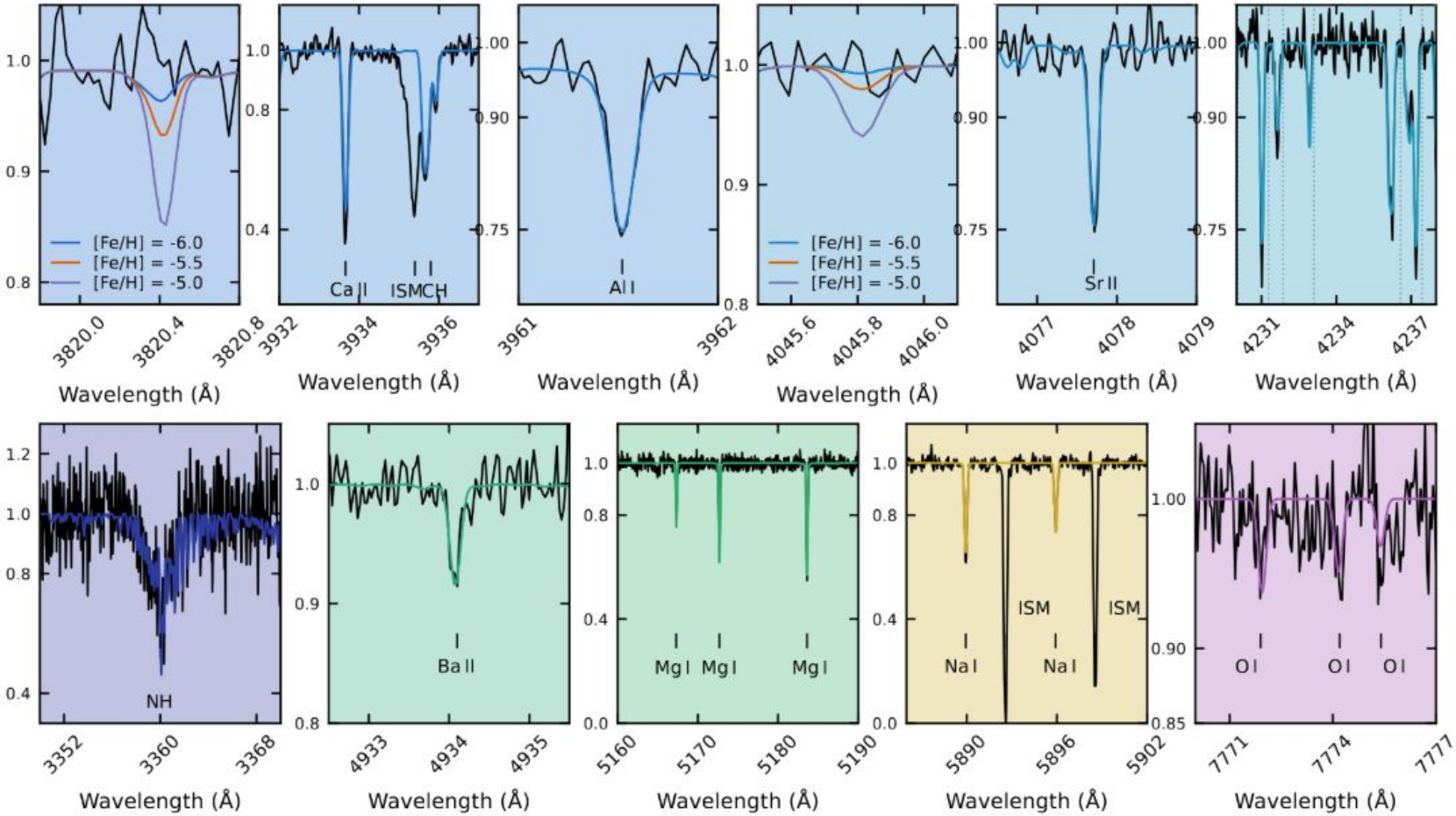


Solar Orbiter. / ESA & NASA/Solar Orbiter/EUI team; Data processing: E. Kraaikamp (ROB)



ESA & NASA/Solar Orbiter/SPICE team; Data processing: G. Pelouze (IAS).


DA+ (subm)
SDSS DR16 6x6 arcmin field

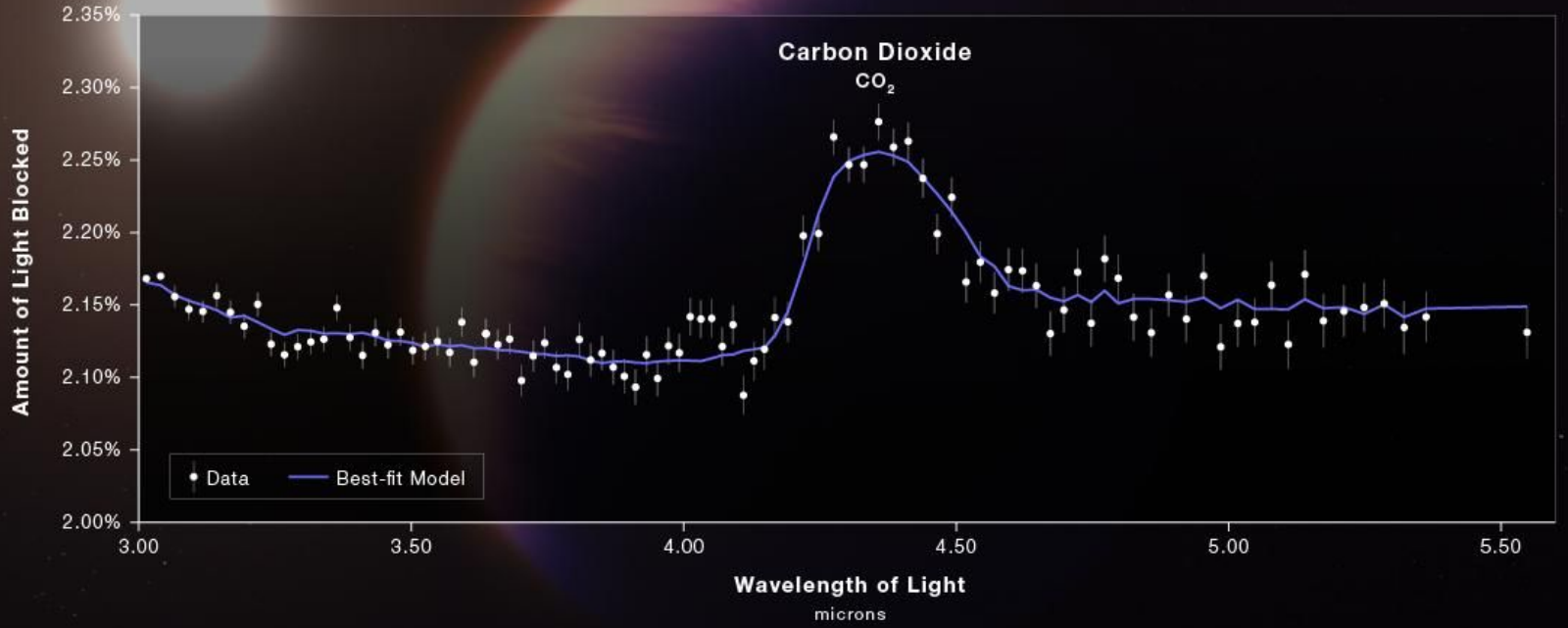

[Fe/H] = -6.0
[Fe/H] = -5.5
[Fe/H] = -5.0
Ca II
ISM
CH
Al I
Sr II
NH
Ba II
Mg I
Mg I
Mg I
ISM
ISM
Na I
Na I
O I
O I
O I
Wavelength (Å)

DA+ (subm)

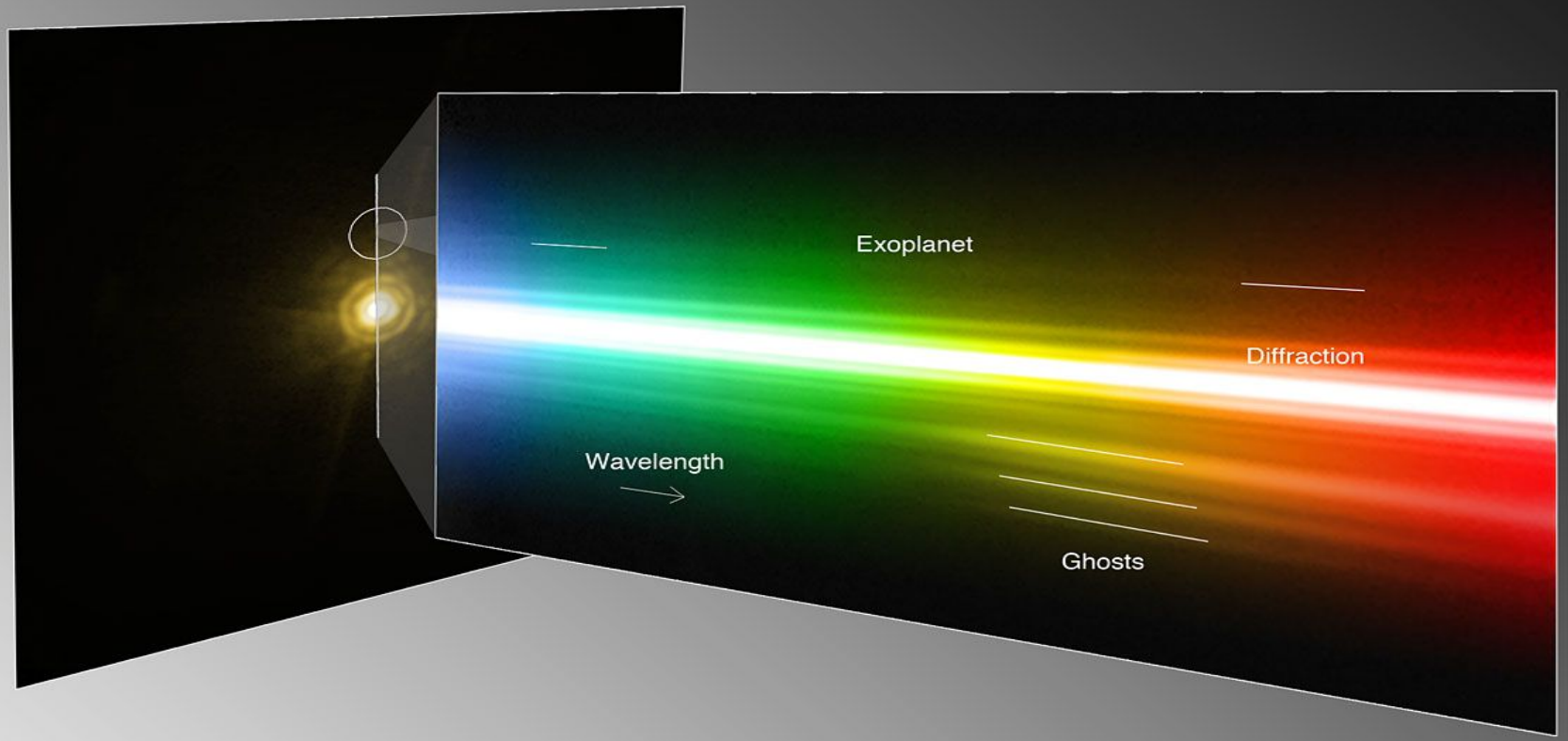
HOT GAS GIANT EXOPLANET WASP-39 b

ATMOSPHERE COMPOSITION

NIRSpec | Bright Object Time-Series Spectroscopy



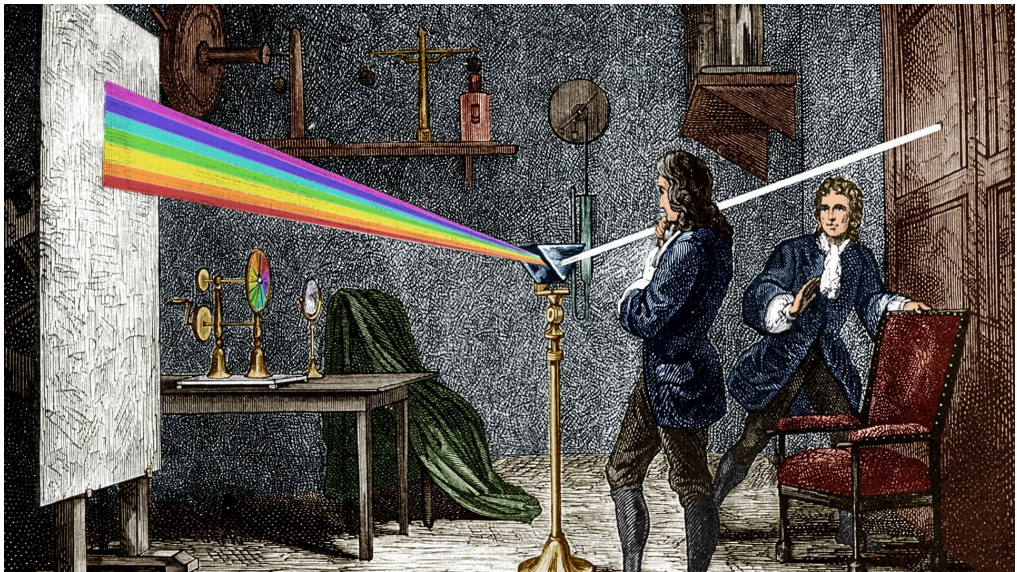
WEBB
SPACE TELESCOPE



HR 8799 planetary system: SO/M. Janson

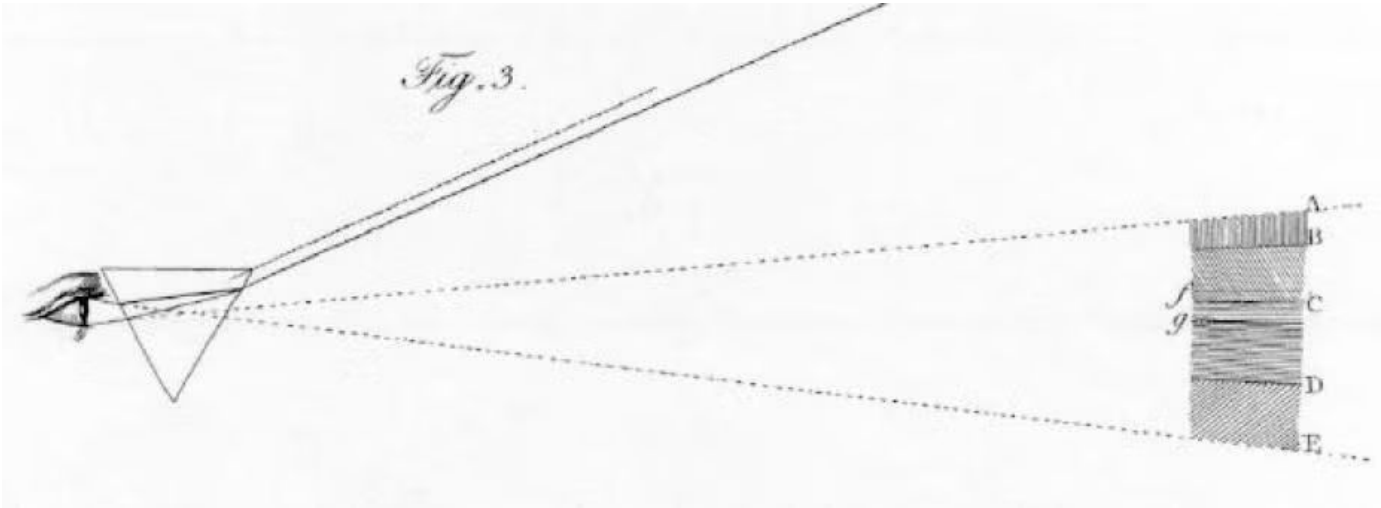
From Newton to Fraunhofer: The discovery of spectral fingerprints

1666 — Isaac Newton: Demonstrates that white light contains different colours using a prism.



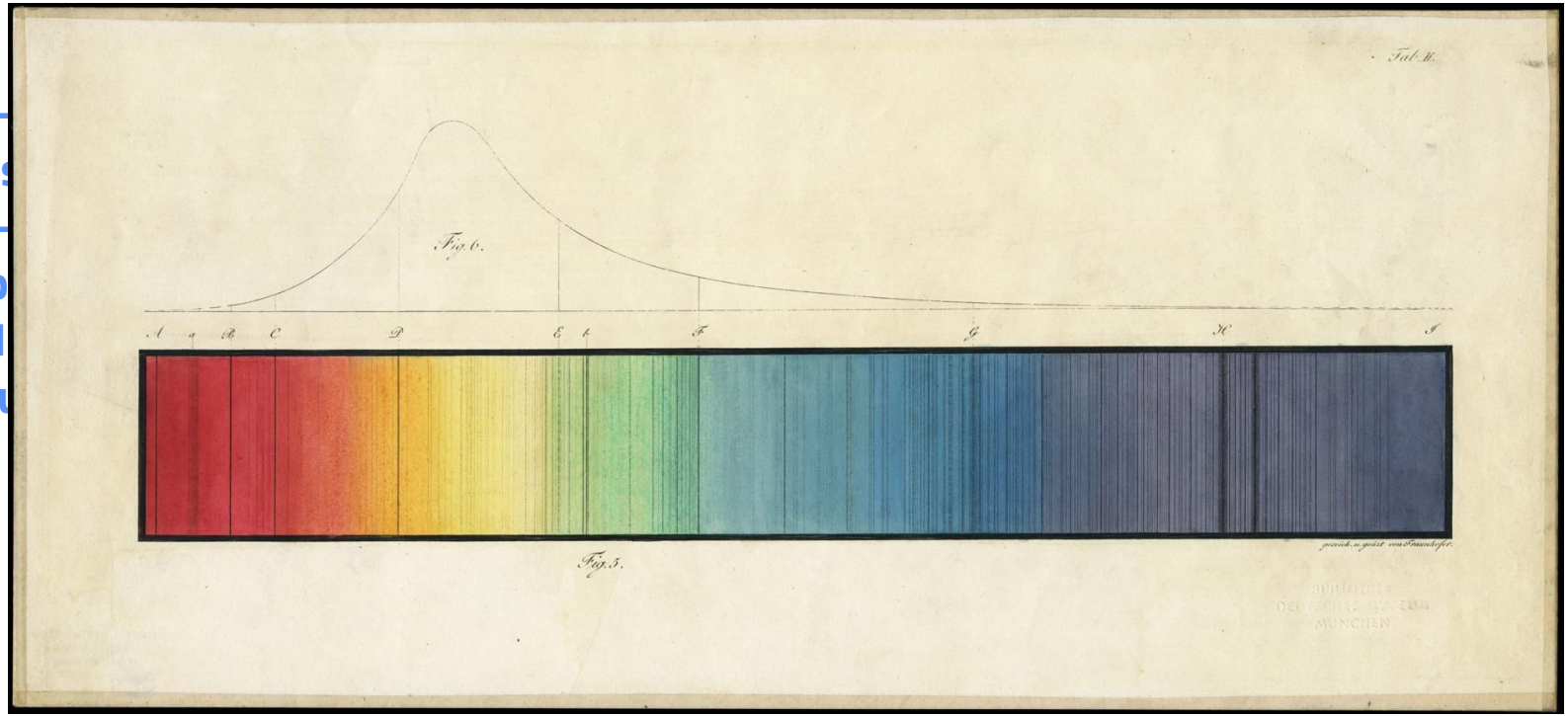
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From Newton to Fraunhofer: The discovery of spectral fingerprints

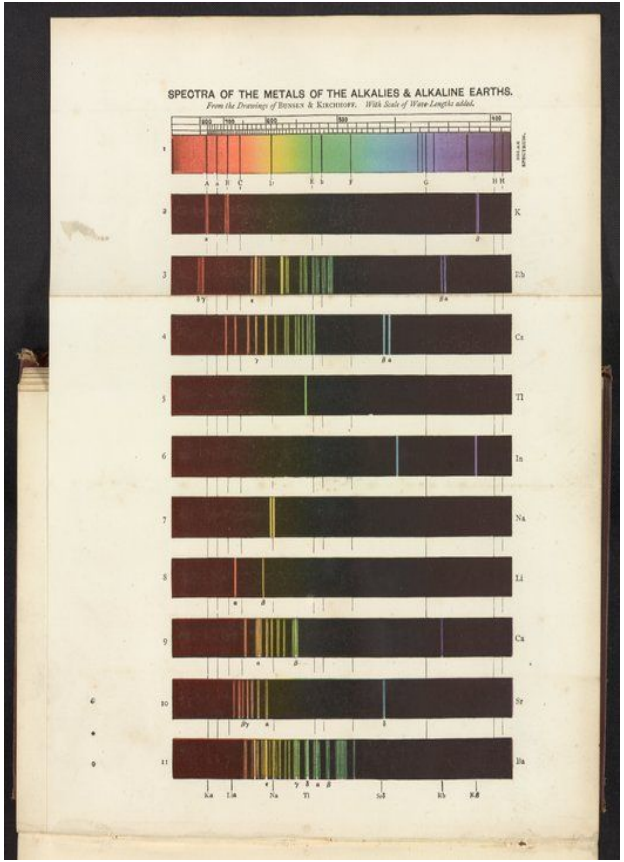
1666 –
contains
1802 –
solar sp
1814–1
maps hu



Source: Fraunhofer Society / historical archives.

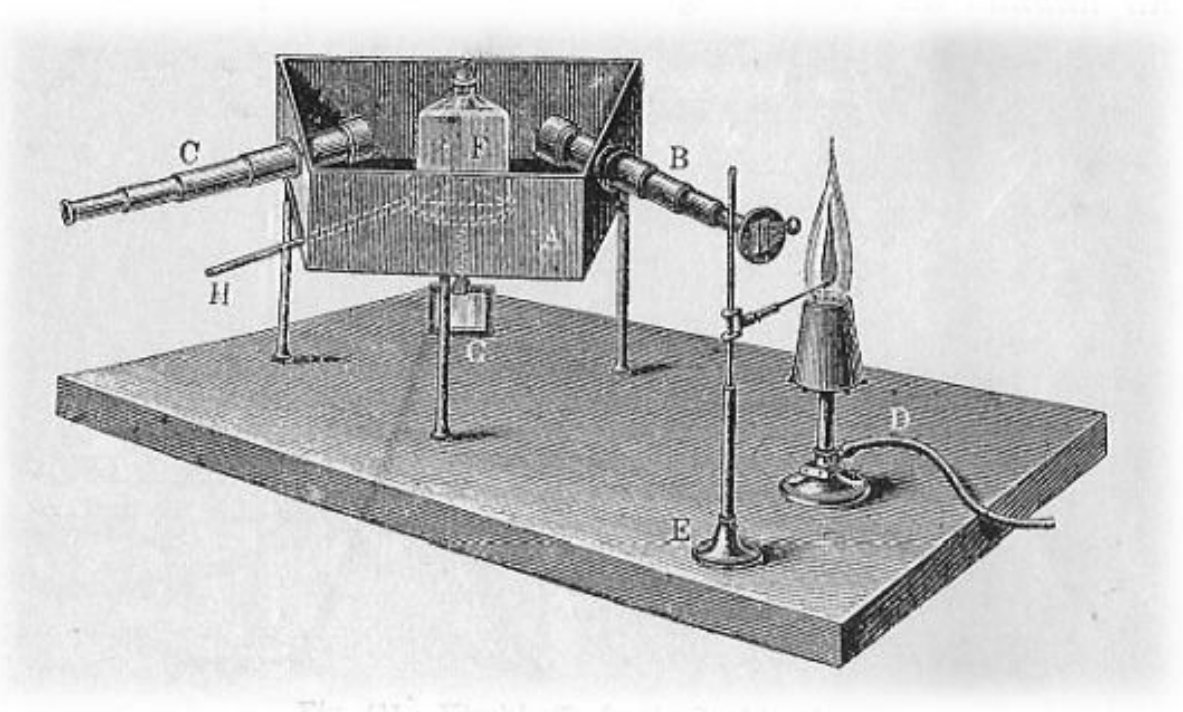
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Kirchhoff & Bunsen, Chemische Analyse durch Spectralbeobachtungen (1860)

From Newton to Fraunhofer: The discovery of spectral fingerprints

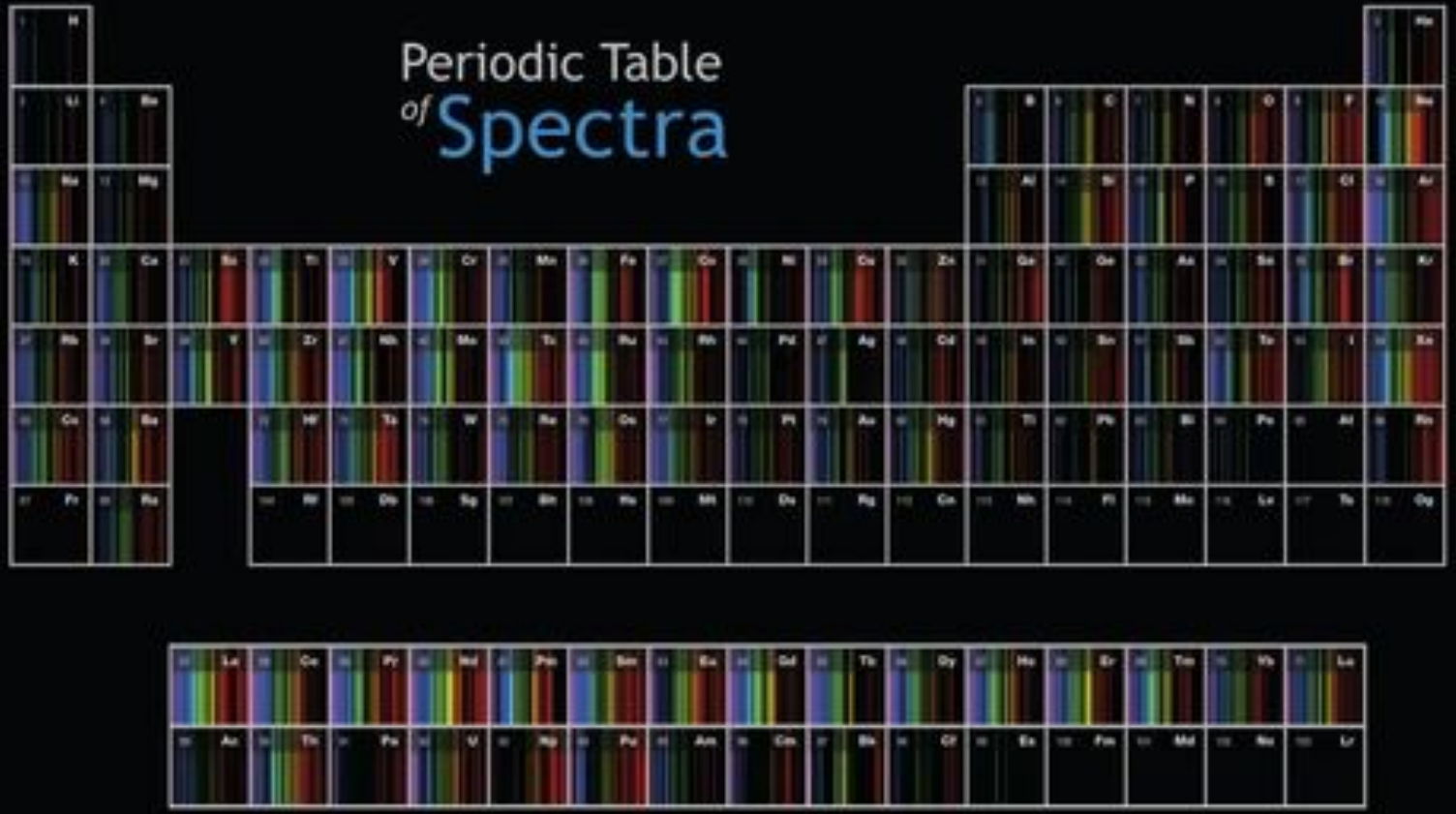


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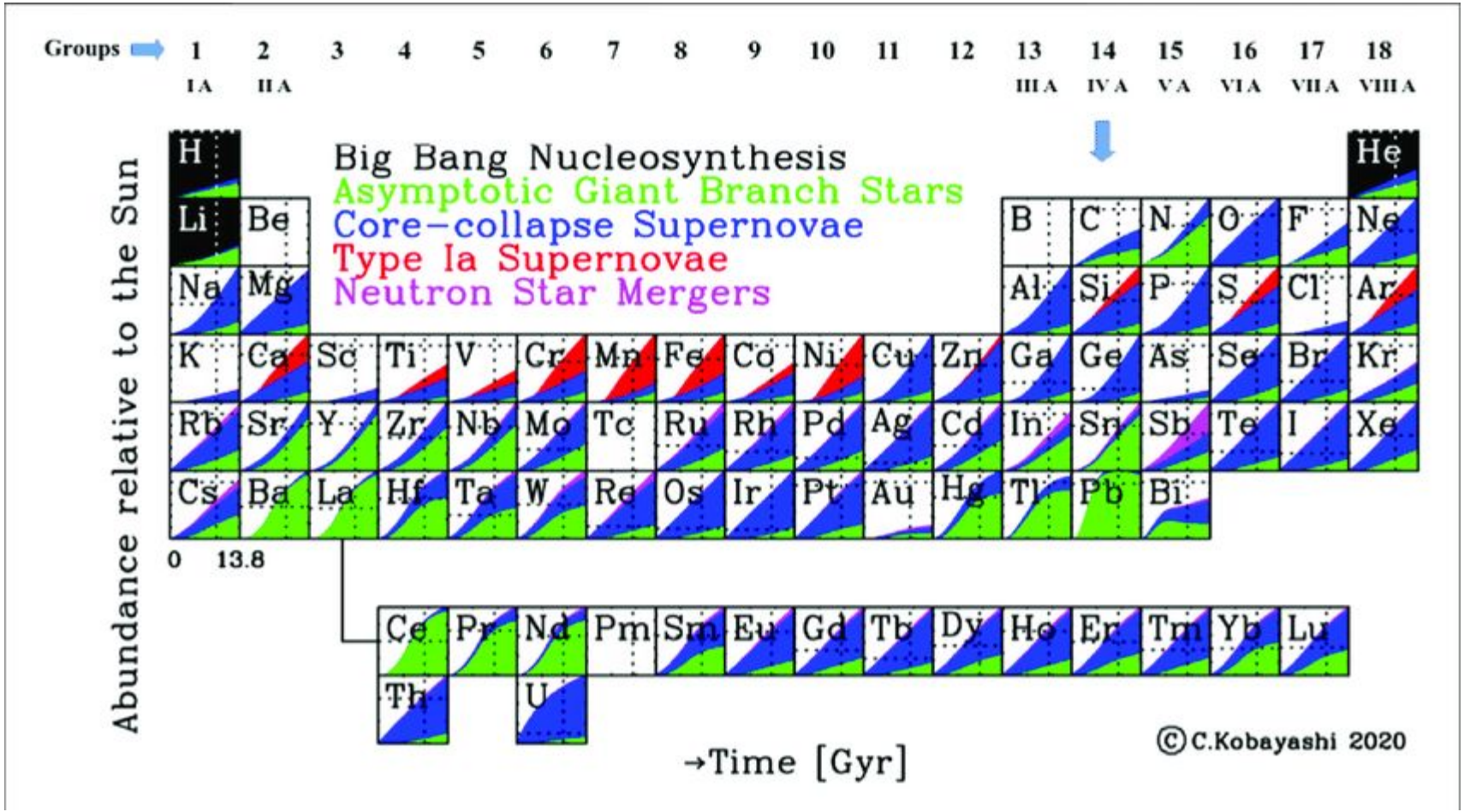
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Late 19th century: Spectroscopy becomes a fundamental tool for stellar classification and astrophysics.

Periodic Table of Spectra

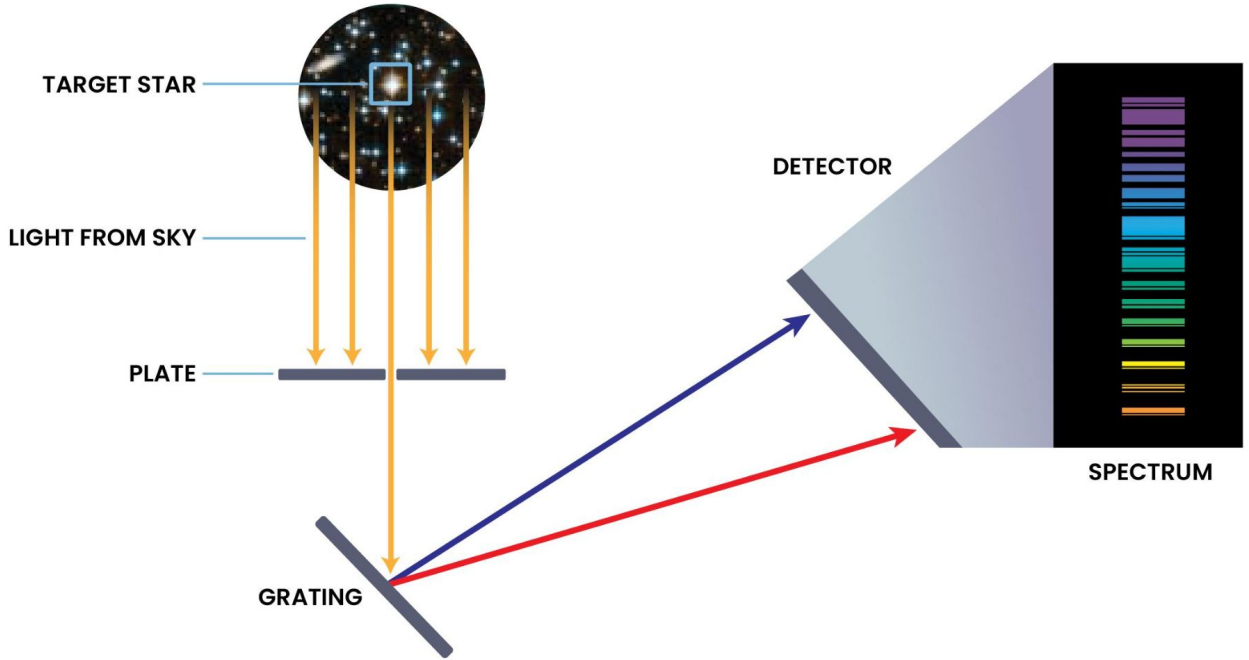


field-tested systems



Kobayashi et al. 2020

How a Spectrograph Works: Dispersing and recording light



How a Spectrograph Works: Dispersing and recording light

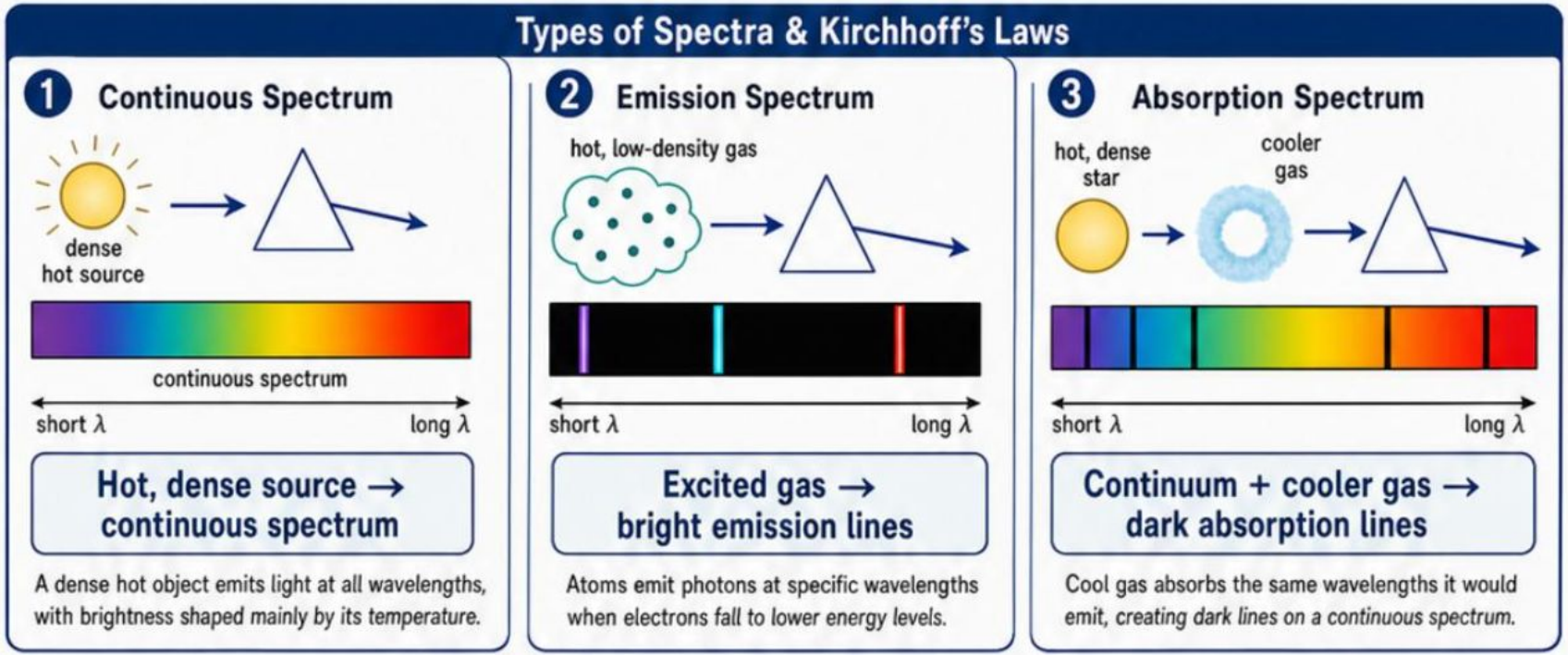
Entrance slit > **Collimator** > **Disperser** > **Camera** > **Detector**

Light selection → Parallel beam → Wavelength separation → Focusing → Signal recording

$$F_\lambda = f(\lambda)$$

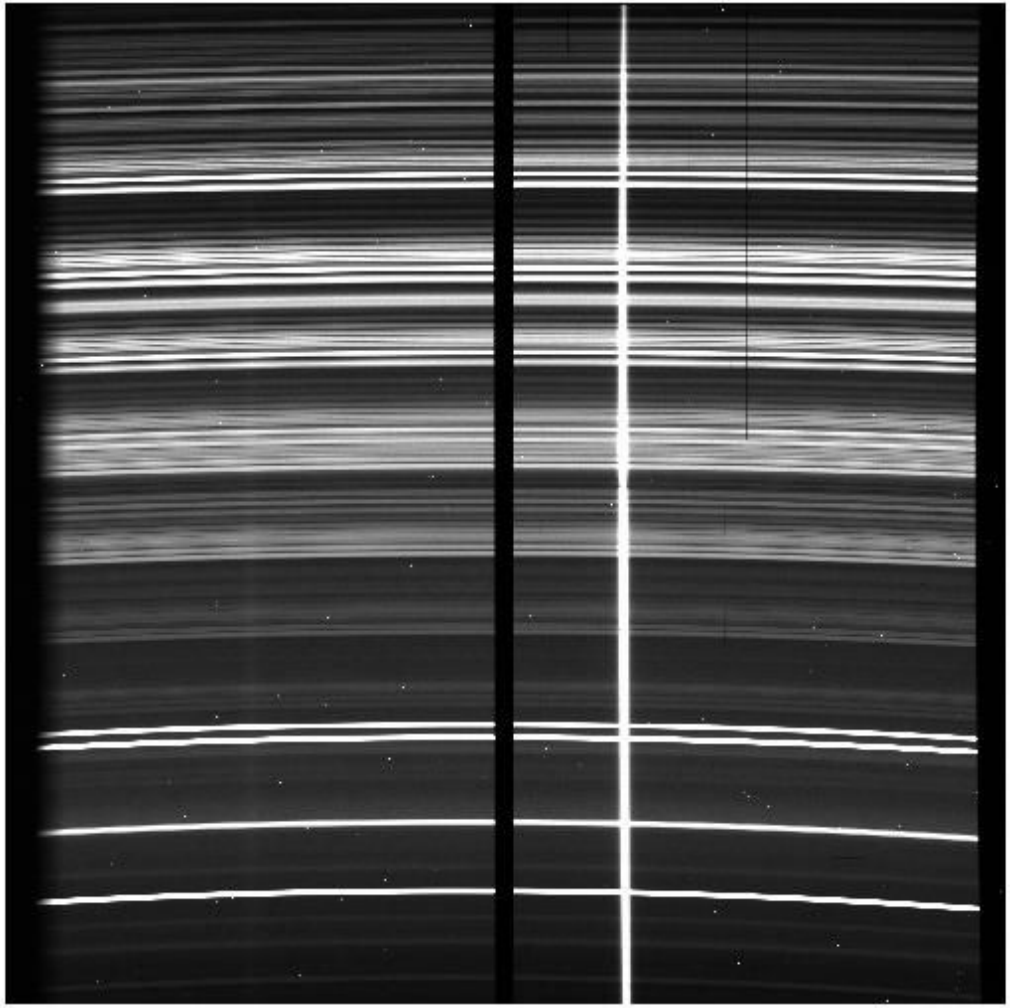
$$R = \frac{\lambda}{\Delta\lambda}$$

How a Spectrograph Works: Dispersing and recording light



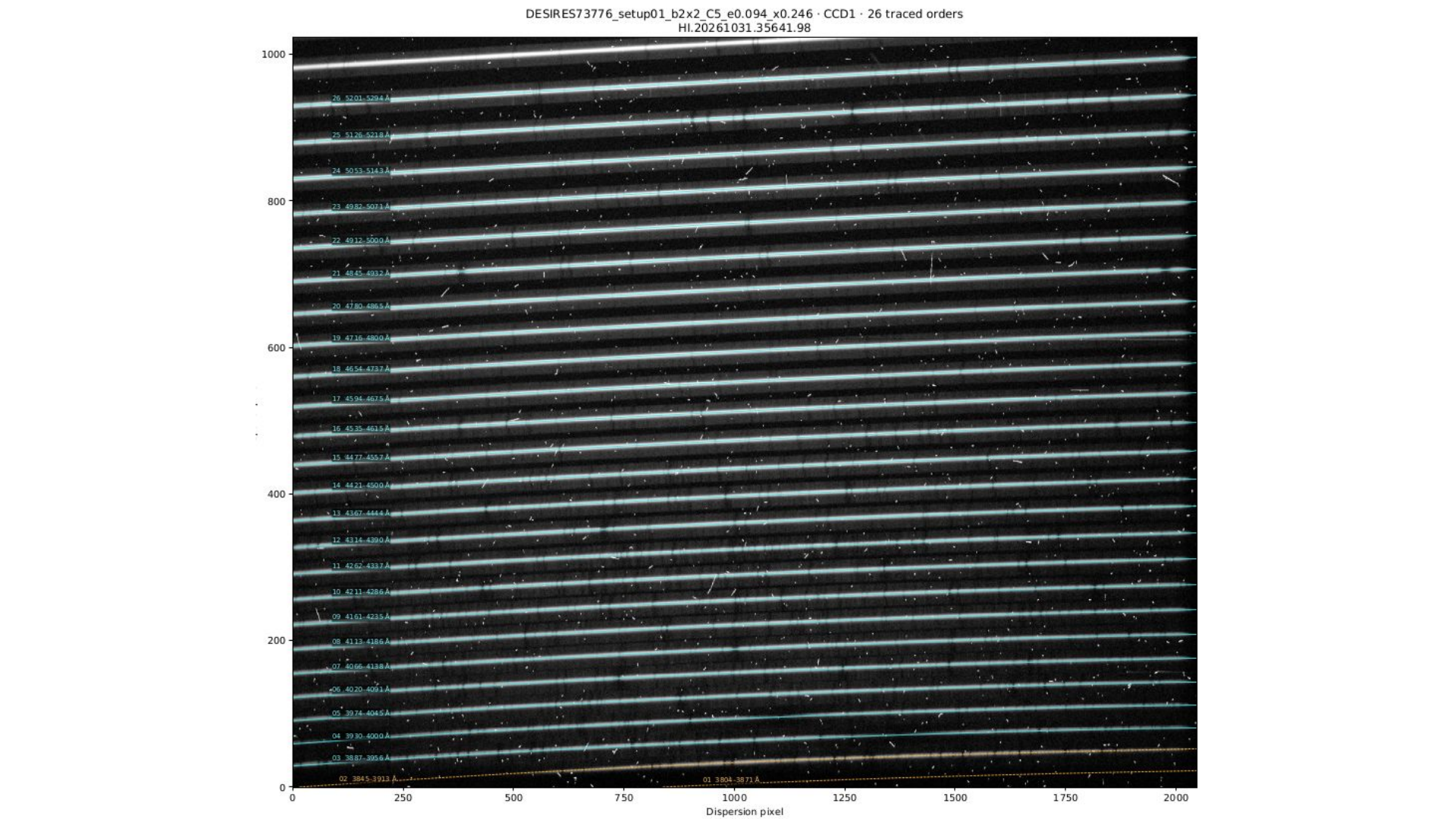
Different Spectrographs: Resolution, multiplexing and spatial information

Spectrograph type	Main feature	Example
Long-slit	Information along one slit	OSIRIS, ALFOSC



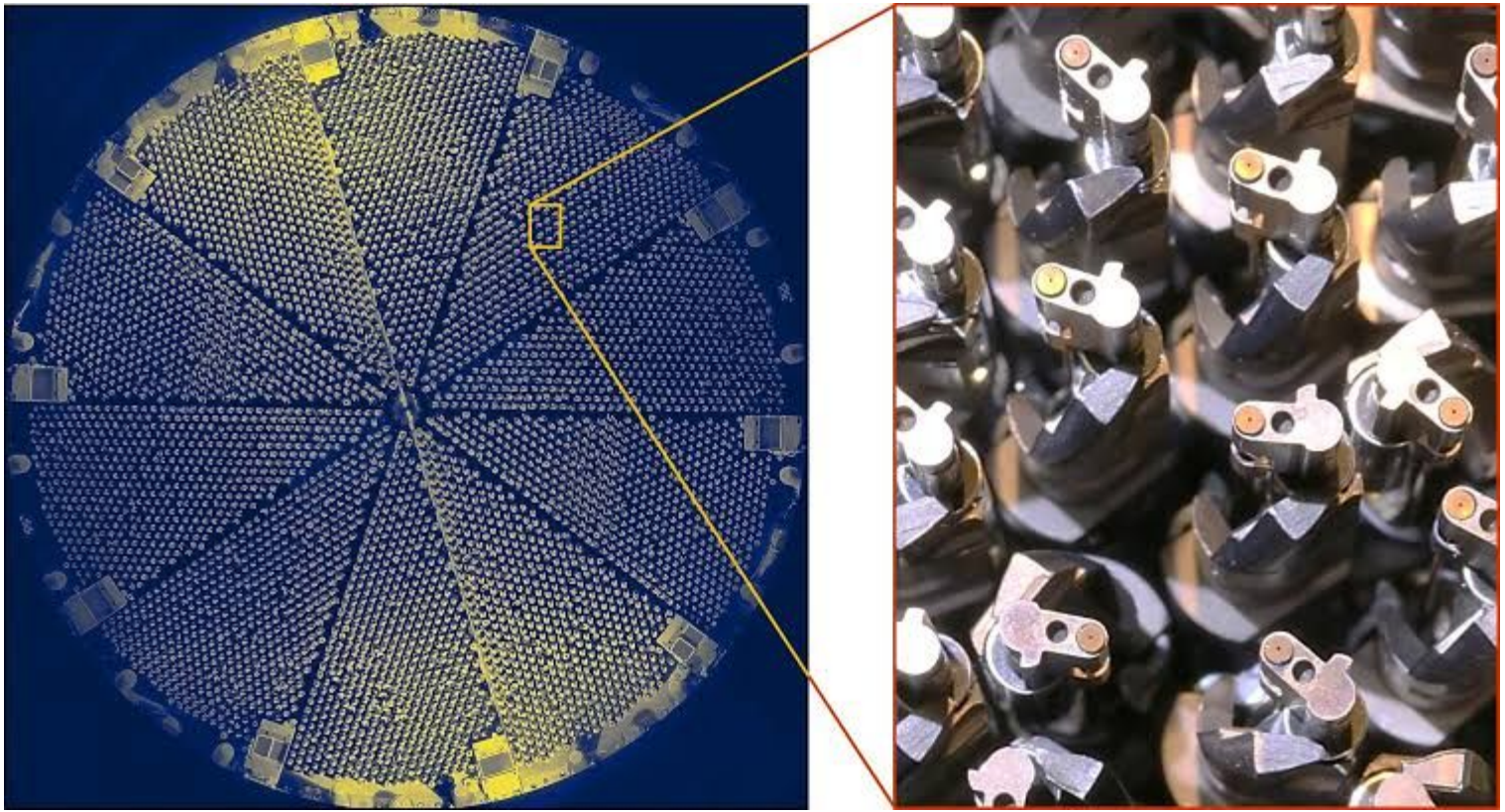
Different Spectrographs: Resolution, multiplexing and spatial information

Spectrograph type	Main feature	Example
Long-slit	Information along one slit	OSIRIS, ALFOSC
Echelle	High spectral resolving power	UVES, HIRES


DESIRES73776_setup01_b2x2_C5_e0.094_x0.246 · CCD1 · 26 traced orders
HI.20261031.35641.98
26 5201-5294 Å
25 5126-5218 Å
24 5053-5143 Å
23 4982-5071 Å
22 4912-5000 Å
21 4845-4932 Å
20 4780-4865 Å
19 4716-4800 Å
18 4654-4737 Å
17 4594-4675 Å
16 4535-4615 Å
15 4477-4557 Å
14 4421-4500 Å
13 4367-4444 Å
12 4314-4390 Å
11 4262-4337 Å
10 4211-4286 Å
09 4161-4235 Å
08 4113-4186 Å
07 4066-4138 Å
06 4020-4091 Å
05 3974-4045 Å
04 3930-4000 Å
03 3887-3956 Å
02 3845-3913 Å
01 3804-3871 Å
0
200
400
600
800
1000
0
250
500
750
1000
1250
1500
1750
2000
Dispersion pixel

Different Spectrographs: Resolution, multiplexing and spatial information

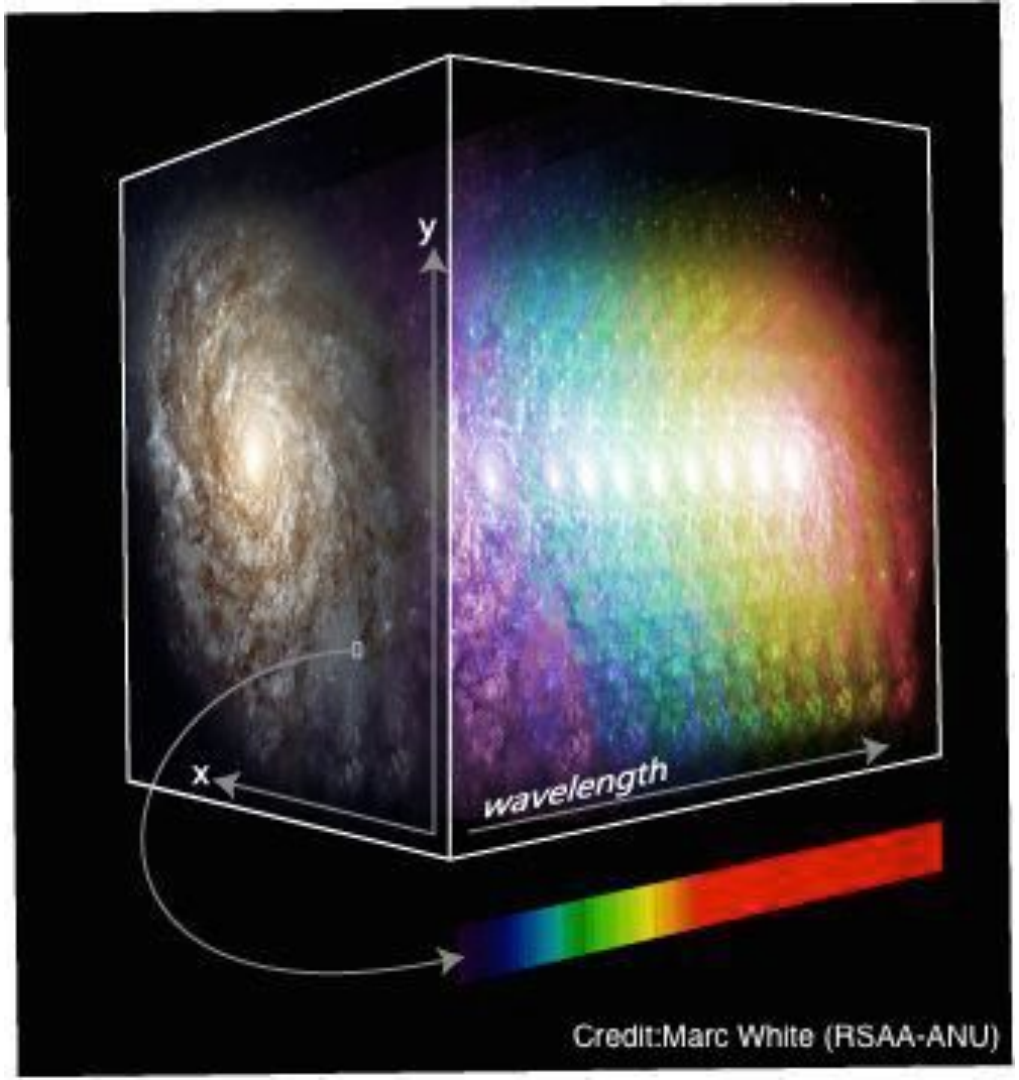
Spectrograph type	Main feature	Example
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Echelle	High spectral resolving power	UVES, HIRES
Multi-object	Simultaneous spectra	DESI, WEAVE



Dark Energy Spectroscopic Instrument

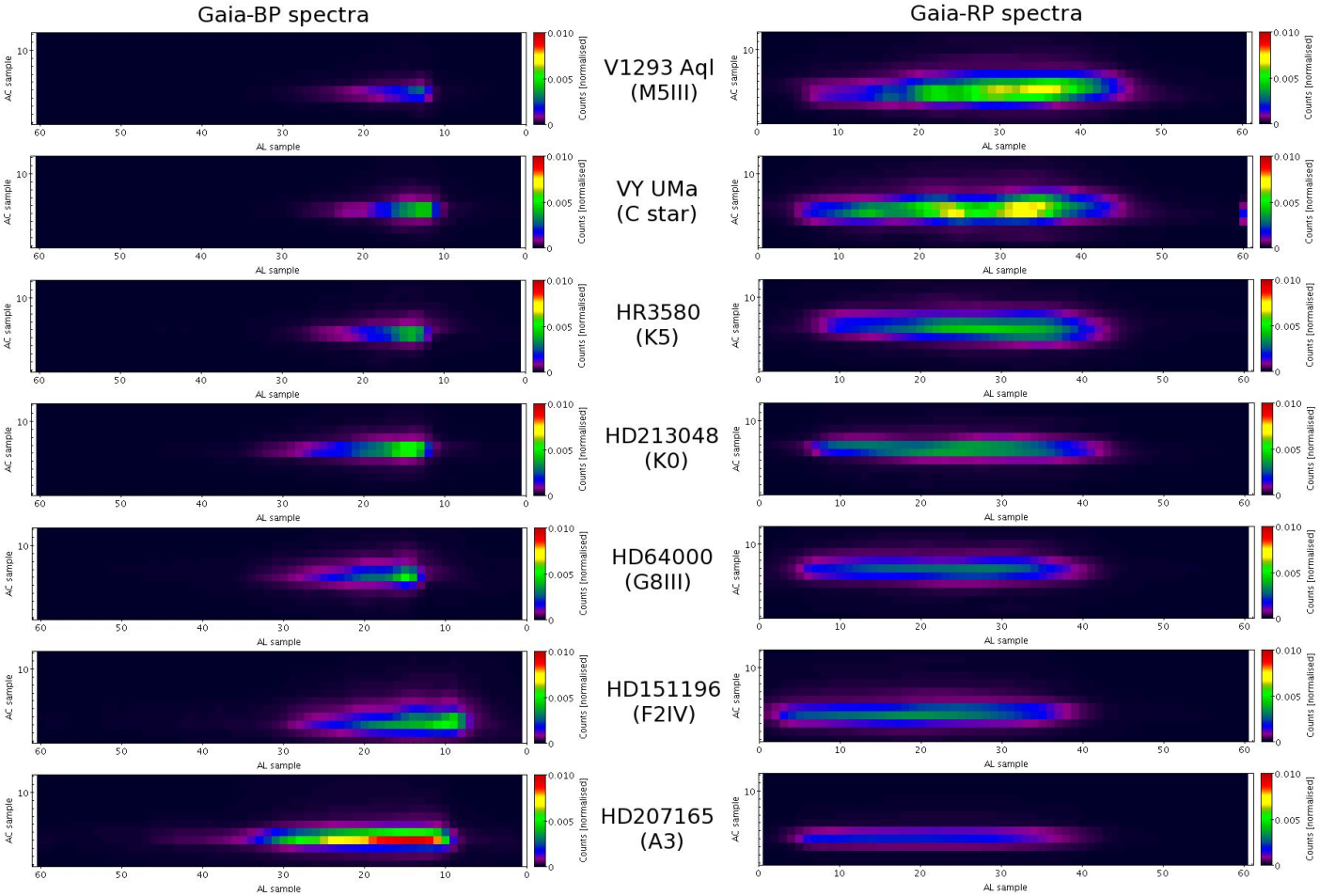
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Echelle	High spectral resolving power	UVES, HIRES
Multi-object	Simultaneous spectra	DESI, WEAVE
IFU	spectrum at each spatial sampling element	MEGARA,MUSE


y
x
wavelength
Credit:Marc White (RSAA-ANU)

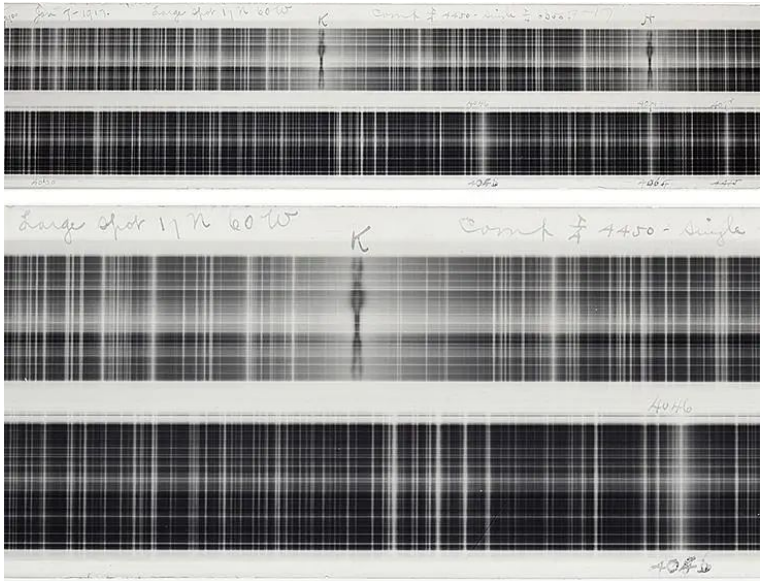
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Long-slit	Information along one slit	OSIRIS, ALFOSC
Echelle	High spectral resolving power	UVES, HIRES
Multi-object	Simultaneous spectra	DESI, WEAVE
IFU	spectrum at each spatial sampling element	MEGARA,MUSE
Slitless	Dispersed spectra without a conventional slit	Gaia BP/RP


Gaia-BP spectra
Gaia-RP spectra
V1293 Aql
(M5III)
VY UMa
(C star)
HR3580
(K5)
HD213048
(K0)
HD64000
(G8III)
HD151196
(F2IV)
HD207165
(A3)
AC sample
AL sample
Counts [normalised]

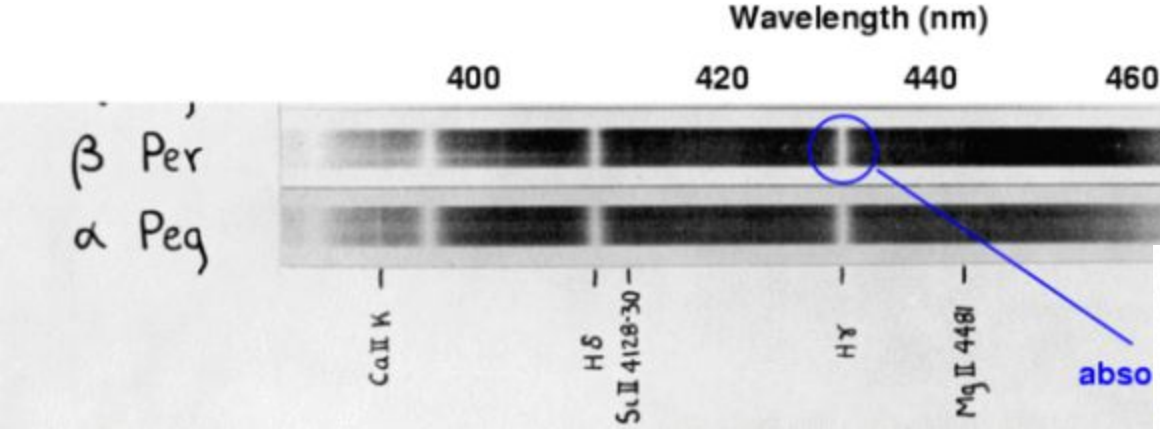
The Digital Revolution: From photographic plates to CCD detectors





Annie J. Cannon was the curator of photographs at the Harvard College Observatory, charged with the care of some 300,000 photographic plates of stars made by Harvard astronomers. Bettmann / Getty Images

The Digital Revolution: From photographic plates to CCD detectors





WIKIPEDIA: Henry Draper and his team