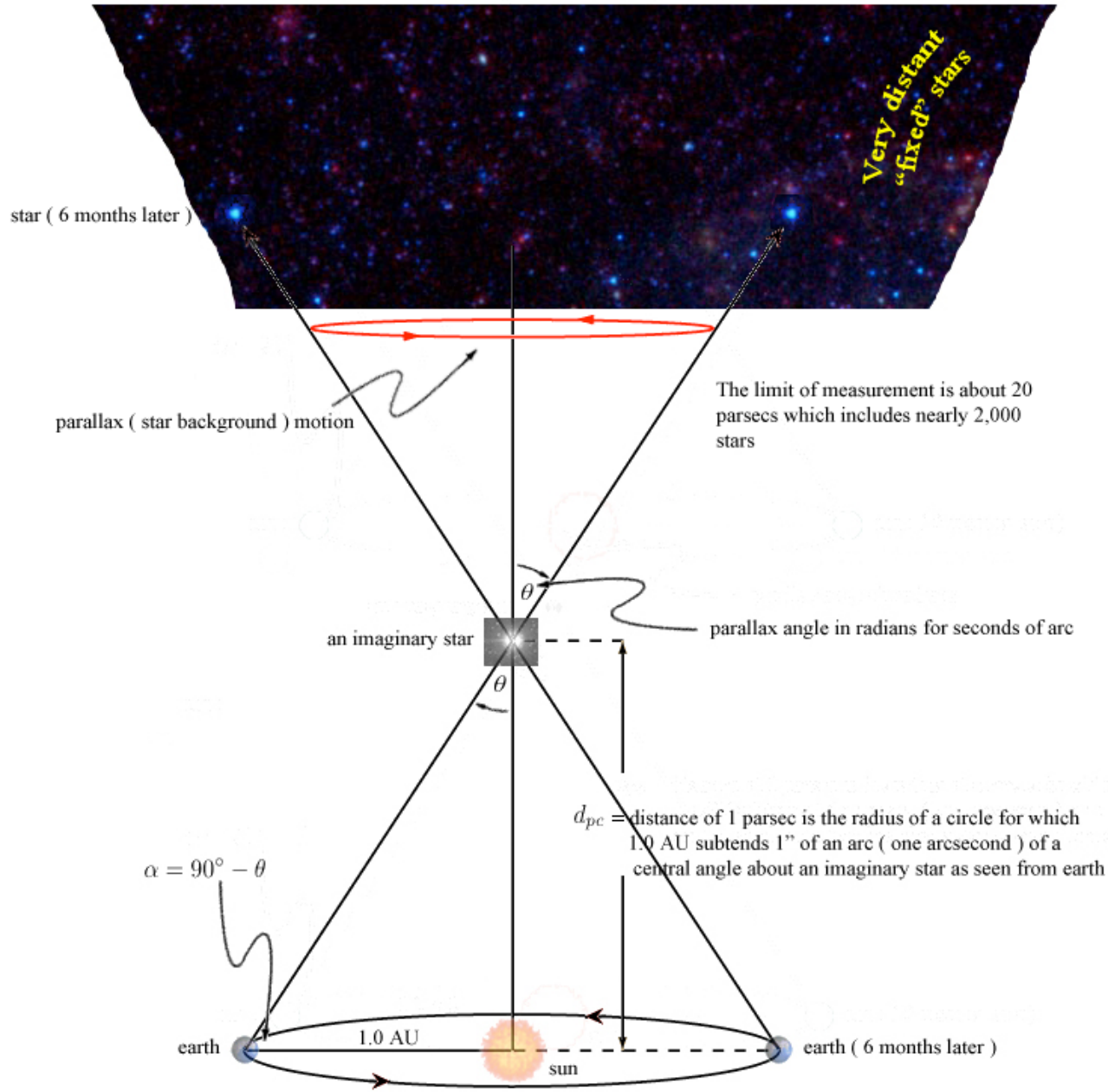

Structure and Evolution
of Stars
Lecture 2


NASA, ESA, CSA, STScI,
Webb ERO Production Team


© Drew Evans Astrophotography

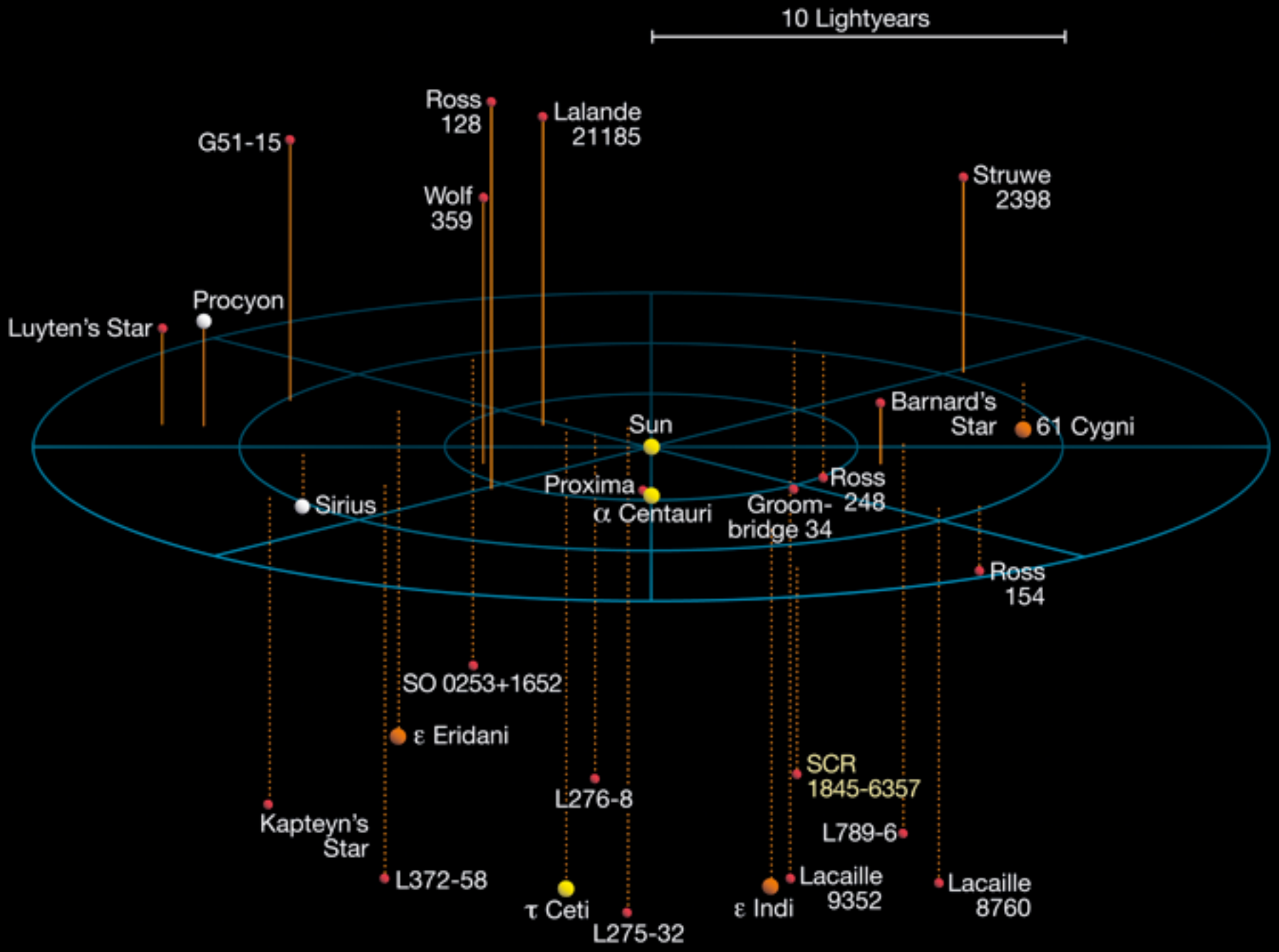


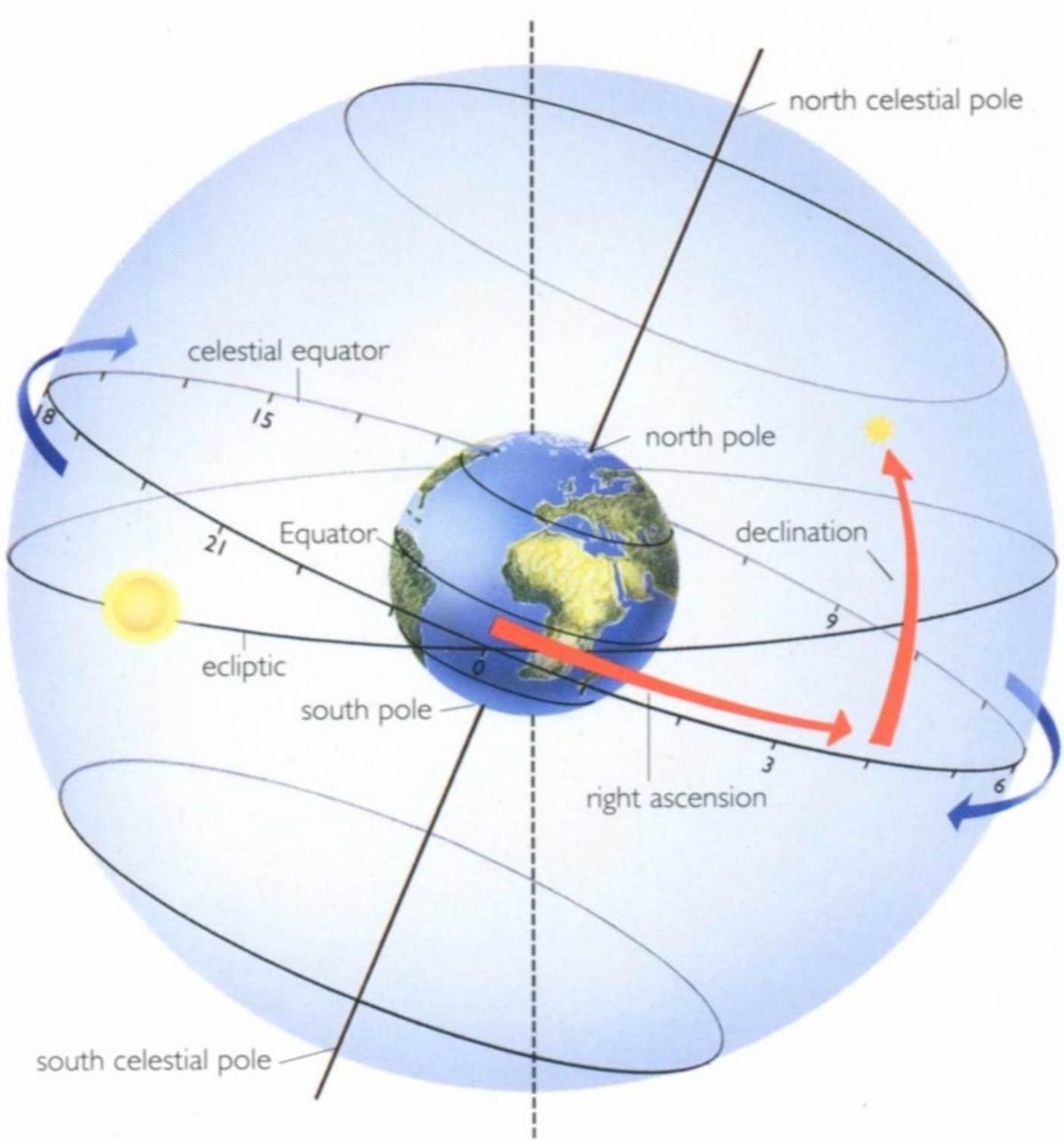

Where:

$\theta$ = angle of parallax in radians for seconds of arc

$d_{pc} = 1/\theta$, distance to an imaginary star in parsecs and is the radius of a circle for which 1.0 AU subtends 1.0" ( one second ) of arc of a central angle about an imaginary star as seen from earth

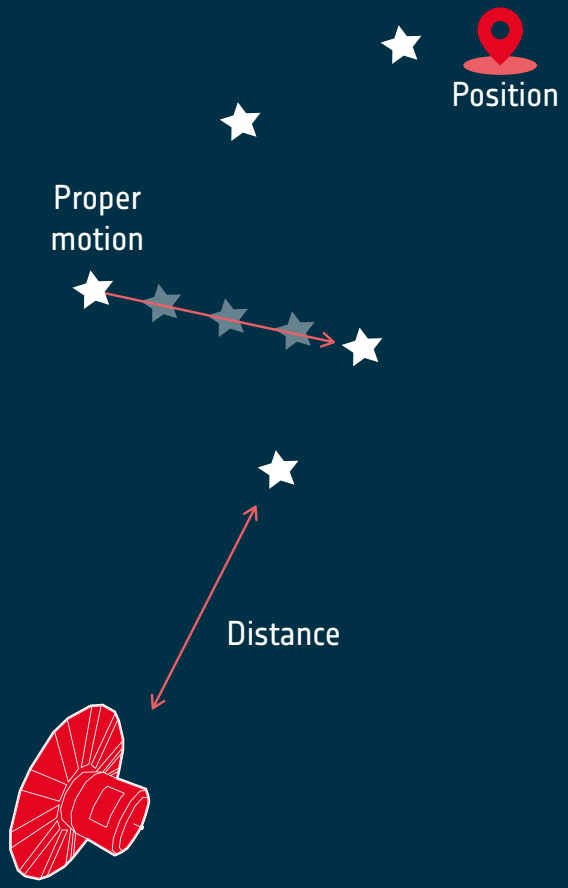
note: the word parsec stands for "Parallax of one arcsecond"


10 Lightyears
Ross 128
Lalande 21185
G51-15
Wolf 359
Struwe 2398
Procyon
Luyten's Star
Barnard's Star
61 Cygni
Sun
Proxima
α Centauri
Ross 248
Groom-bridge 34
Sirius
Ross 154
SO 0253+1652
ε Eridani
SCR 1845-6357
L276-8
Kapteyn's Star
L789-6
L372-58
Lacaille 9352
Lacaille 8760
τ Ceti
ε Indi
L275-32

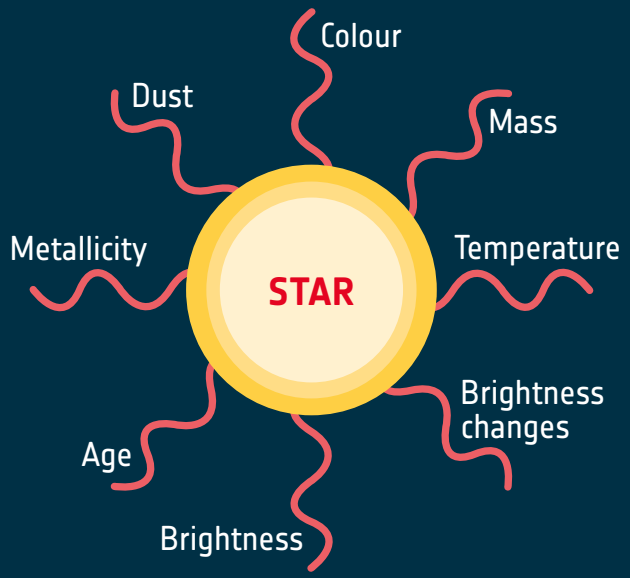

north celestial pole
celestial equator
18
15
north pole
Equator
21
declination
9
ecliptic
0
south pole
3
6
right ascension
south celestial pole

# GAIA'S OBSERVING TECHNIQUES

Techniques to study the stars in our cosmic neighbourhood.

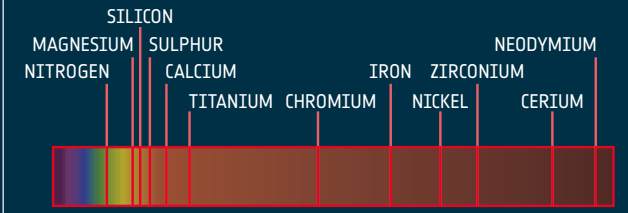



## ASTROMETRY

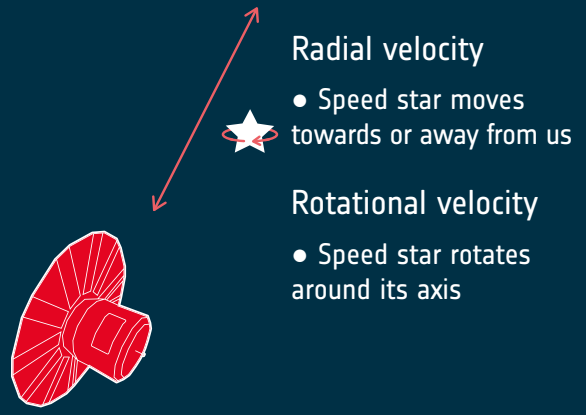



## PHOTOMETRY

Chemical composition




Spectrum of light



Radial velocity

- Speed star moves towards or away from us

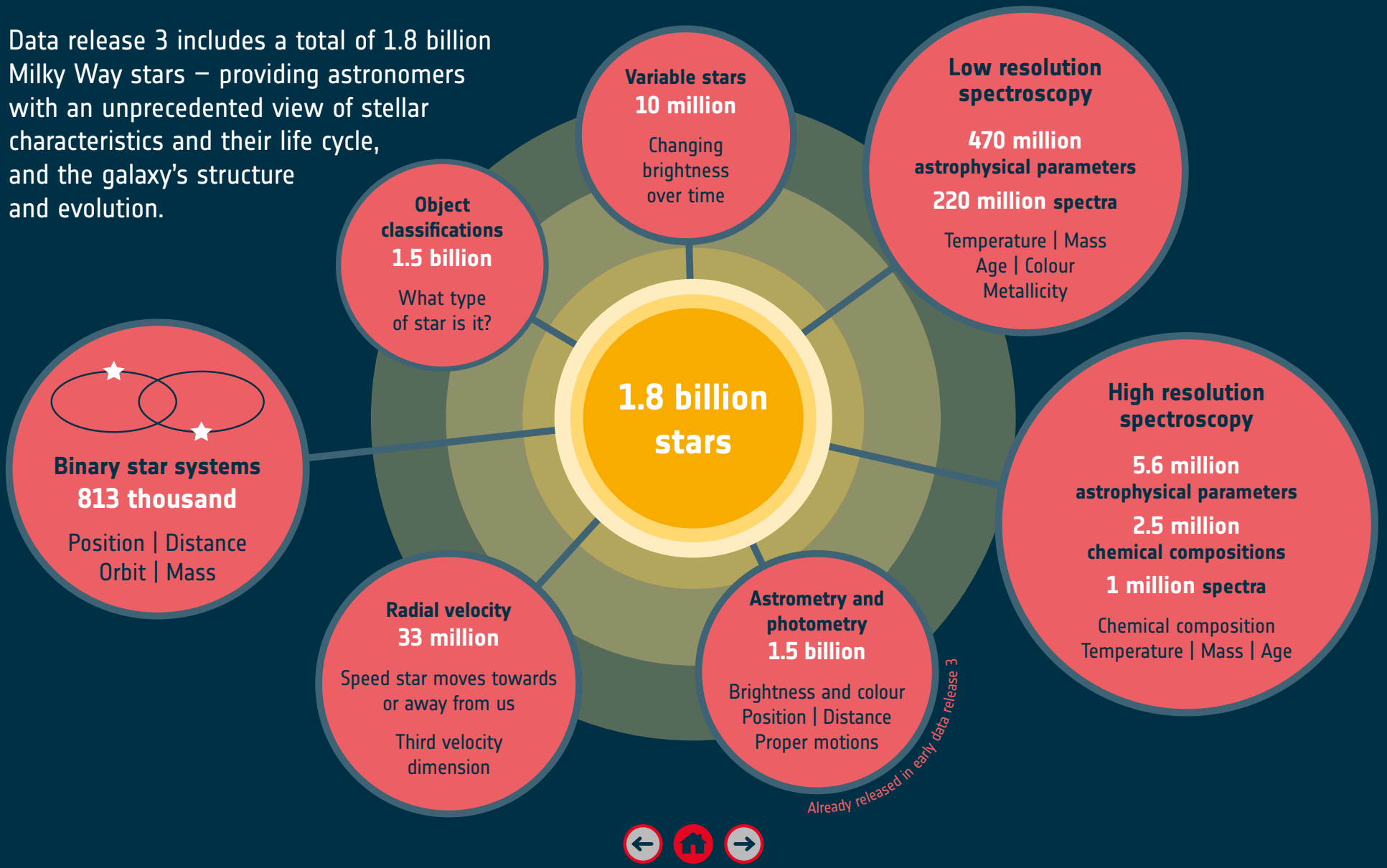
Rotational velocity

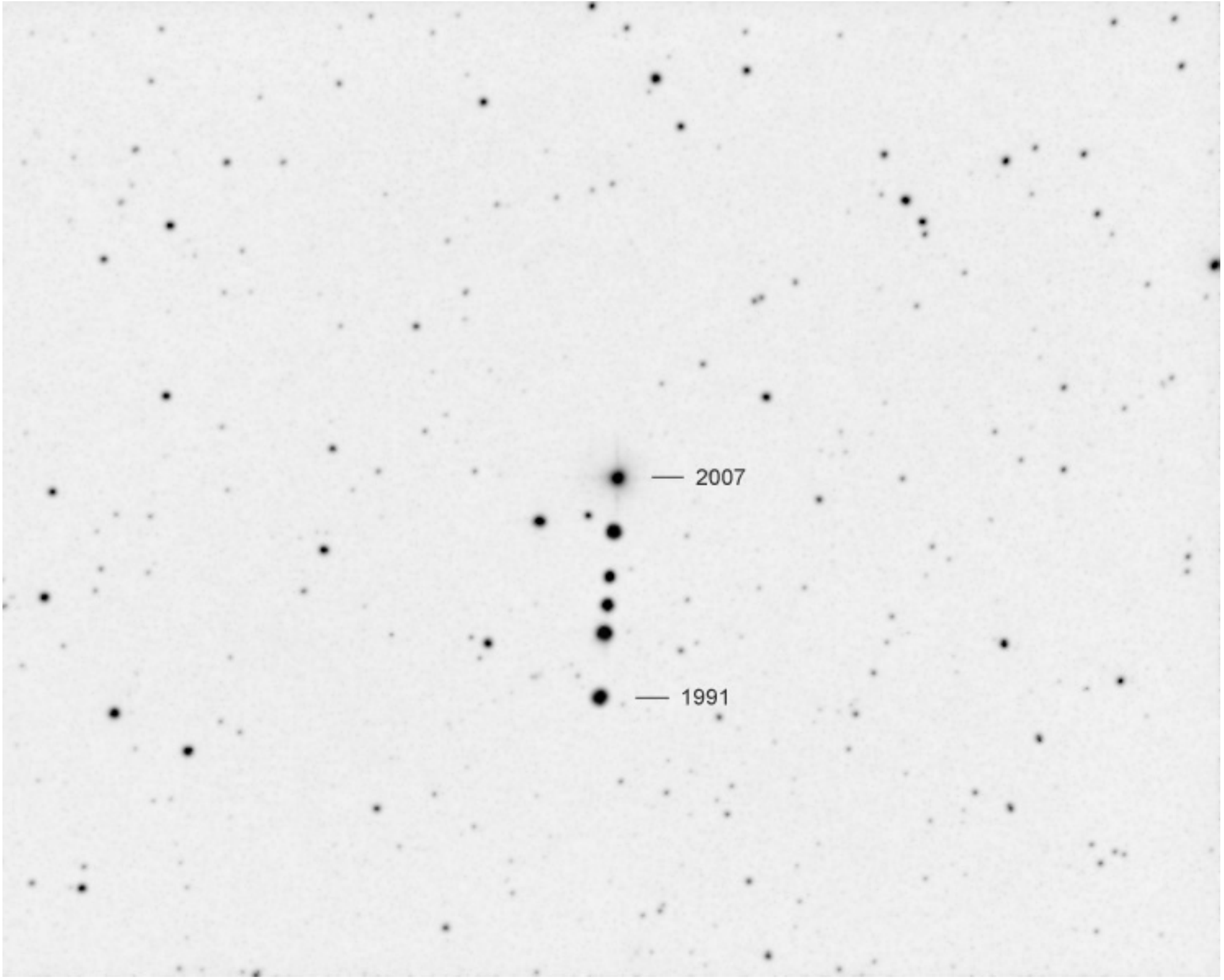
- Speed star rotates around its axis

## SPECTROSCOPY

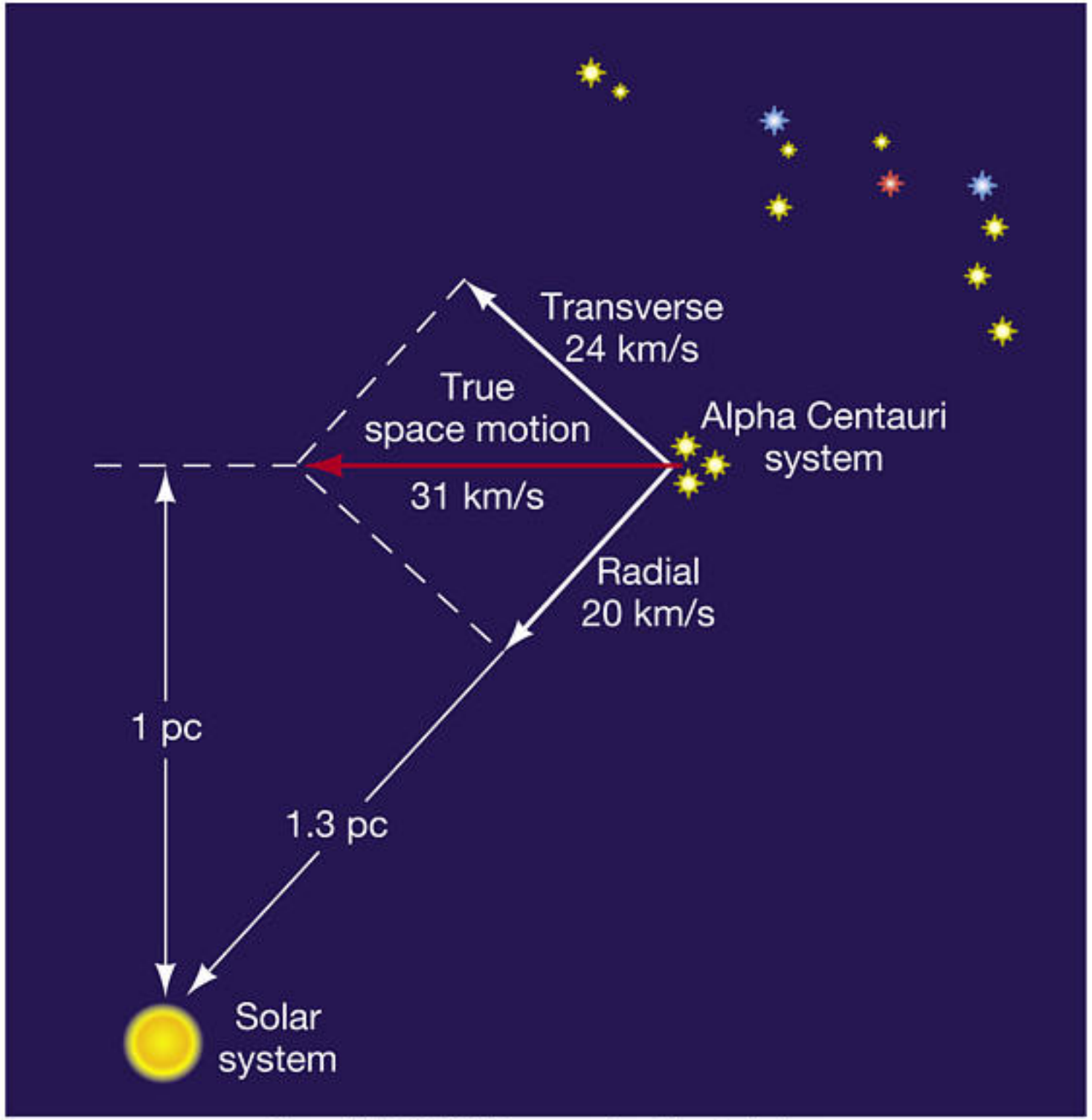
# MILKY WAY STARS

Data release 3 includes a total of 1.8 billion Milky Way stars – providing astronomers with an unprecedented view of stellar characteristics and their life cycle, and the galaxy's structure and evolution.



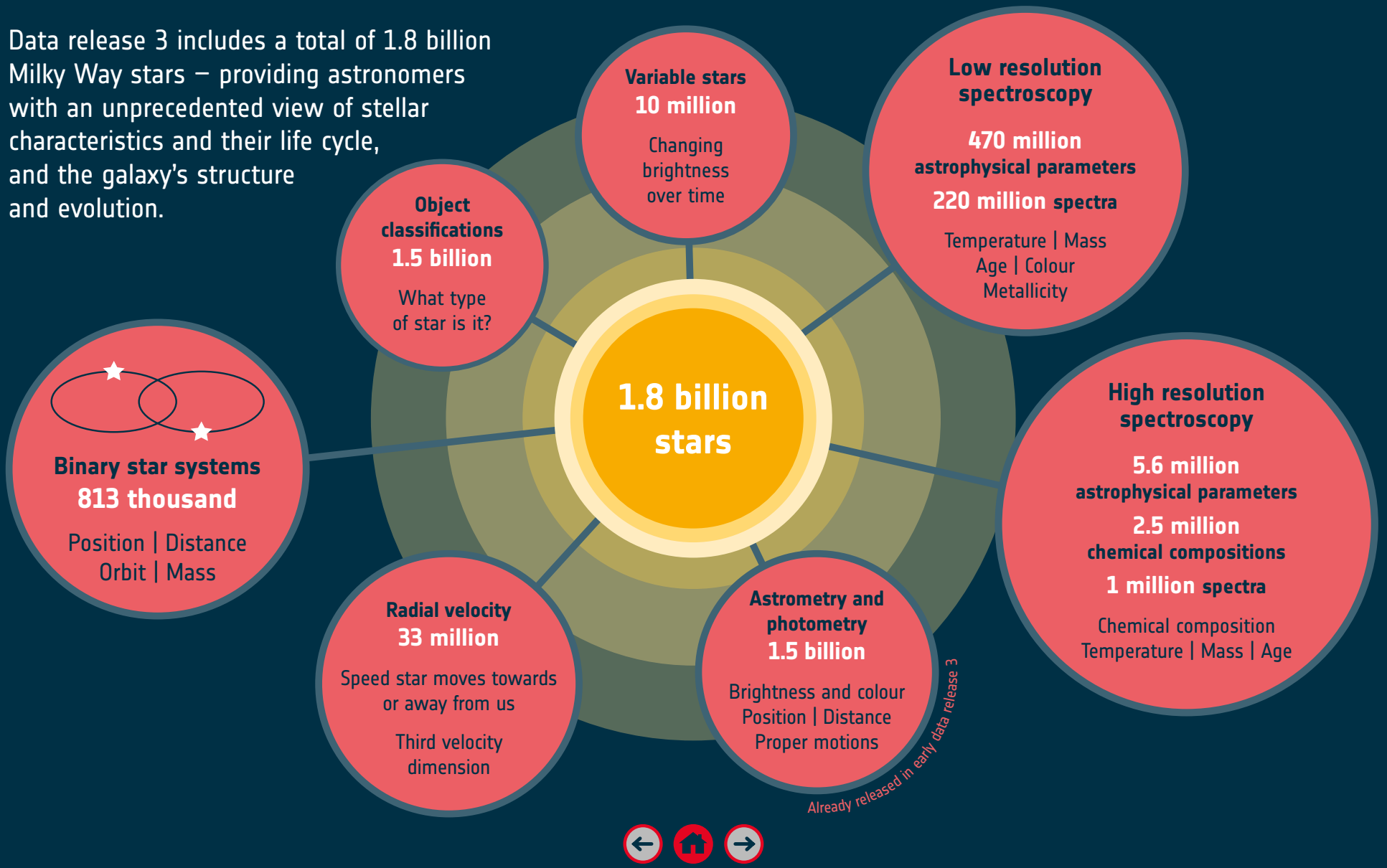

2007
1991

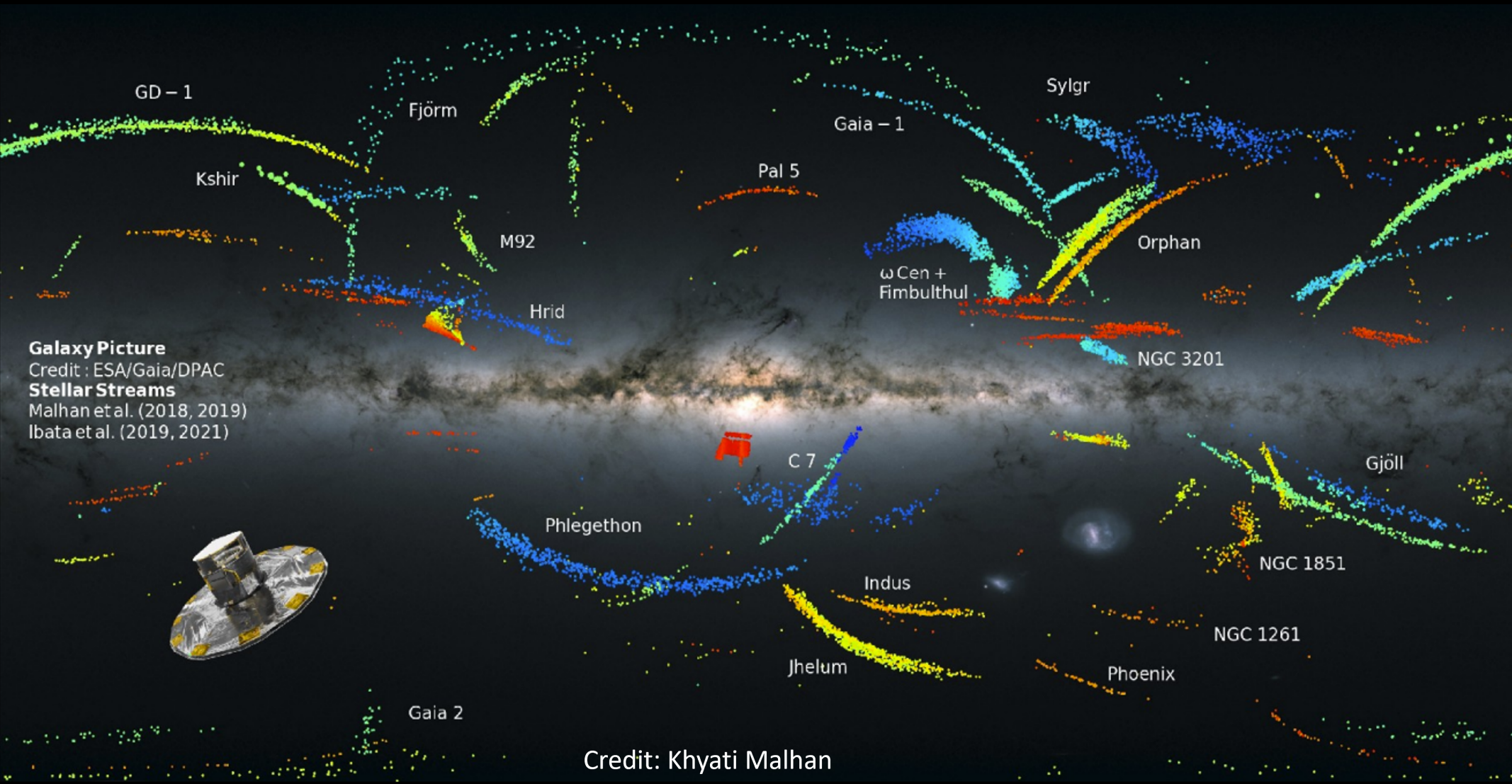

150 JAHRE DOPPLER-PRINZIP
PHYSIKER
s6
REPUBLIK ÖSTERREICH
H. HERGER
1992



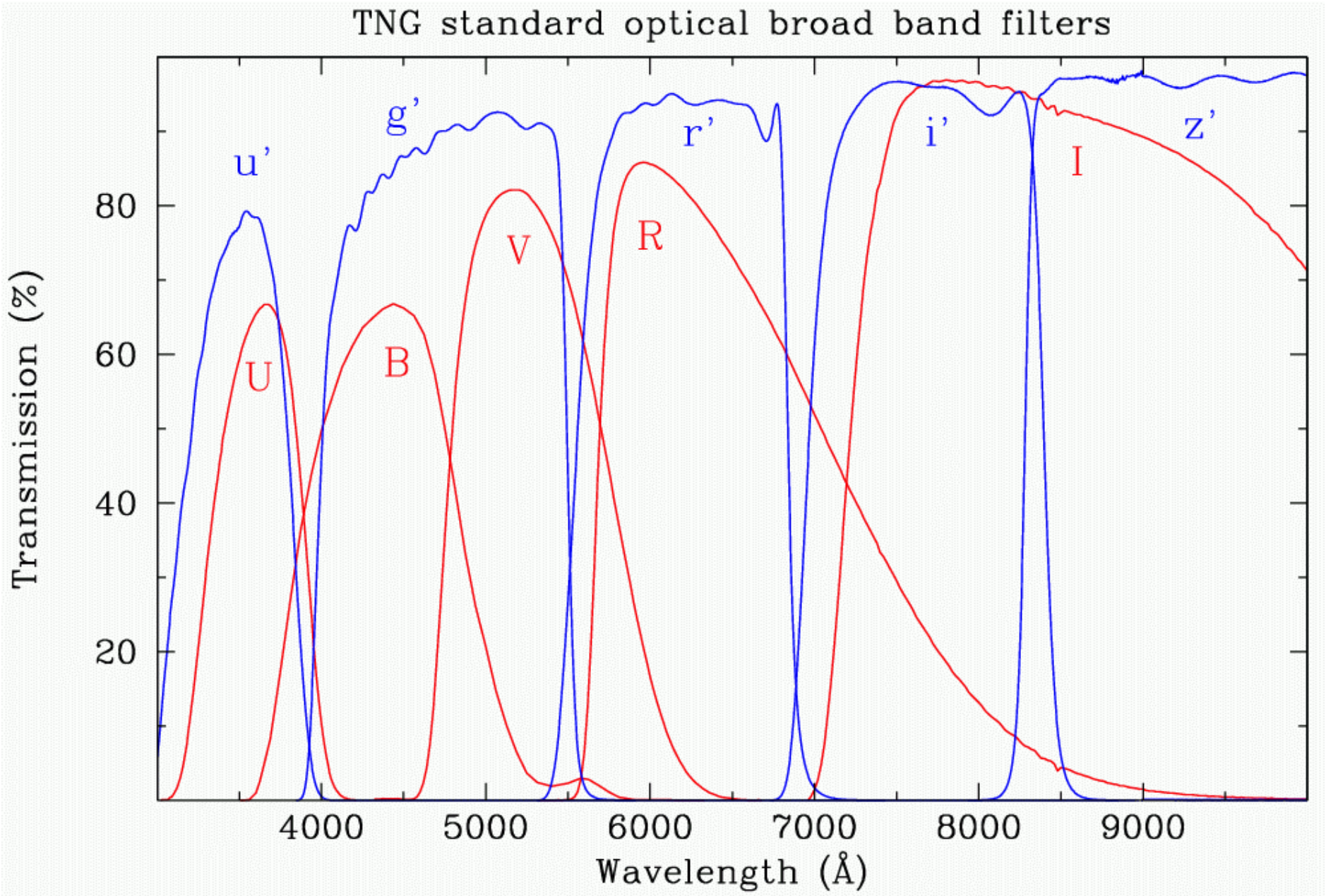
# MILKY WAY STARS

Data release 3 includes a total of 1.8 billion Milky Way stars – providing astronomers with an unprecedented view of stellar characteristics and their life cycle, and the galaxy's structure and evolution.

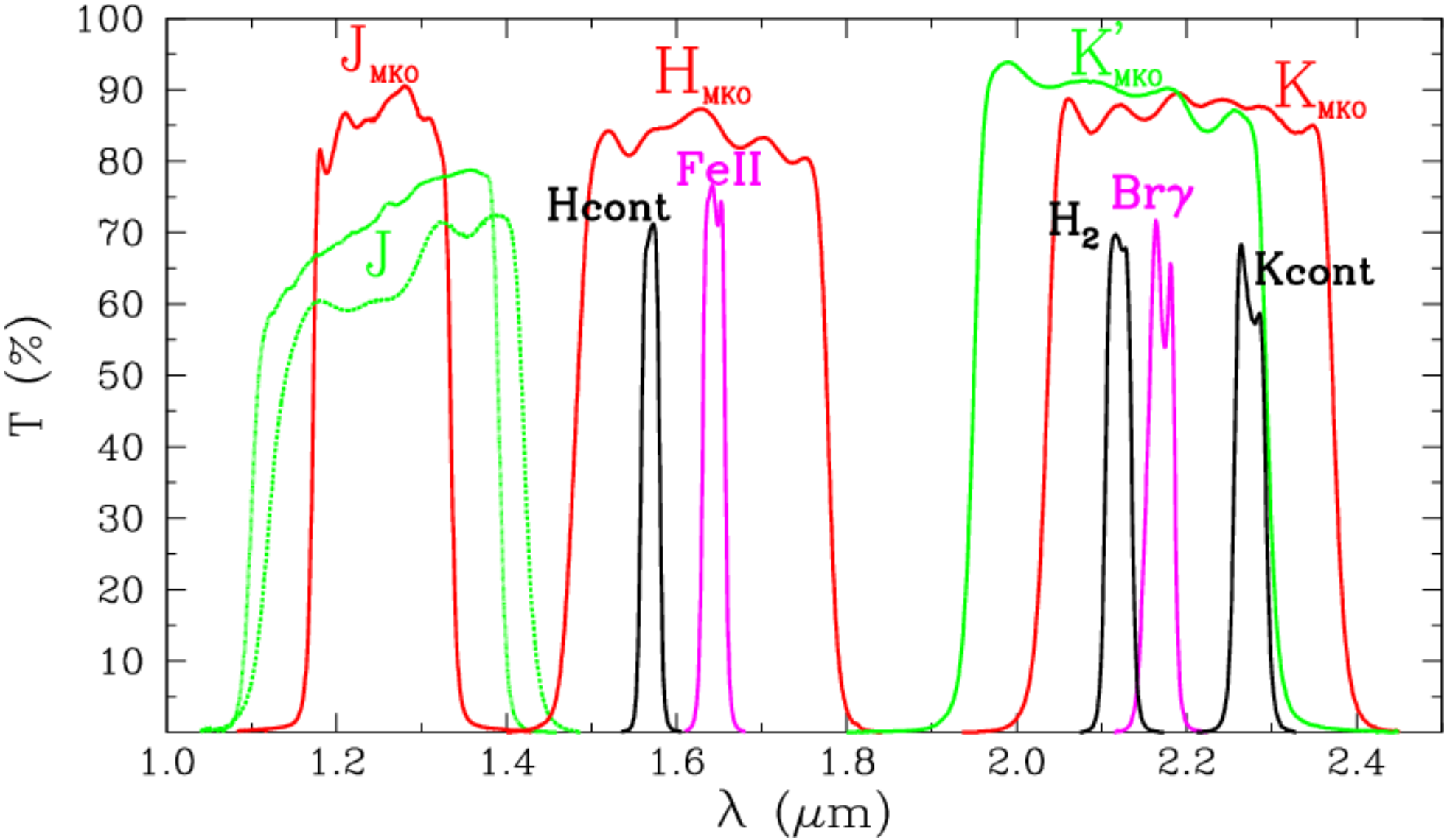


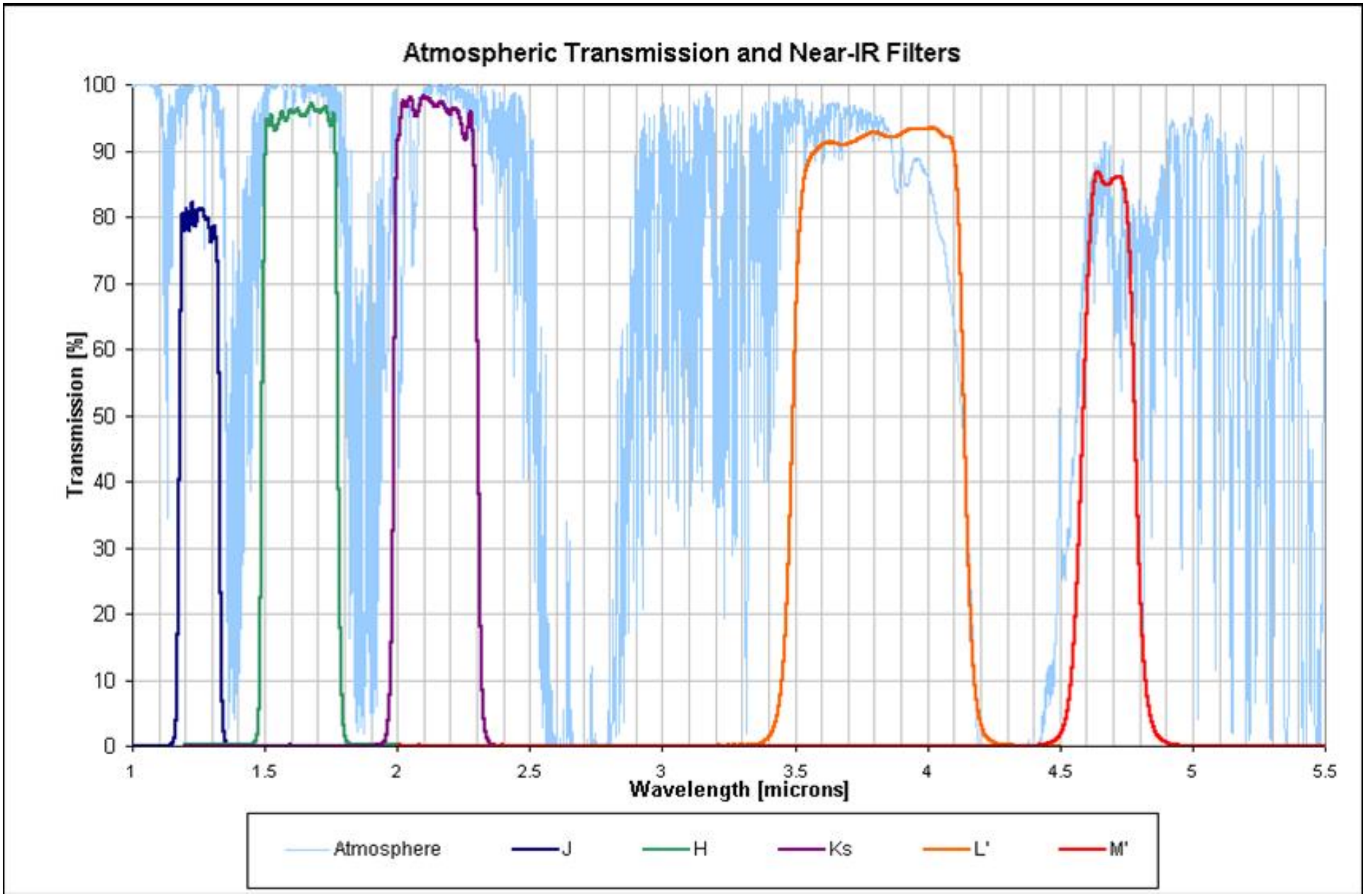


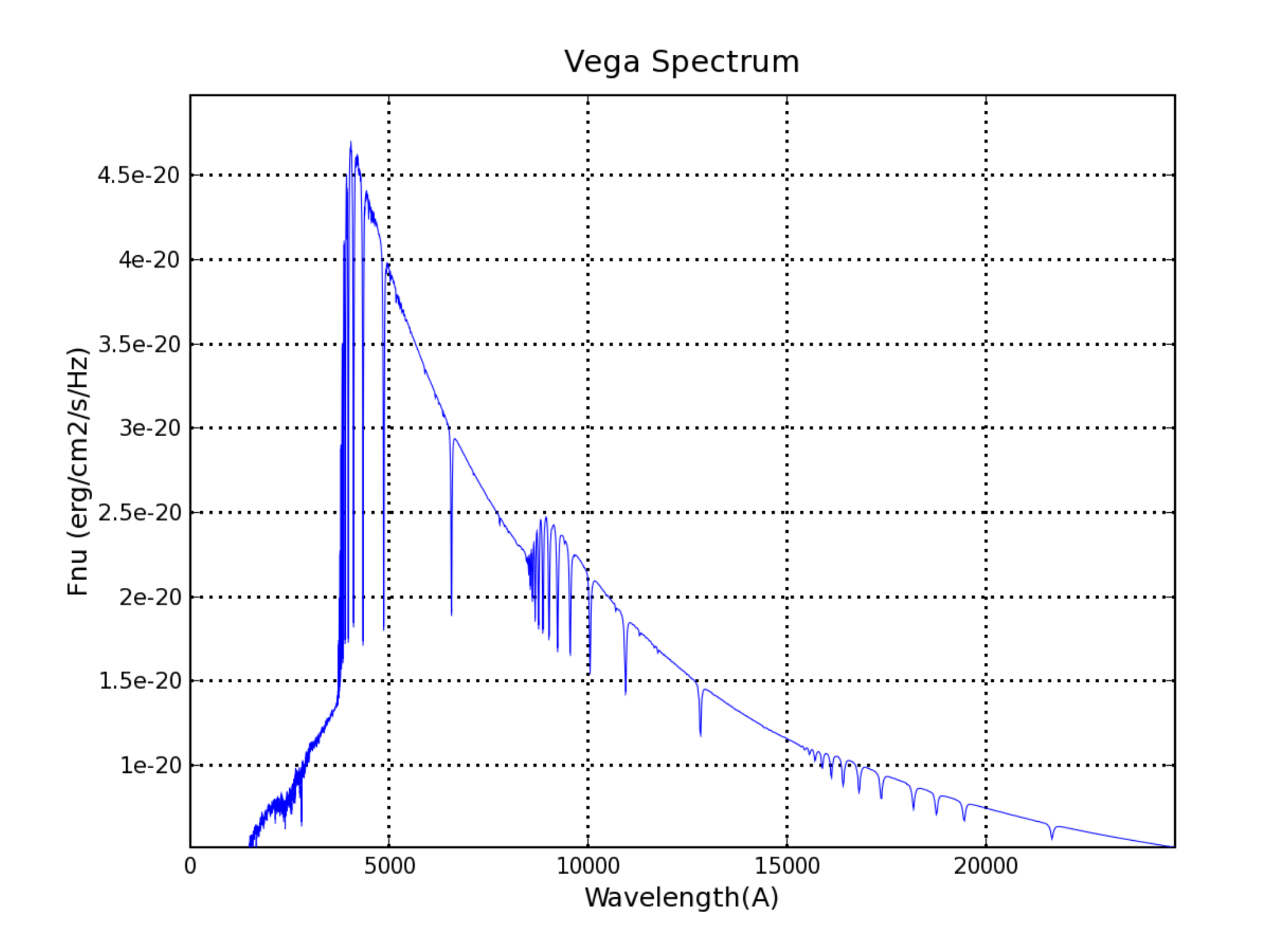

Credit: Khyati Malhan

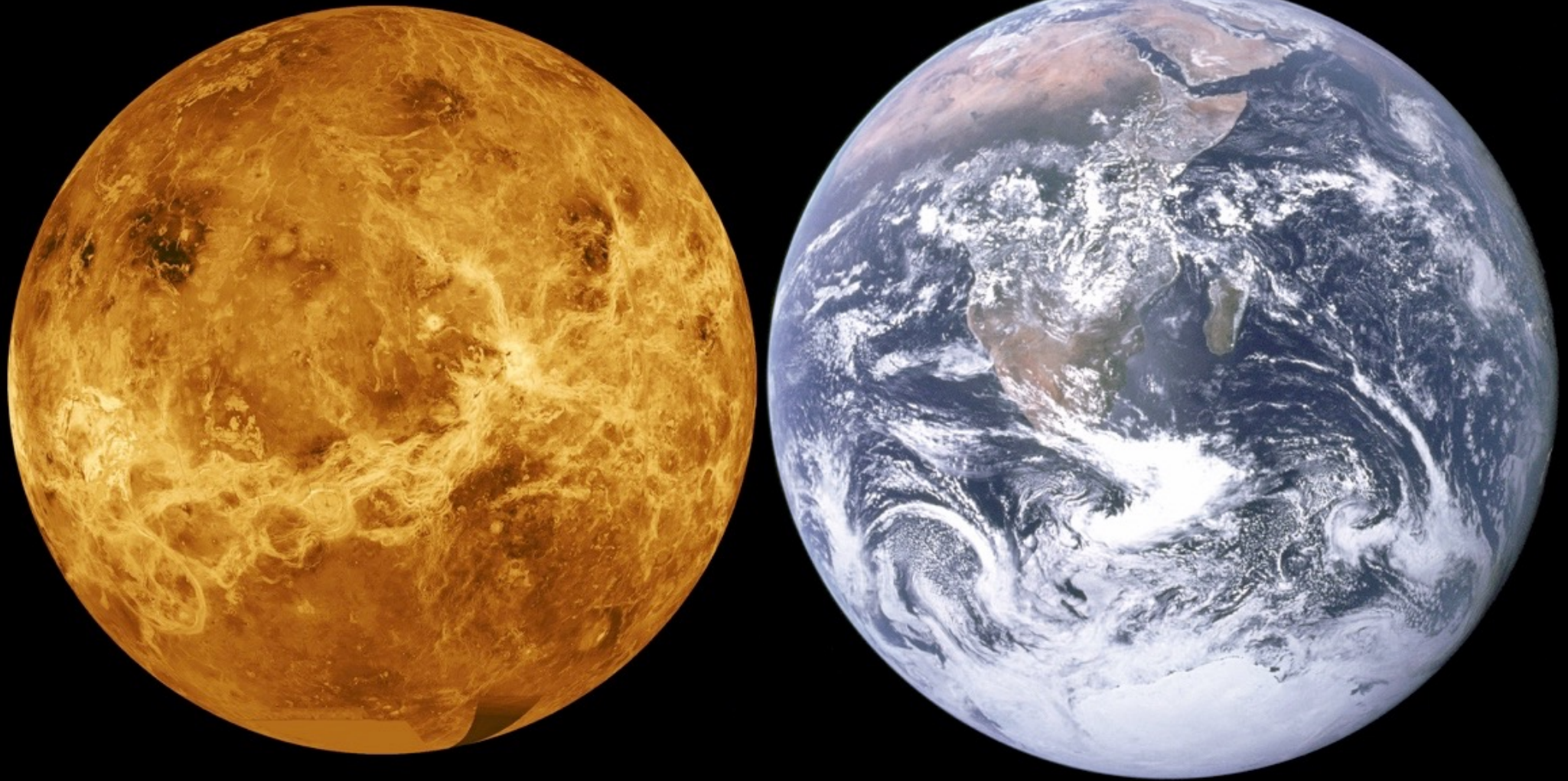

TNG standard optical broad band filters
Transmission (%)
20
40
60
80
4000
5000
6000
7000
8000
9000
Wavelength (Å)
u'
g'
r'
i'
z'
U
B
V
R
I

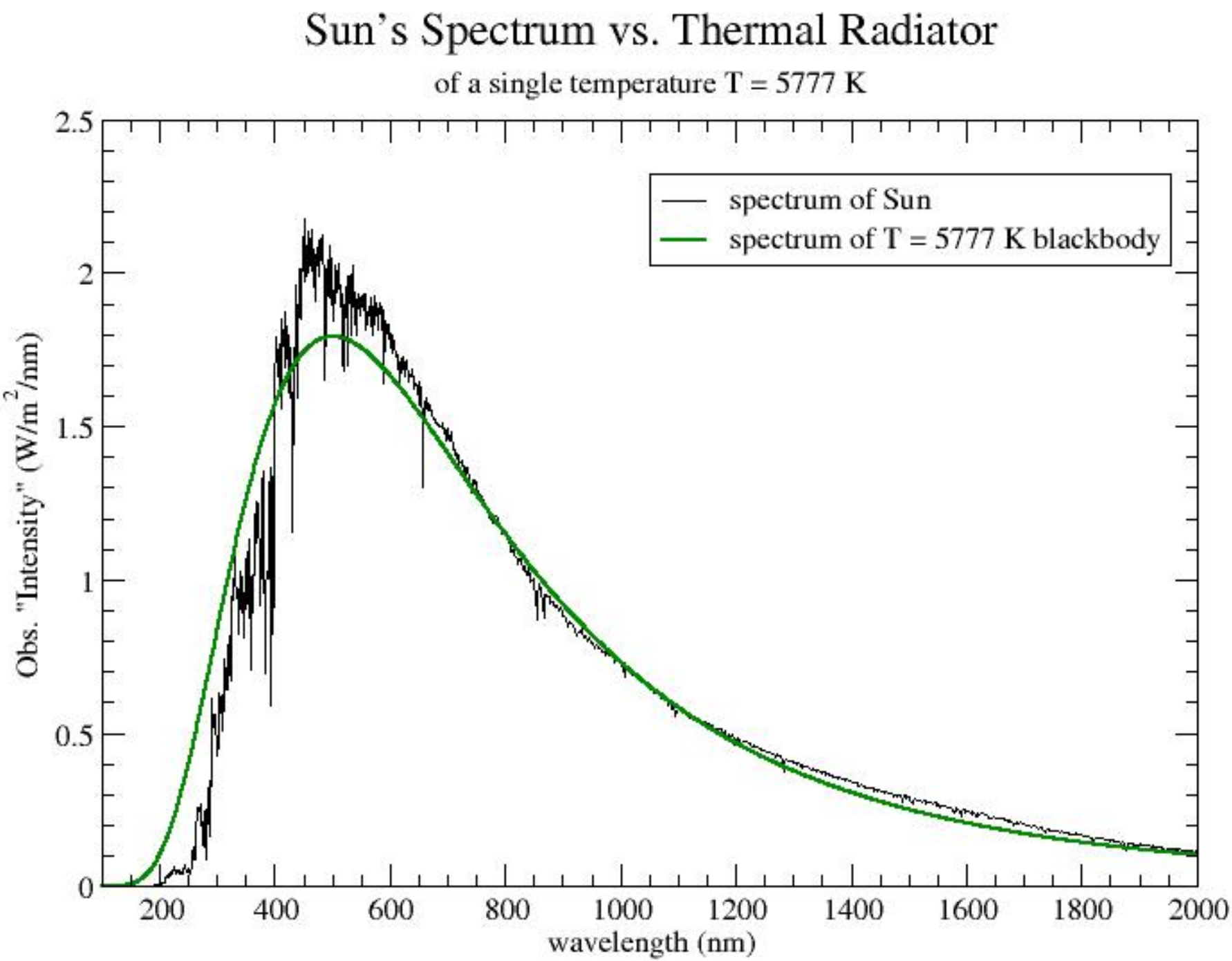

I-BAND
B-BAND 61148
V-BAND 61774
R-BAND 61147

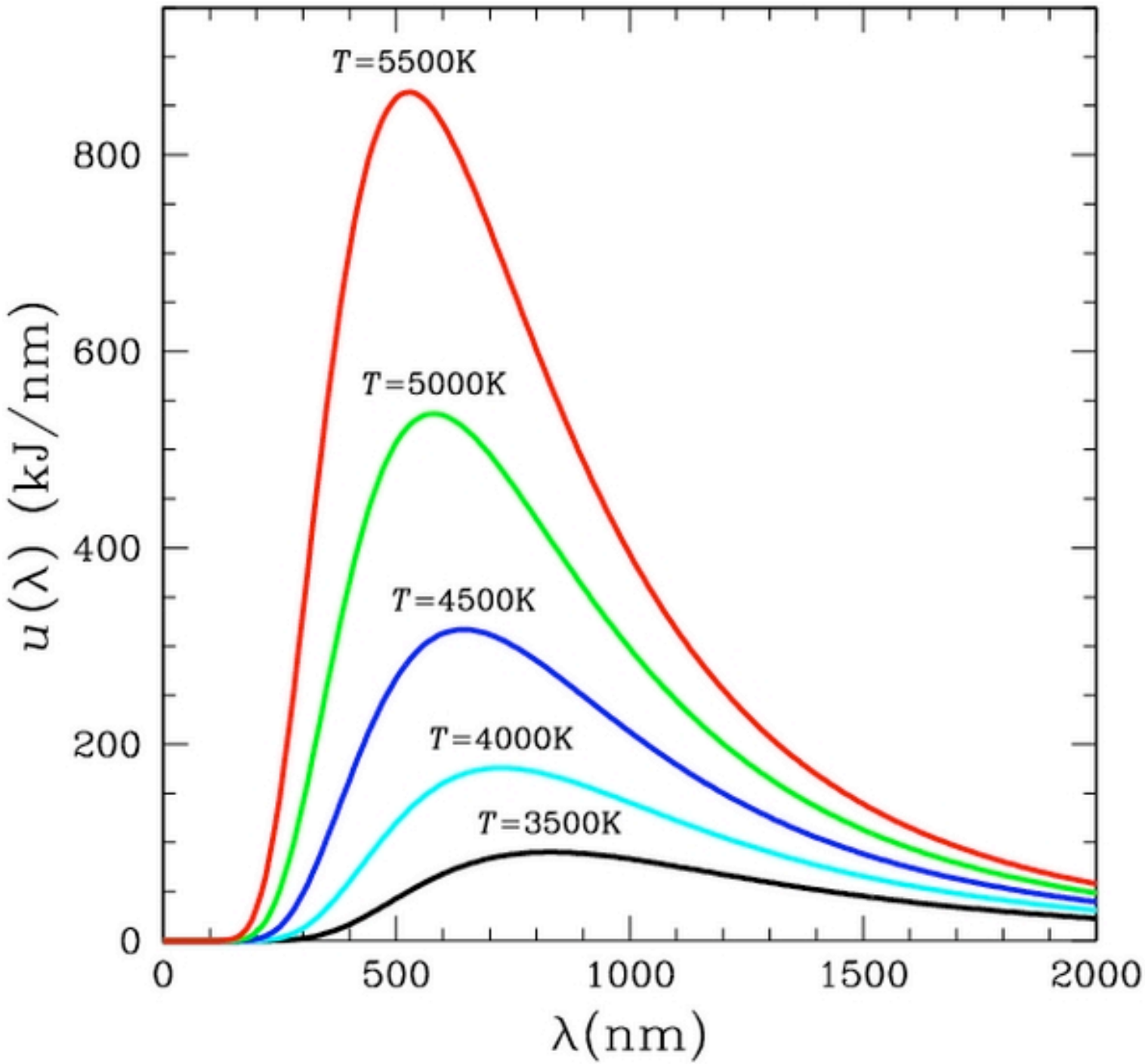

100
90
80
70
60
50
40
30
20
10
T (%)
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
λ (μm)
J MKO
J
H MKO
Hcont
FeII
K' MKO
K MKO
H2
Brγ
Kcont


Atmospheric Transmission and Near-IR Filters
Transmission [%]
100
90
80
70
60
50
40
30
20
10
0
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
Wavelength [microns]
Atmosphere
J
H
Ks
L'
M'

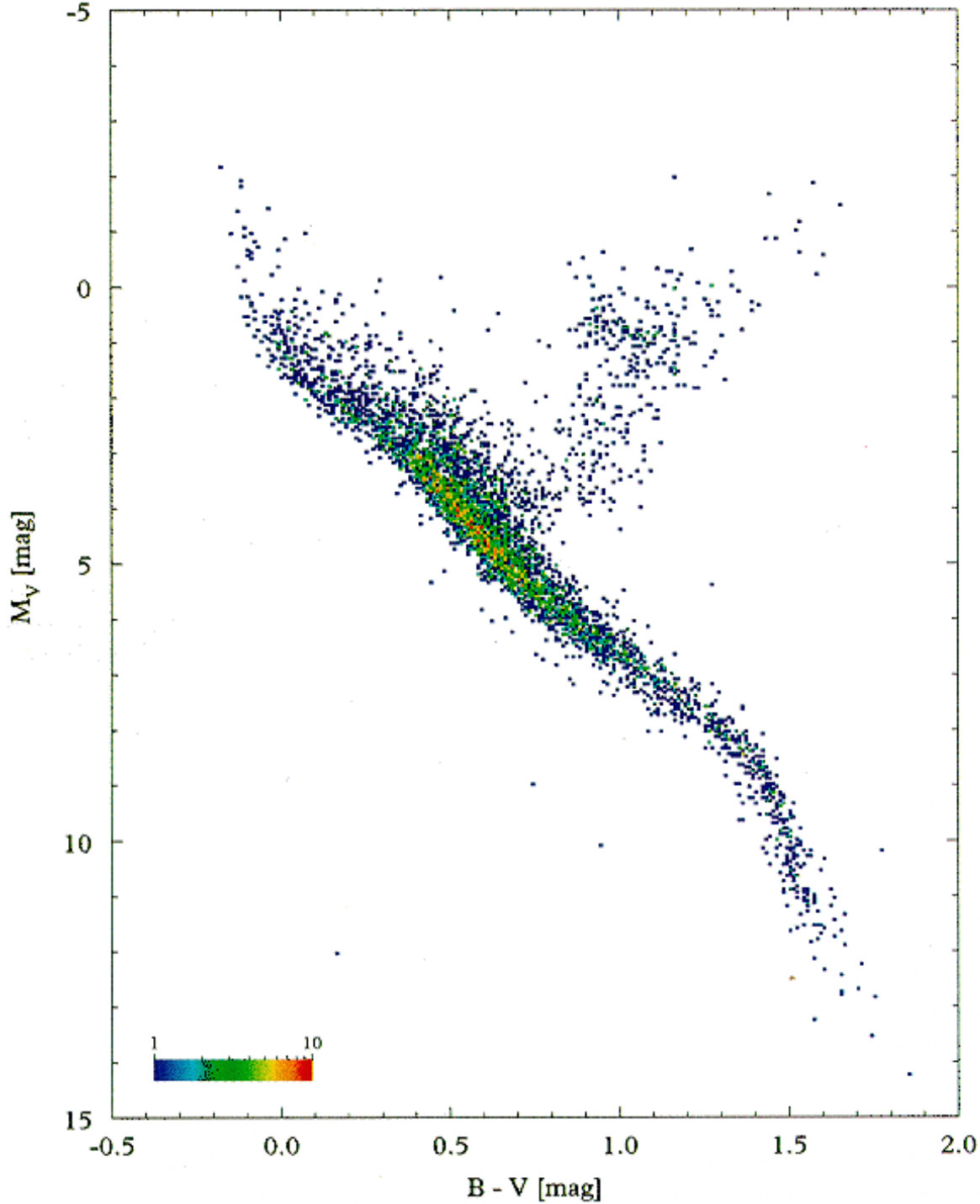

Vega Spectrum
4.5e-20
4e-20
3.5e-20
3e-20
2.5e-20
2e-20
1.5e-20
1e-20
Fnu (erg/cm2/s/Hz)
0
5000
10000
15000
20000
Wavelength(A)

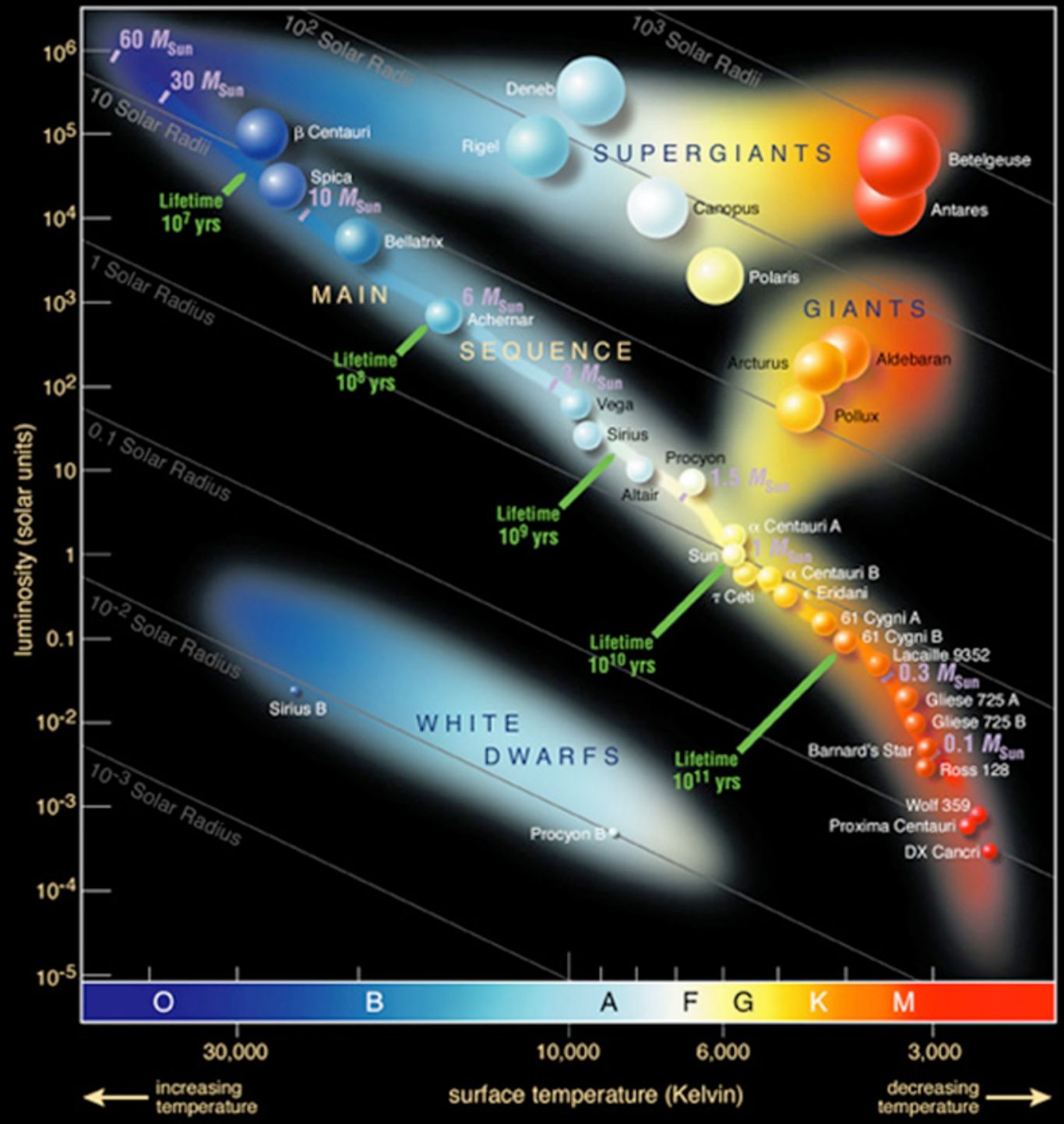



Sun's Spectrum vs. Thermal Radiator
of a single temperature T = 5777 K
spectrum of Sun
spectrum of T = 5777 K blackbody
Obs. "Intensity" (W/m 2 /nm)
wavelength (nm)
0
0.5
1
1.5
2
2.5
200
400
600
800
1000
1200
1400
1600
1800
2000


T=5500K
T=5000K
T=4500K
T=4000K
T=3500K
800
600
400
200
0
u(λ) (kJ/nm)
0
500
1000
1500
2000
λ(nm)


I-BAND
B-BAND 61148
V-BAND 61774
R-BAND 61147


-5
0
5
10
15
$M_V$ [mag]
-0.5
0.0
0.5
1.0
1.5
2.0
B - V [mag]
1
10


luminosity (solar units)
$10^6$
$10^5$
$10^4$
$10^3$
$10^2$
10
1
0.1
$10^{-2}$
$10^{-3}$
$10^{-4}$
$10^{-5}$
60 $M_{Sun}$
30 $M_{Sun}$
$10^2$ Solar Radii
$10^3$ Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
$10^{-2}$ Solar Radius
$10^{-3}$ Solar Radius
β Centauri
Spica
10 $M_{Sun}$
Bellatrix
Lifetime $10^7$ yrs
Deneb
Rigel
SUPERGIANTS
Canopus
Betelgeuse
Antares
Polaris
GIANTS
Arcturus
Aldebaran
Pollux
MAIN
SEQUENCE
6 $M_{Sun}$
Achernar
Lifetime $10^8$ yrs
3 $M_{Sun}$
Vega
Sirius
Procyon
Altair
1.5 $M_{Sun}$
Lifetime $10^9$ yrs
α Centauri A
1 $M_{Sun}$
Sun
α Centauri B
τ Ceti
ε Eridani
Lifetime $10^{10}$ yrs
61 Cygni A
61 Cygni B
Lacaille 9352
0.3 $M_{Sun}$
Gliese 725 A
Gliese 725 B
Barnard's Star
0.1 $M_{Sun}$
Ross 128
Lifetime $10^{11}$ yrs
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
WHITE
DWARFS
Procyon B
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature