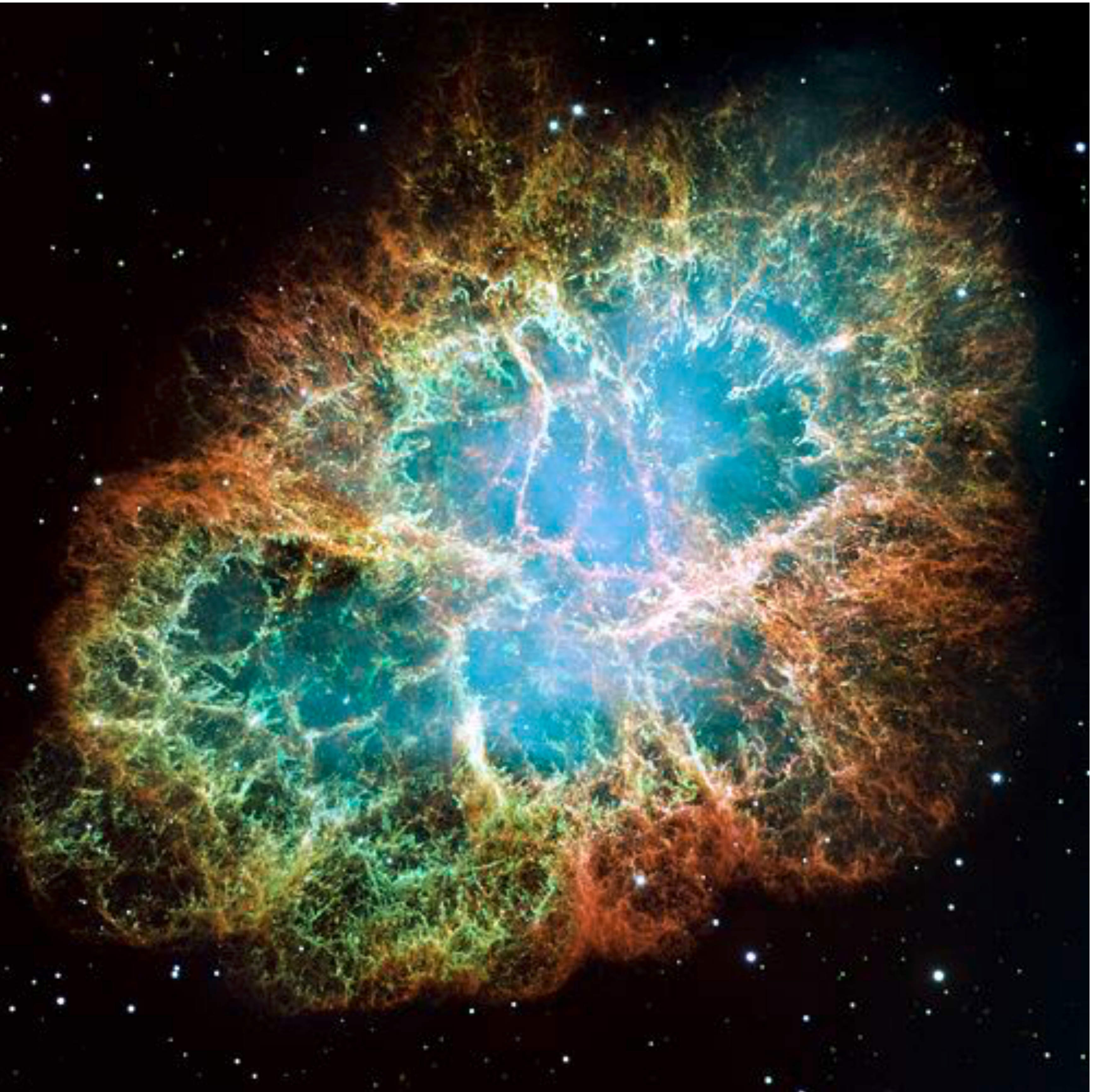
Supernovae



Crab supernova remnant

Supernova observations

Only a three supernovae have been observed within the Milky way galaxy and five anywhere before the use of telescopes:

1. HB9 was marked on star charts from India about 5000 years ago.

2. SN 185 was viewed by Chinese astronomers in 185 CE

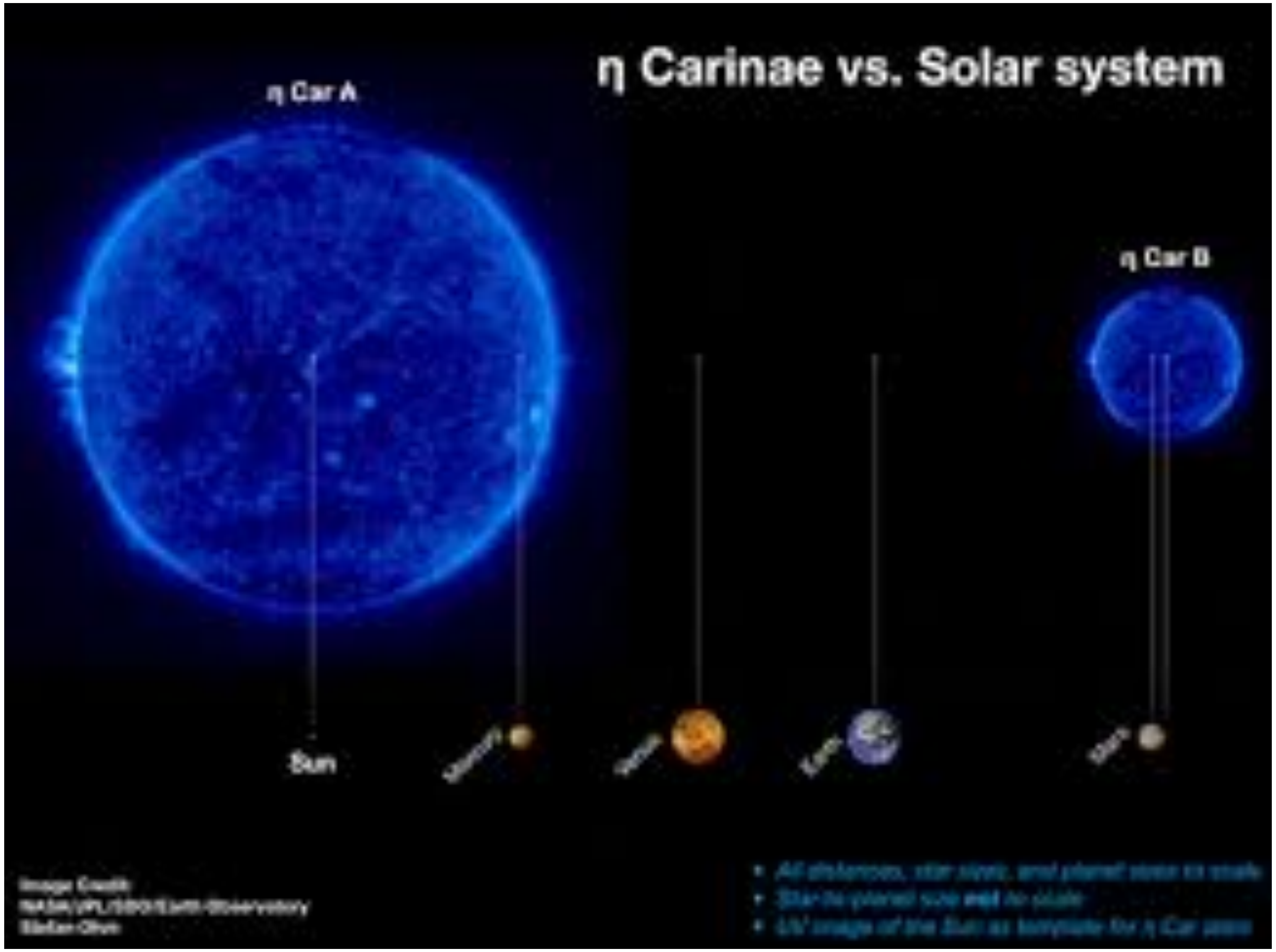
3. On about April 30, 1006 a magnitude -9 star suddenly appeared in the constellation Lupus , bright enough to be seen in daytime and to read by at night. It was reported by astrologers in Europe, the Middle East, and Asia.

4. July 4, 1054, Yang Wei-T'e documented a “guest star” in Taurus, which gradually became invisible after a year. It was also observed in Japan, Korea and Arabia. It was also visible in daylight. This supernova is the source of the Crab nebula (Crab supernova remnant). (Milky Way)

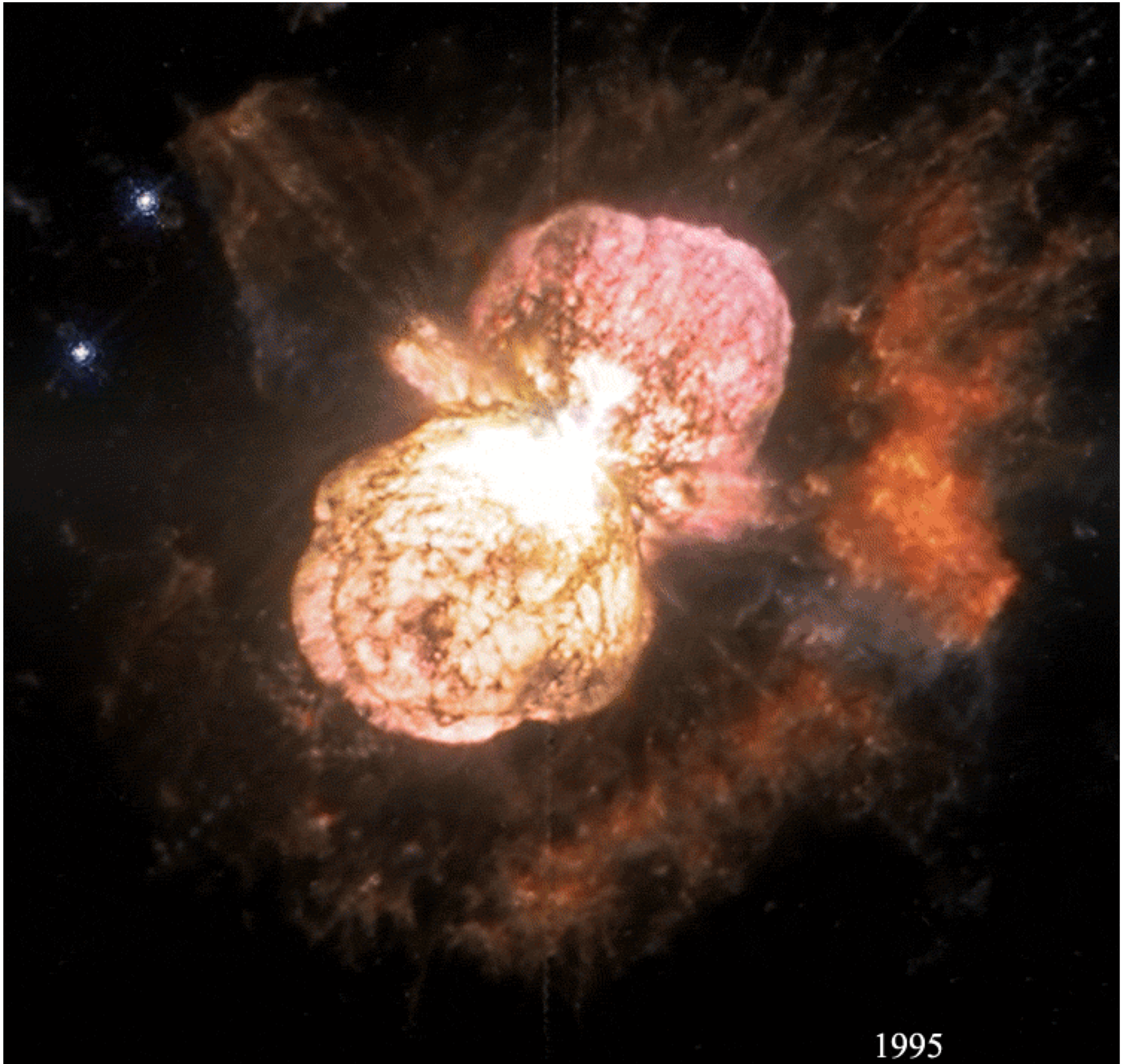
5. Tycho Brahe recorded a supernova in 1572. (Tycho's supernova) (Milky Way)

- Johannes Kepler (Tycho Brahe's student) recorded a supernova in 1604. (Kepler's supernova) (Milky Way)
- The closest supernova since Kepler's supernova occured in the Large Magellenic Cloud in 1987. (SN 1987A)

Luminous Blue Variables

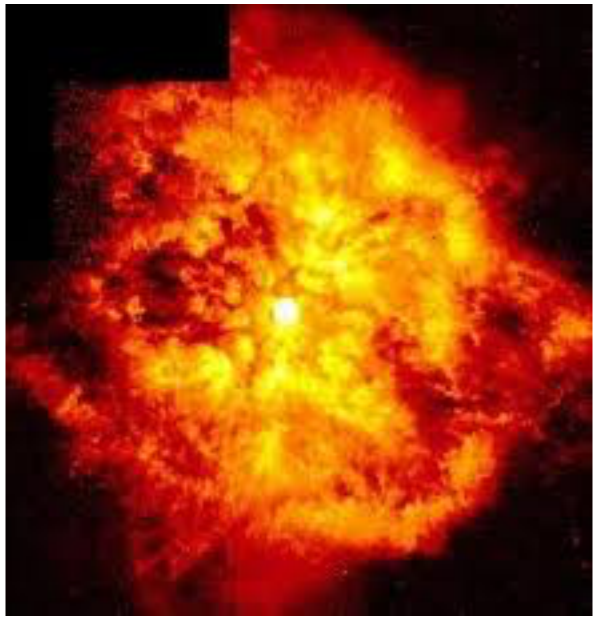


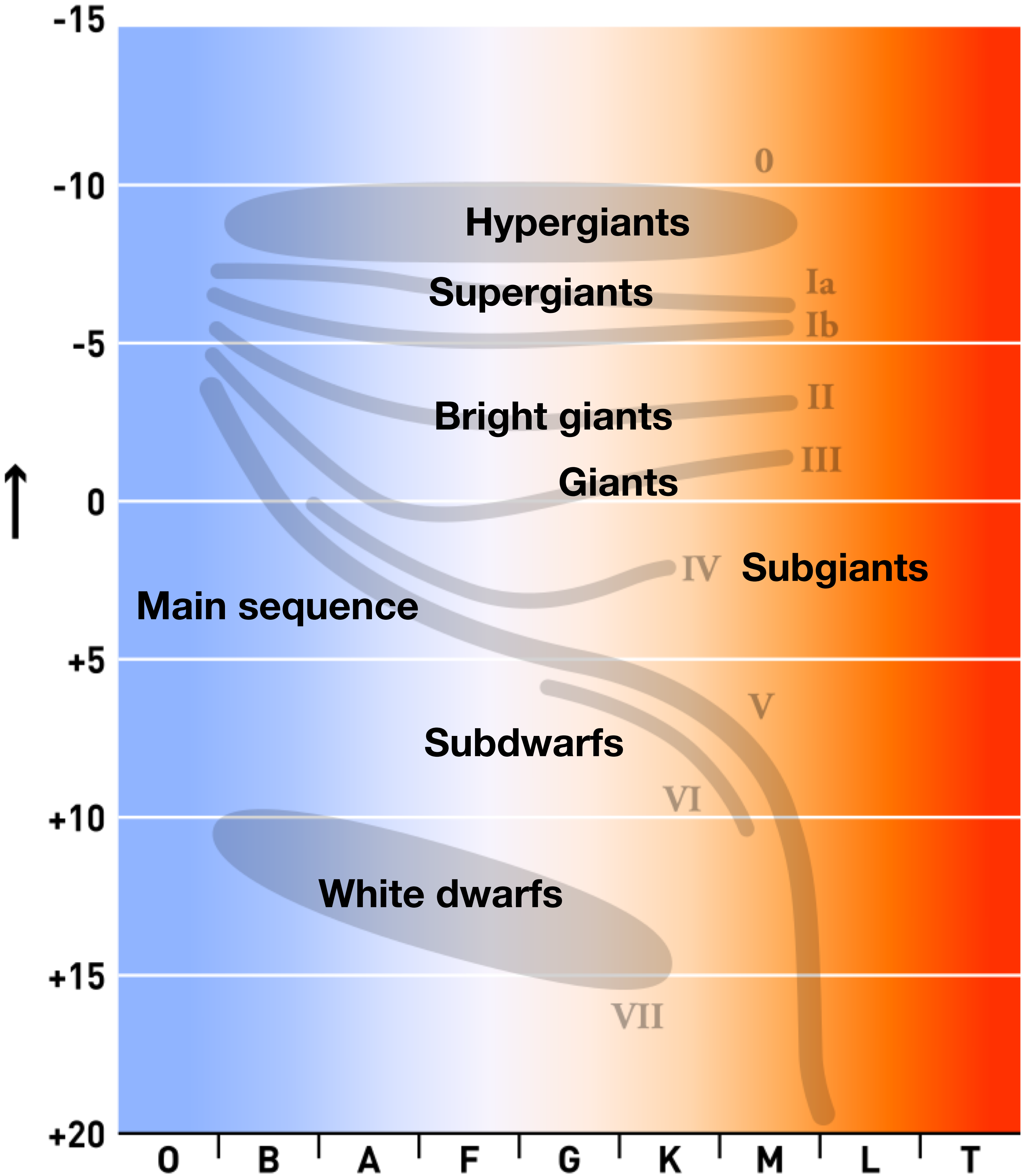
Eta Carinae was larger than the orbit of mercury

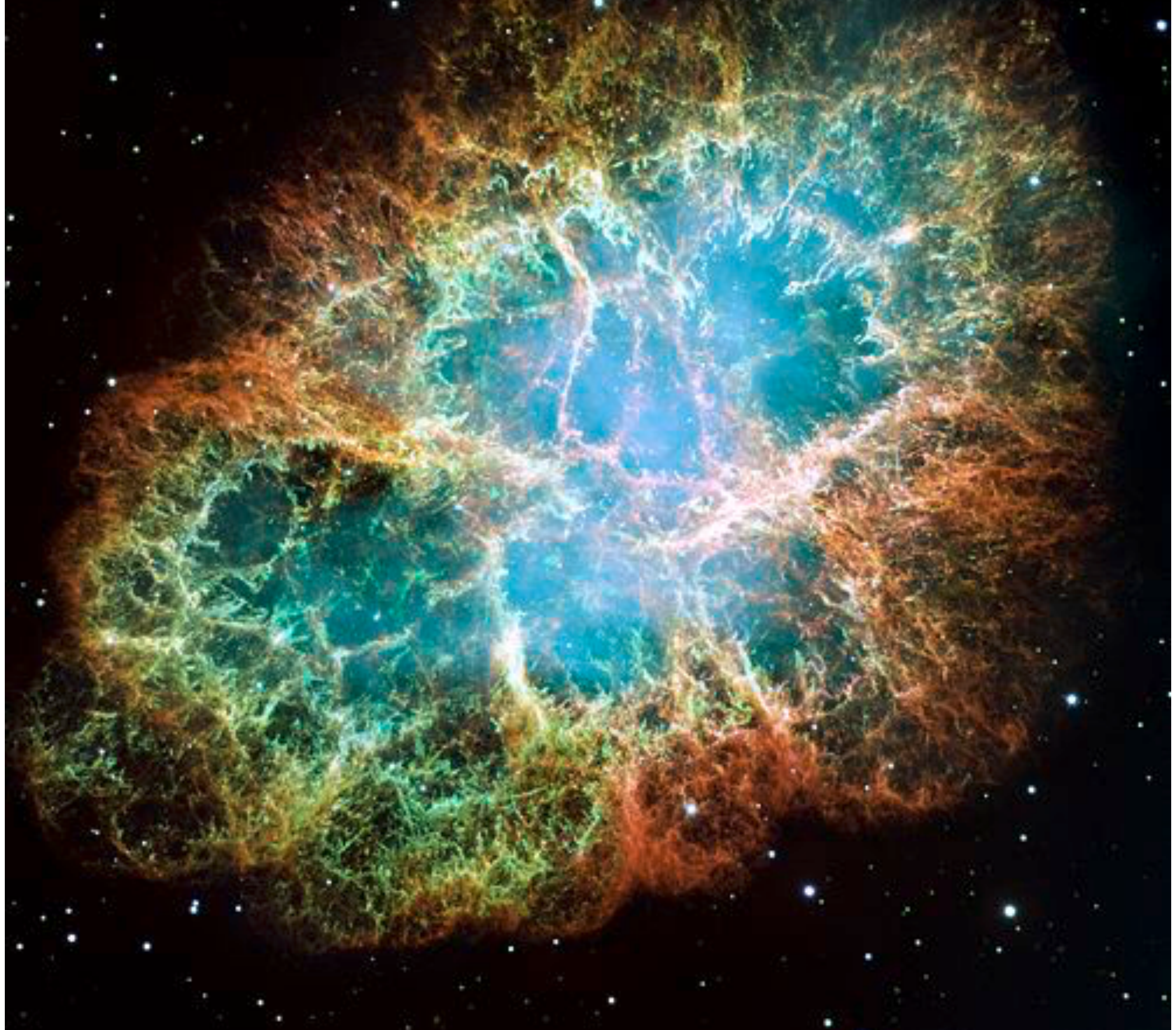


Most of this is just dust; the star hasn't really exploded yet, but it may "soon".

Wolf-Rayet stars



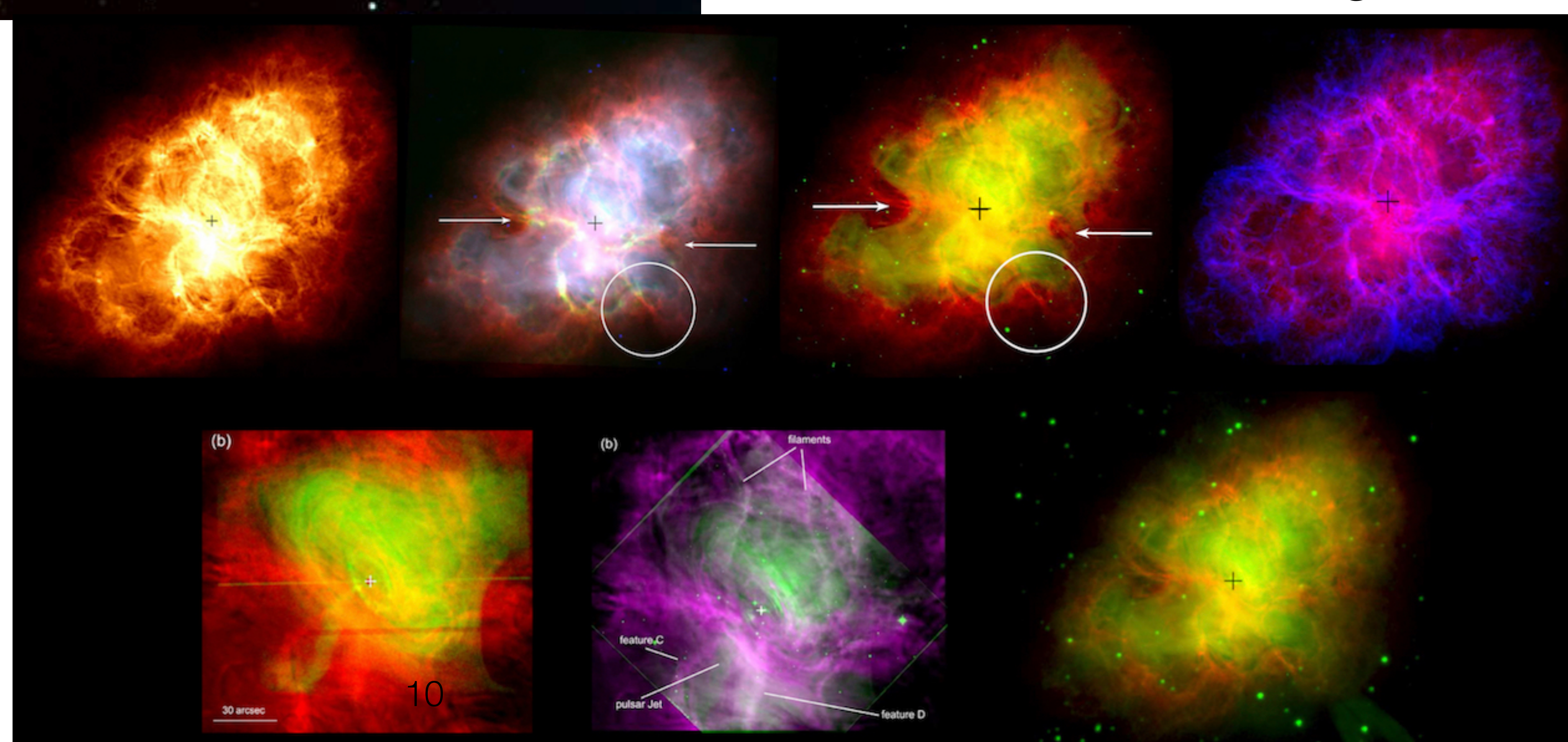

-15
-10
-5
0
+5
+10
+15
+20
0
Hypergiants
Ia
Supergiants
Ib
II
Bright giants
III
Giants
IV
Subgiants
Main sequence
V
Subdwarfs
VI
White dwarfs
VII
O
B
A
F
G
K
M
L
T

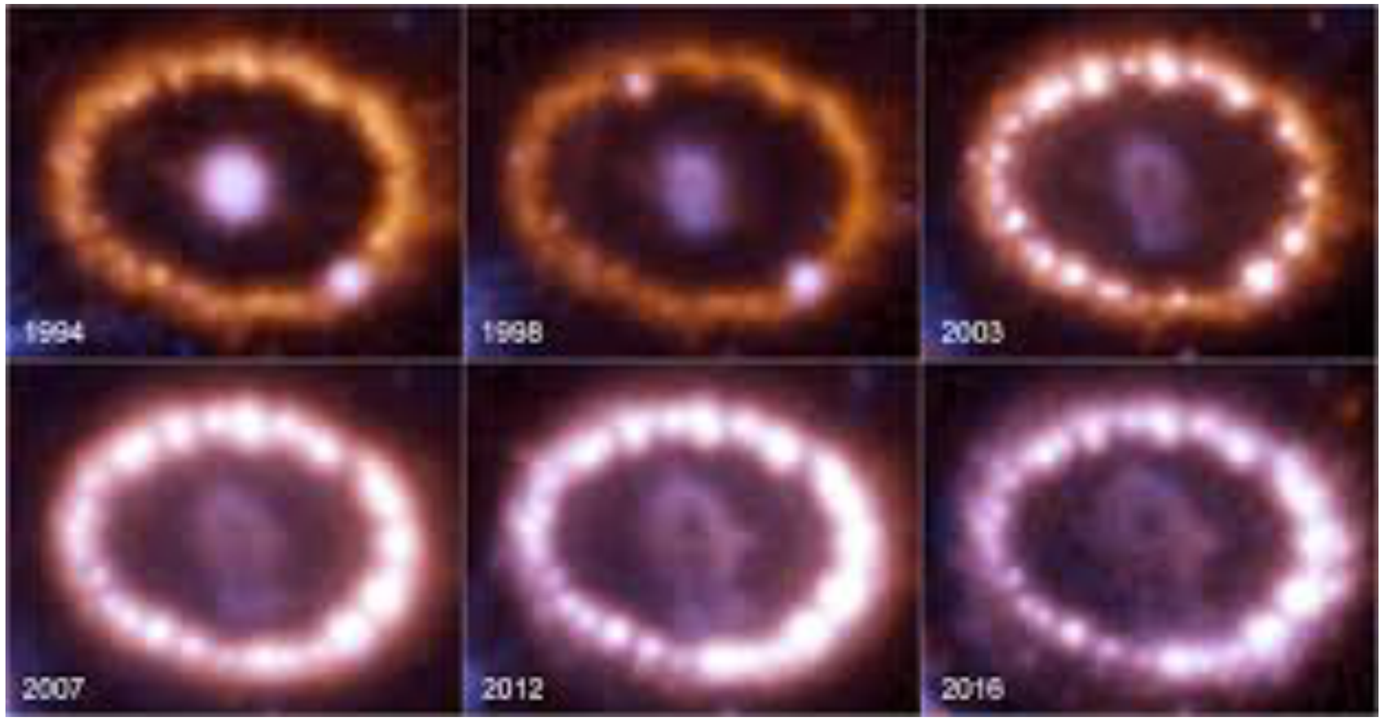


Crab supernova remnant

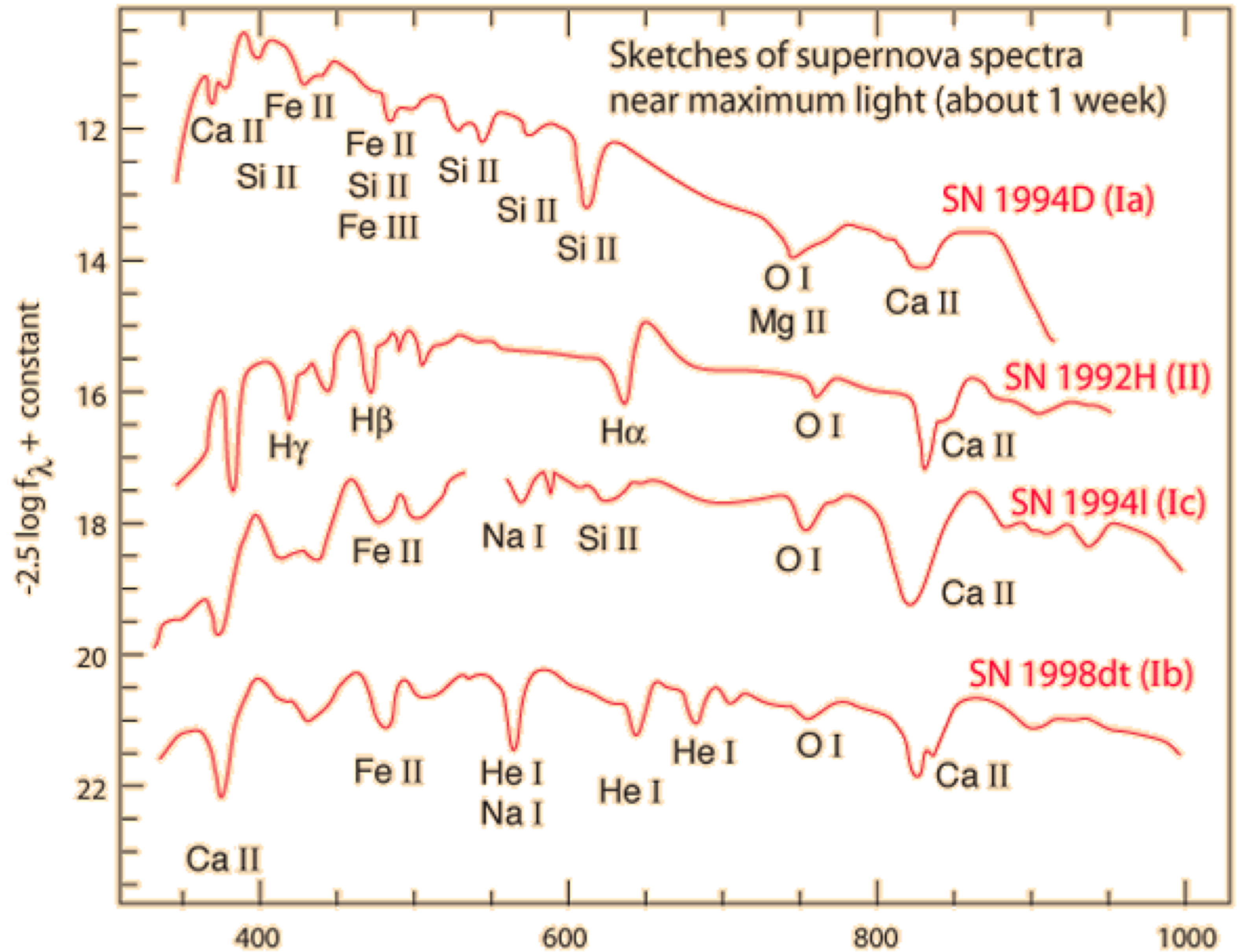
Hubble space telescope, visible

Various wavelengths:

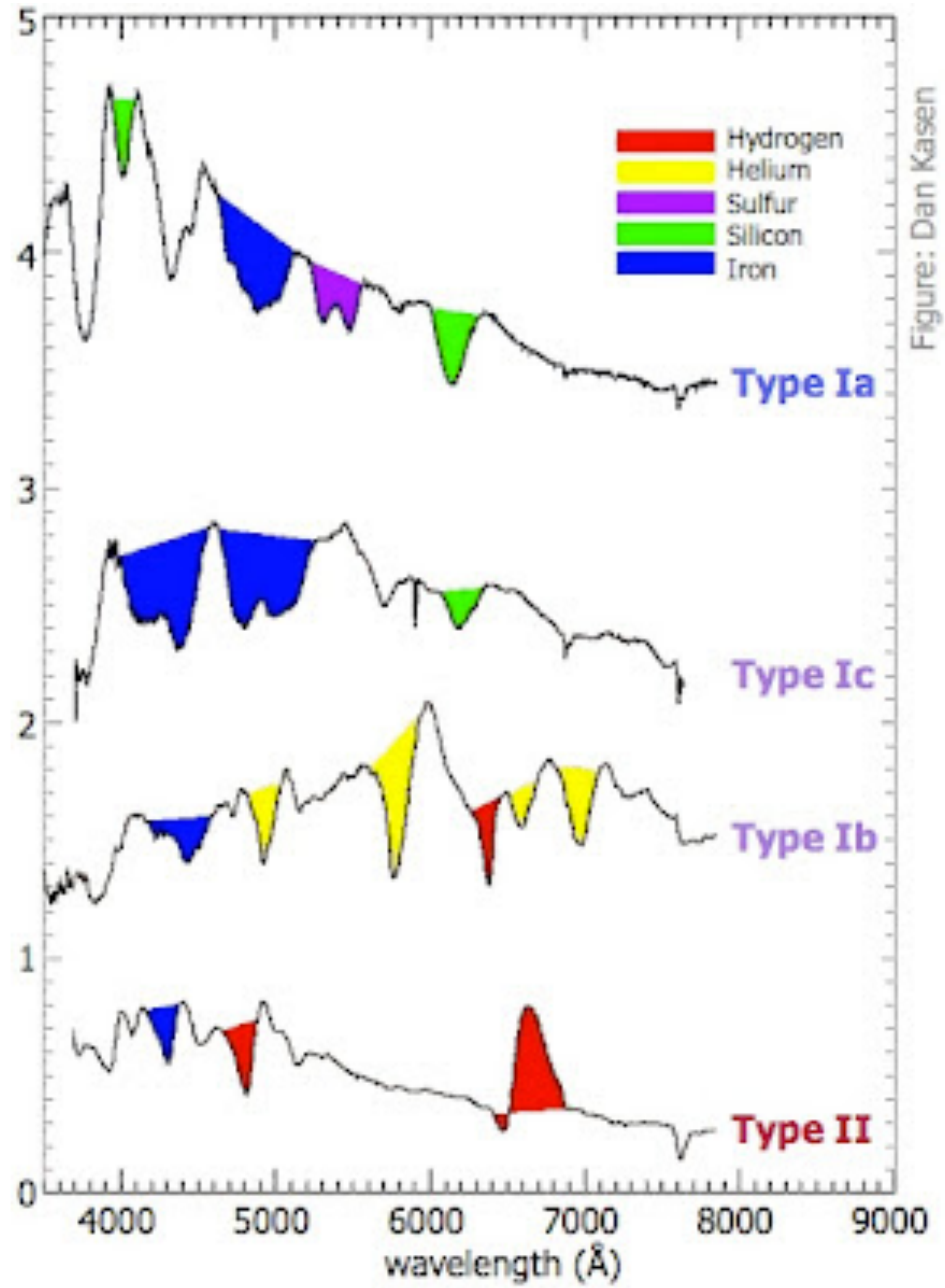




SN 1987A

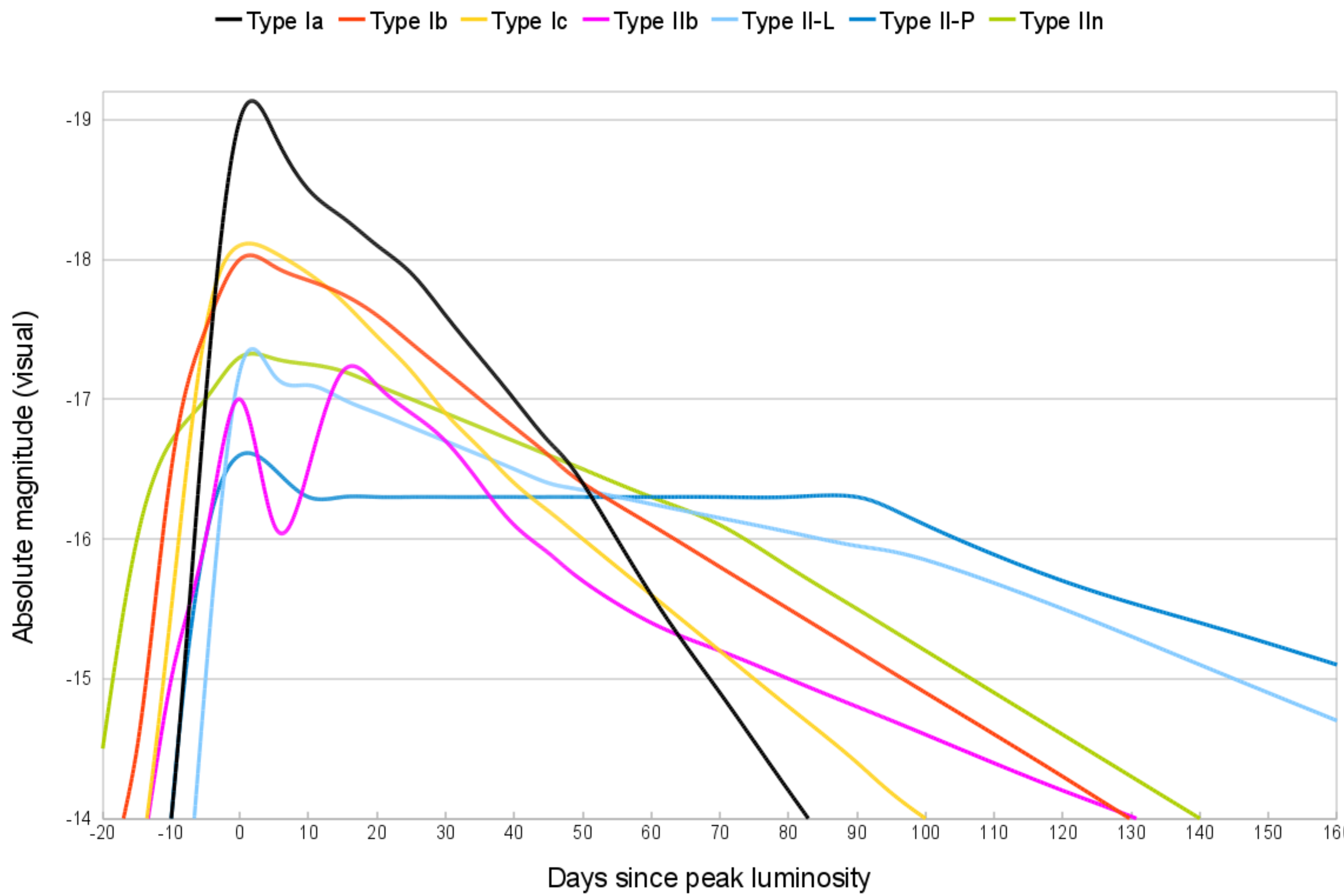


Sketches of spectra from Carroll & Ostlie, data attributed to Thomas Matheson of National Optical Astronomy Observatory.

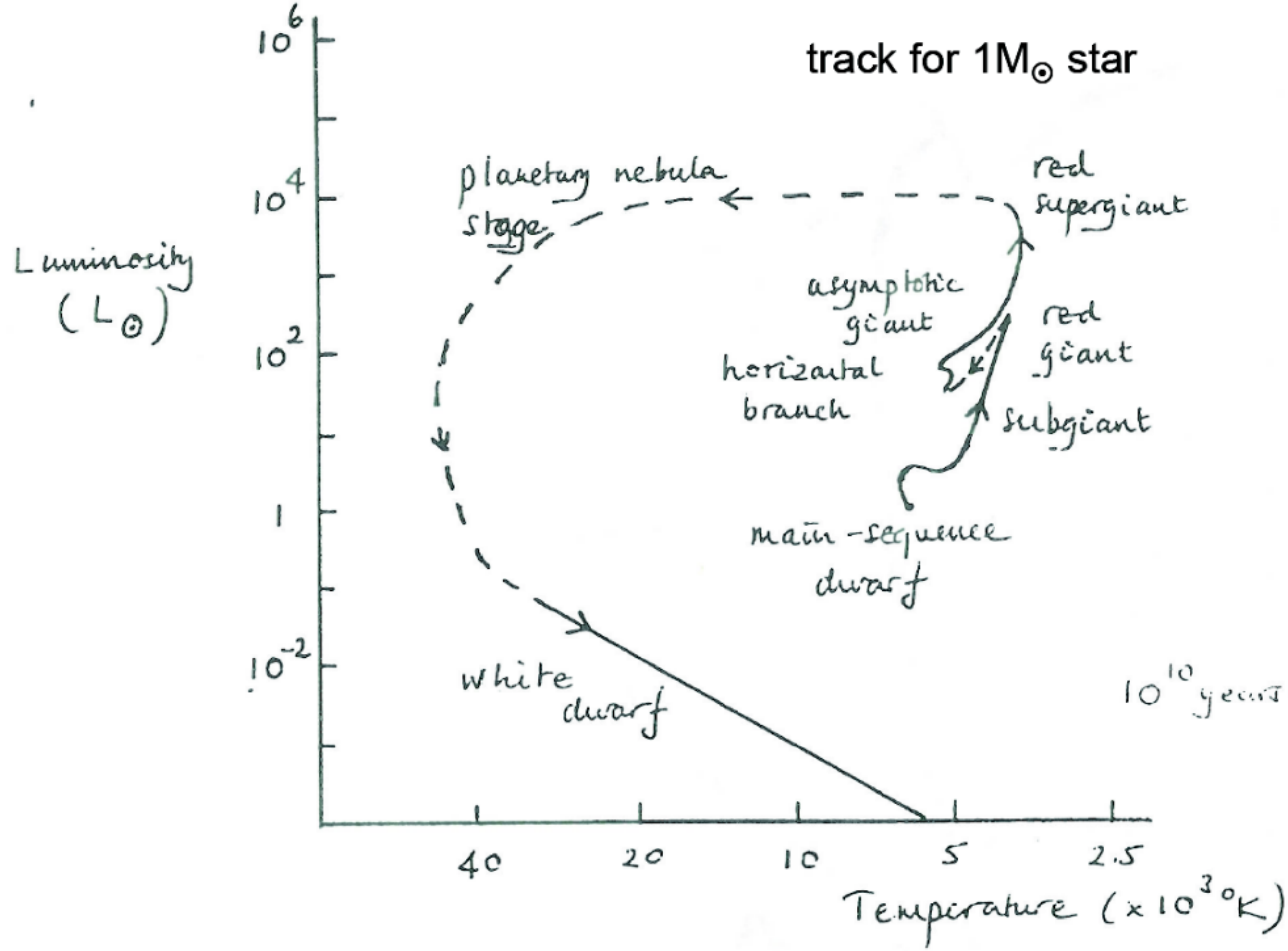


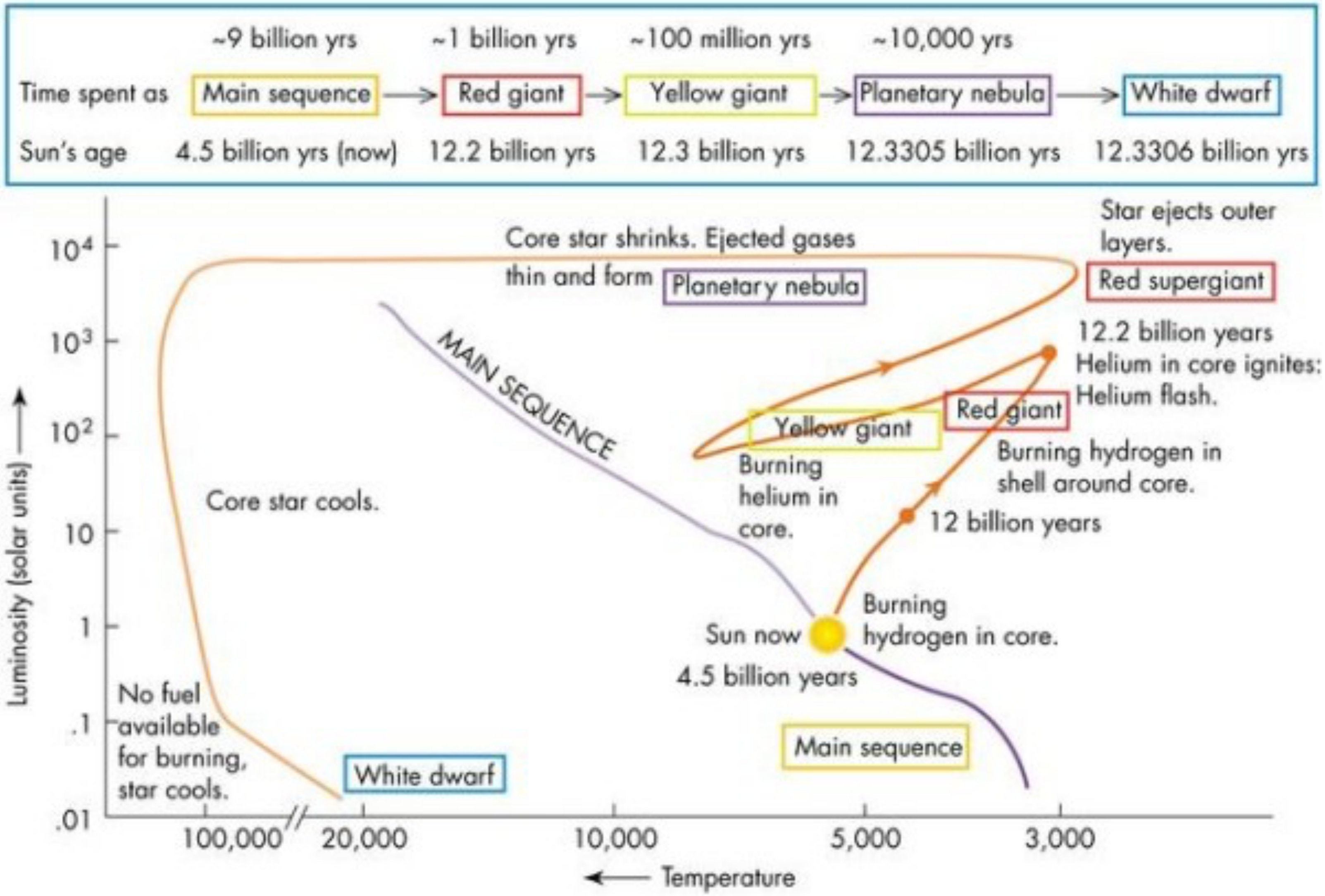
Spectral features seen in the light from supernovae of different types. The y-axis shows the relative flux. I nicked this image from Fritz's (Fritz Röpke) talk, but he clearly took it from somewhere else himself!

Seth Nadathur


Type Ia
Type Ib
Type Ic
Type IIb
Type II-L
Type II-P
Type IIn
-19
-18
-17
-16
-15
-14
Absolute magnitude (visual)
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
Days since peak luminosity

track for $1M_\odot$ star




~9 billion yrs
~1 billion yrs
~100 million yrs
~10,000 yrs
Time spent as
Main sequence
Red giant
Yellow giant
Planetary nebula
White dwarf
Sun's age
4.5 billion yrs (now)
12.2 billion yrs
12.3 billion yrs
12.3305 billion yrs
12.3306 billion yrs
Star ejects outer layers.
Red supergiant
Core star shrinks. Ejected gases thin and form
Planetary nebula
MAIN SEQUENCE
12.2 billion years
Helium in core ignites:
Helium flash.
Red giant
Yellow giant
Burning helium in core.
Burning hydrogen in shell around core.
12 billion years
Core star cools.
Burning hydrogen in core.
Sun now
4.5 billion years
No fuel available for burning, star cools.
White dwarf
Main sequence
Luminosity (solar units)
10^4
10^3
10^2
10
1
.1
.01
100,000
20,000
10,000
5,000
3,000
Temperature

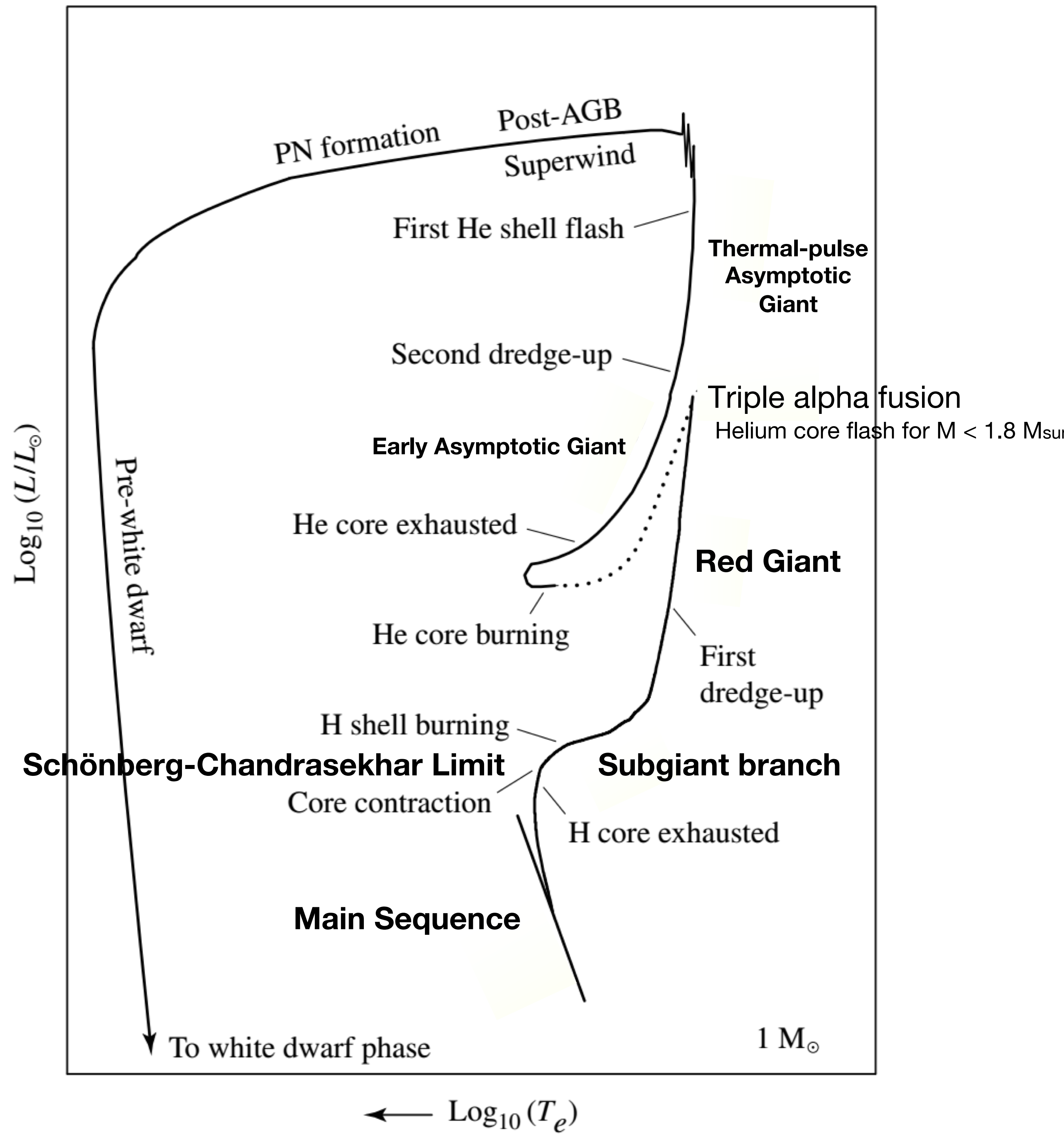
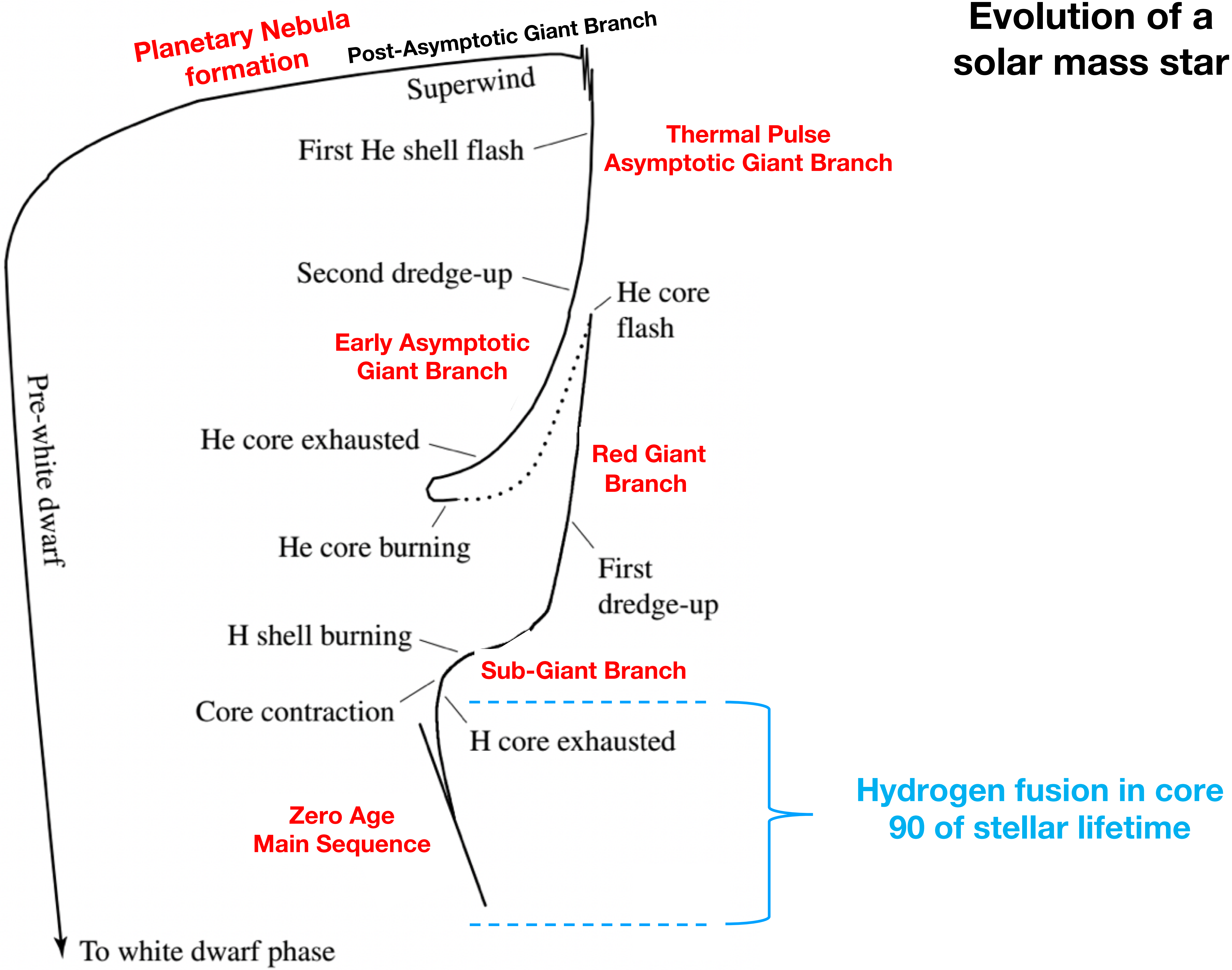
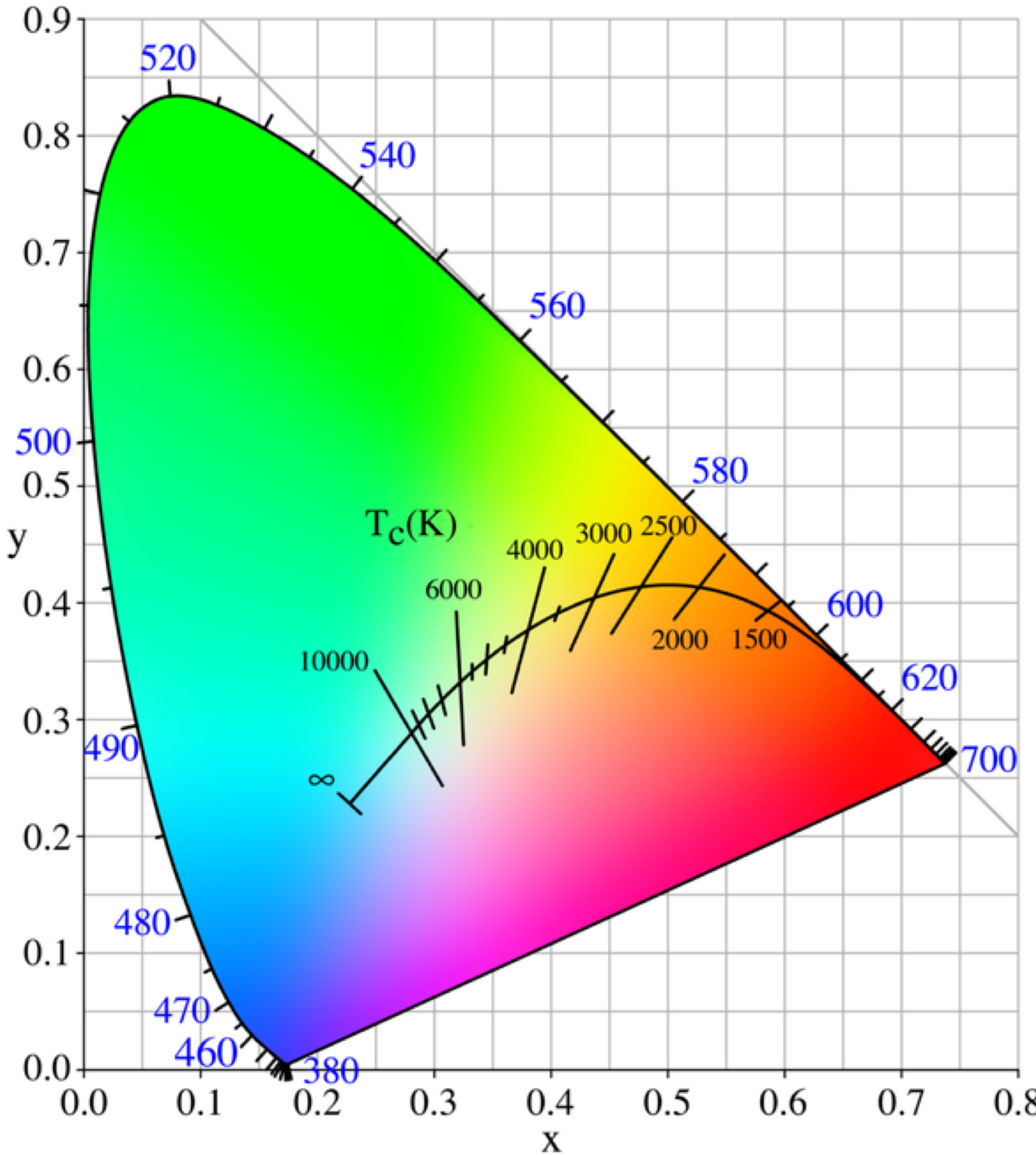


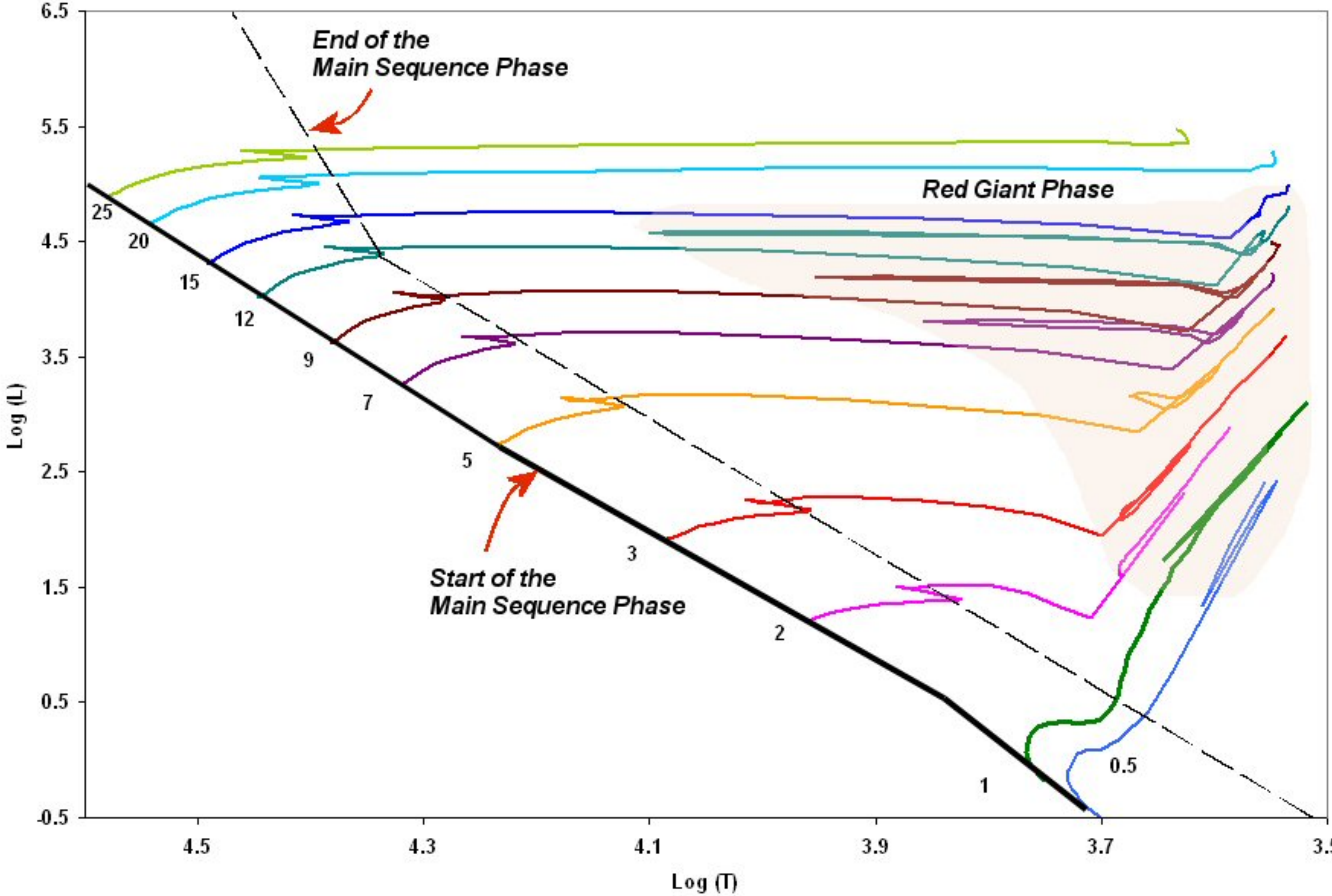
FIGURE 13.4 A schematic diagram of the evolution of a low-mass star of 1 M$_\odot$ from the zero-age main sequence to the formation of a white dwarf star (see Section 16.1). The dotted phase of evolution represents rapid evolution following the helium core flash. The various phases of evolution are labeled as follows: Zero-Age-Main-Sequence (ZAMS), Sub-Giant Branch (SGB), Red Giant Branch (RGB), Early Asymptotic Giant Branch (E-AGB), Thermal Pulse Asymptotic Giant Branch (TP-AGB), Post-Asymptotic Giant Branch (Post-AGB), Planetary Nebula formation (PN formation), and Pre-white dwarf phase leading to white dwarf phase.

Evolution of a solar mass star

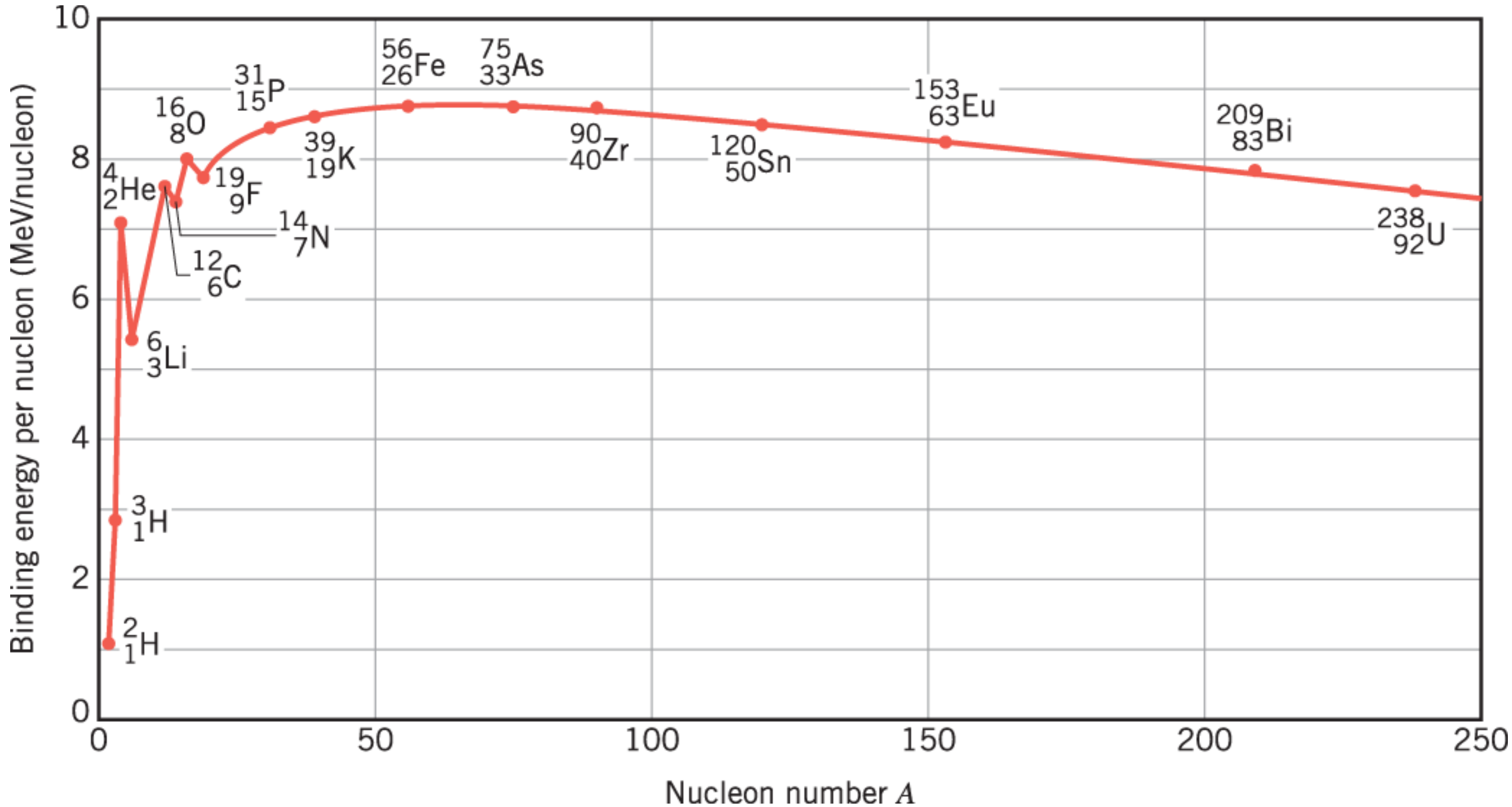




Planckian Locus



End of the
Main Sequence Phase
Red Giant Phase
Start of the
Main Sequence Phase
25
20
15
12
9
7
5
3
2
1
0.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-0.5
4.5
4.3
4.1
3.9
3.7
3.5
Log (L)
Log (T)



The highest point on the curve is iron, which is therefore the endpoint of both fusion and fission reactions.

Which elements

- **have equal numbers of protons and neutrons**
- **have atomic mass number a multiple of 4**
- **are lighter than Iron?**

- **He (2/4)**
- **C (6/12) = 3 He**
- **O (8/16) = 4 He**
- **Ne (10/20) = 5 He**
- **Mg (12/24) = 6 He**
- **Si (14/28) = 7 He**
- **S (16/32) = 8 He**
- **Ca (20/40) = 10 He**

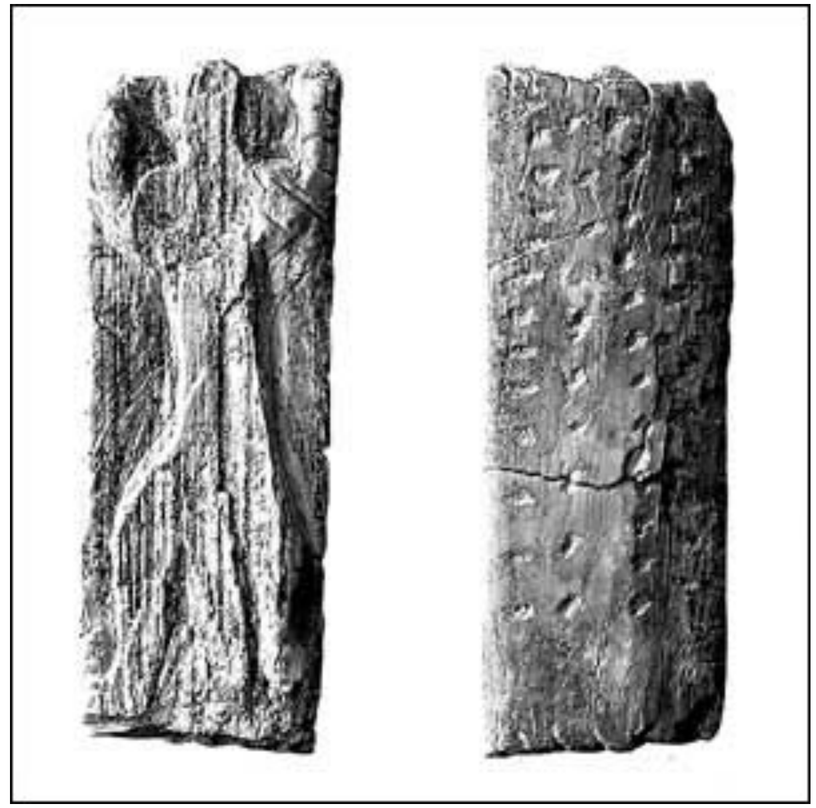
If fusion from Helium is the source of the elements, we may expect these to be the most abundant elements.

From Wikipedia, abundance of the elements:

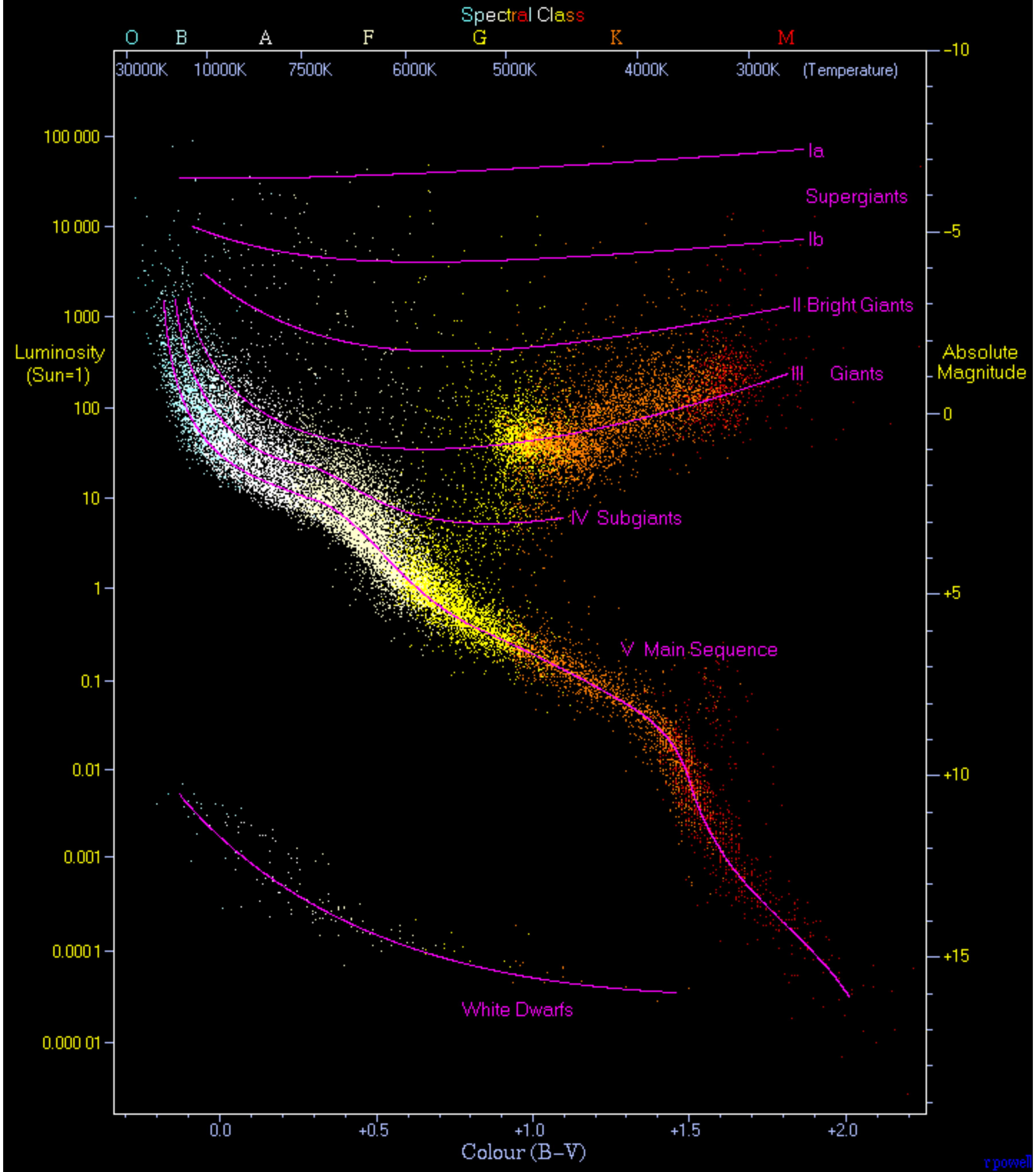
Ten most common elements in the Milky Way Galaxy estimated spectroscopically

Z	Element	Mass fraction (ppm)
1	Hydrogen	739,000
2	Helium	240,000
8	Oxygen	10,400
6	Carbon	4,600
10	Neon	1,340
26	Iron	1,090
7	Nitrogen	960
14	Silicon	650
12	Magnesium	580
16	Sulfur	440

Croswell, Ken (February 1996). *Alchemy of the Heavens*. Anchor. ISBN 0-385-47214-5. Archived from the original on 2011-05-13.



32,000 year old star chart? The human figure has the same proportions that the stars of Orion would have had at that time.



Spectral Class
O
B
A
F
G
K
M
30000K
10000K
7500K
6000K
5000K
4000K
3000K
(Temperature)
Luminosity (Sun=1)
100 000
10 000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.000 01
Absolute Magnitude
-10
-5
0
+5
+10
+15
Ia
Supergiants
Ib
II Bright Giants
III Giants
IV Subgiants
V Main Sequence
White Dwarfs
0.0
+0.5
+1.0
+1.5
+2.0
Colour (B–V)
r powell

Dragon and Phoenix

February 22, 2019 03:20pm ET