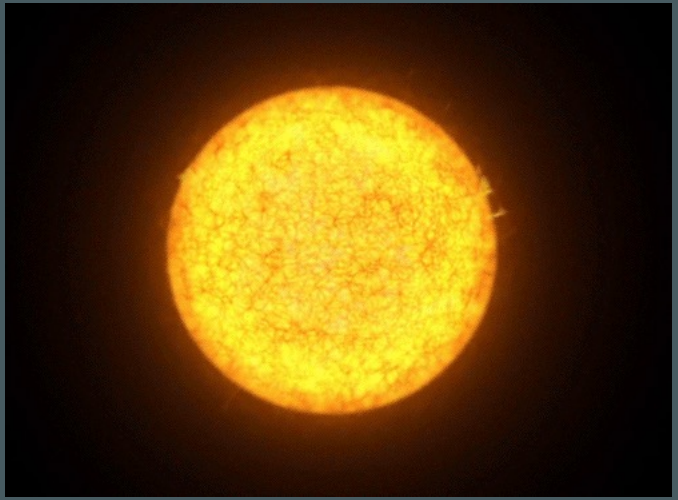
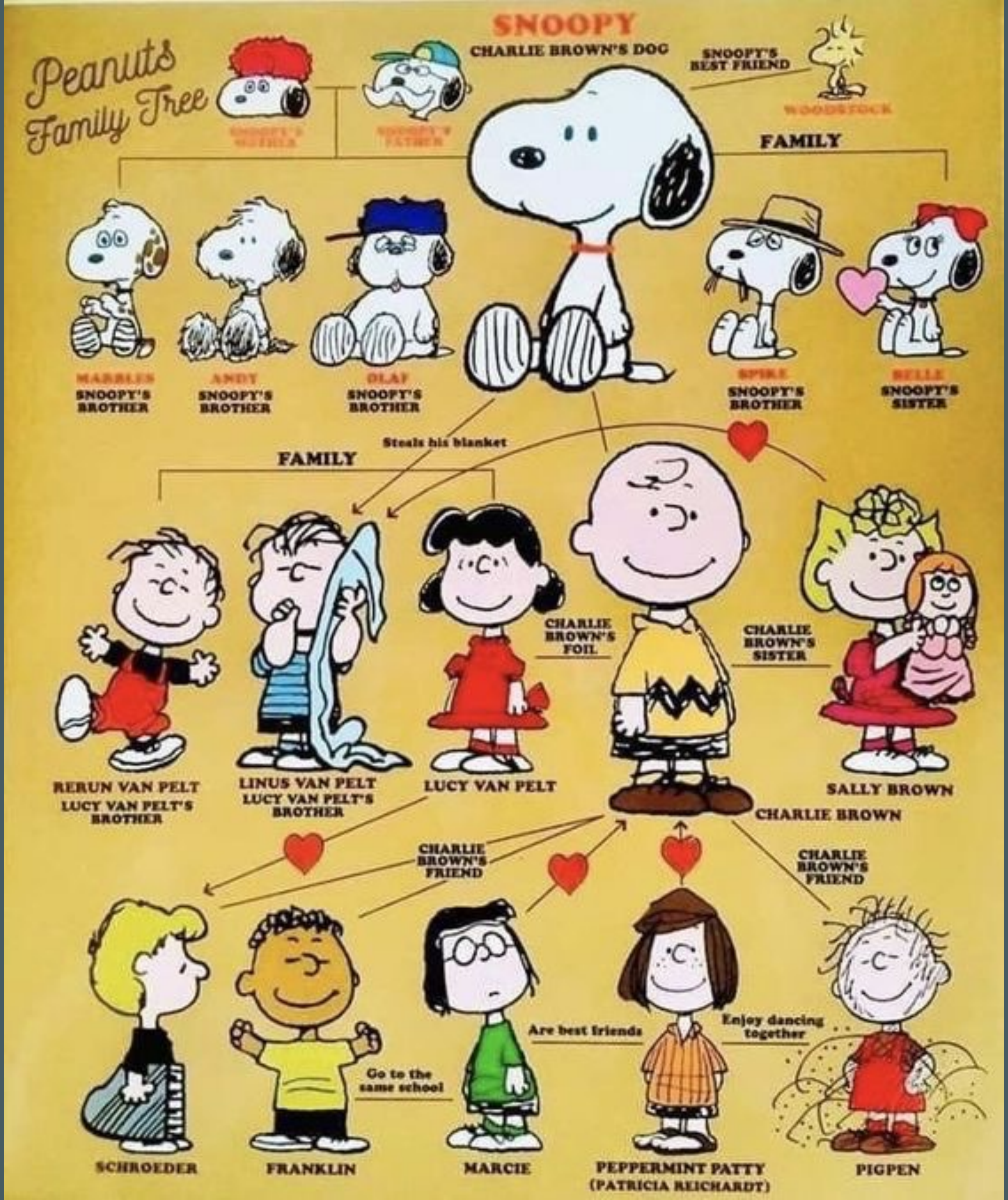
Things That Blink

The Story of Variable Stars

Things That Blink

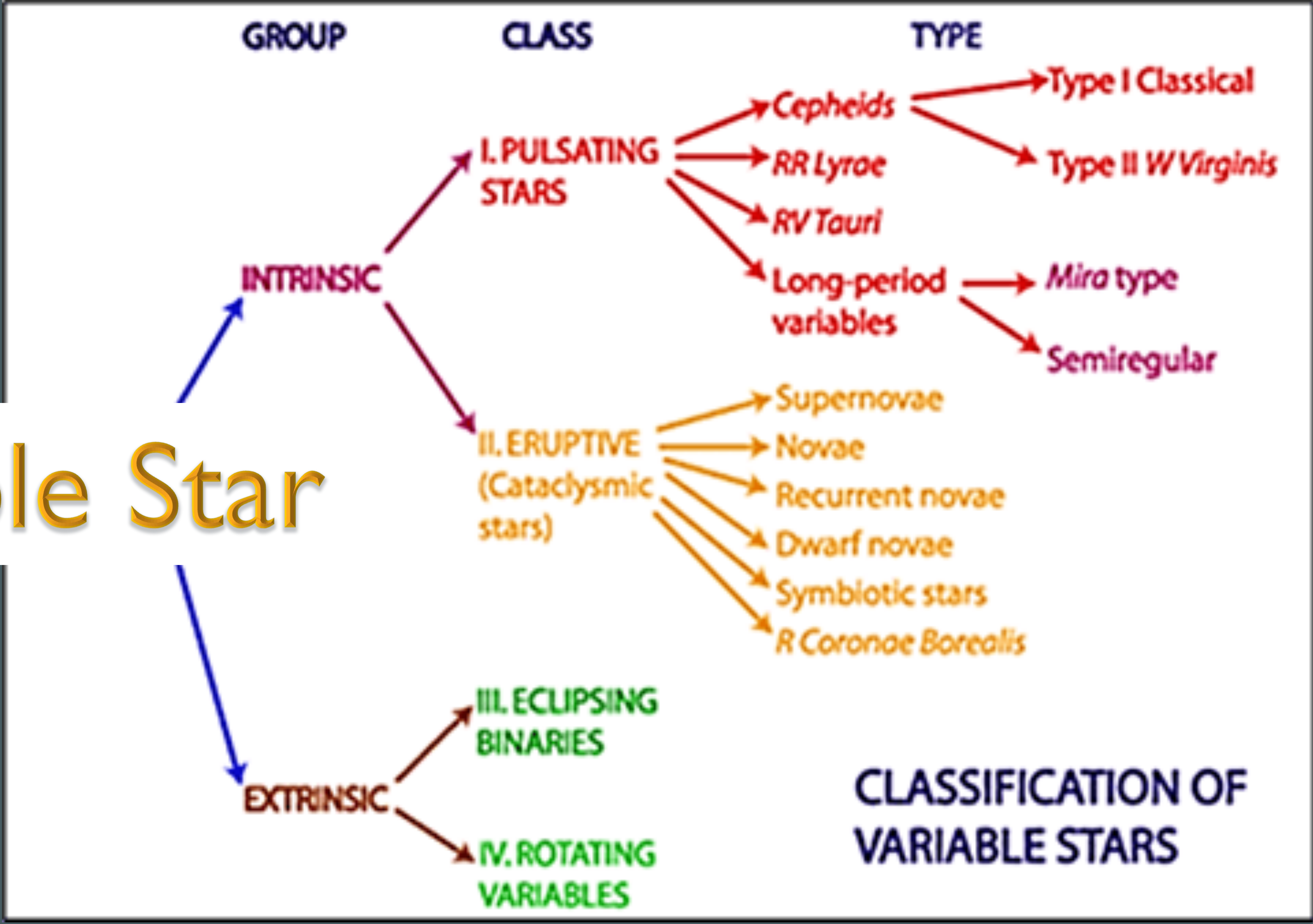


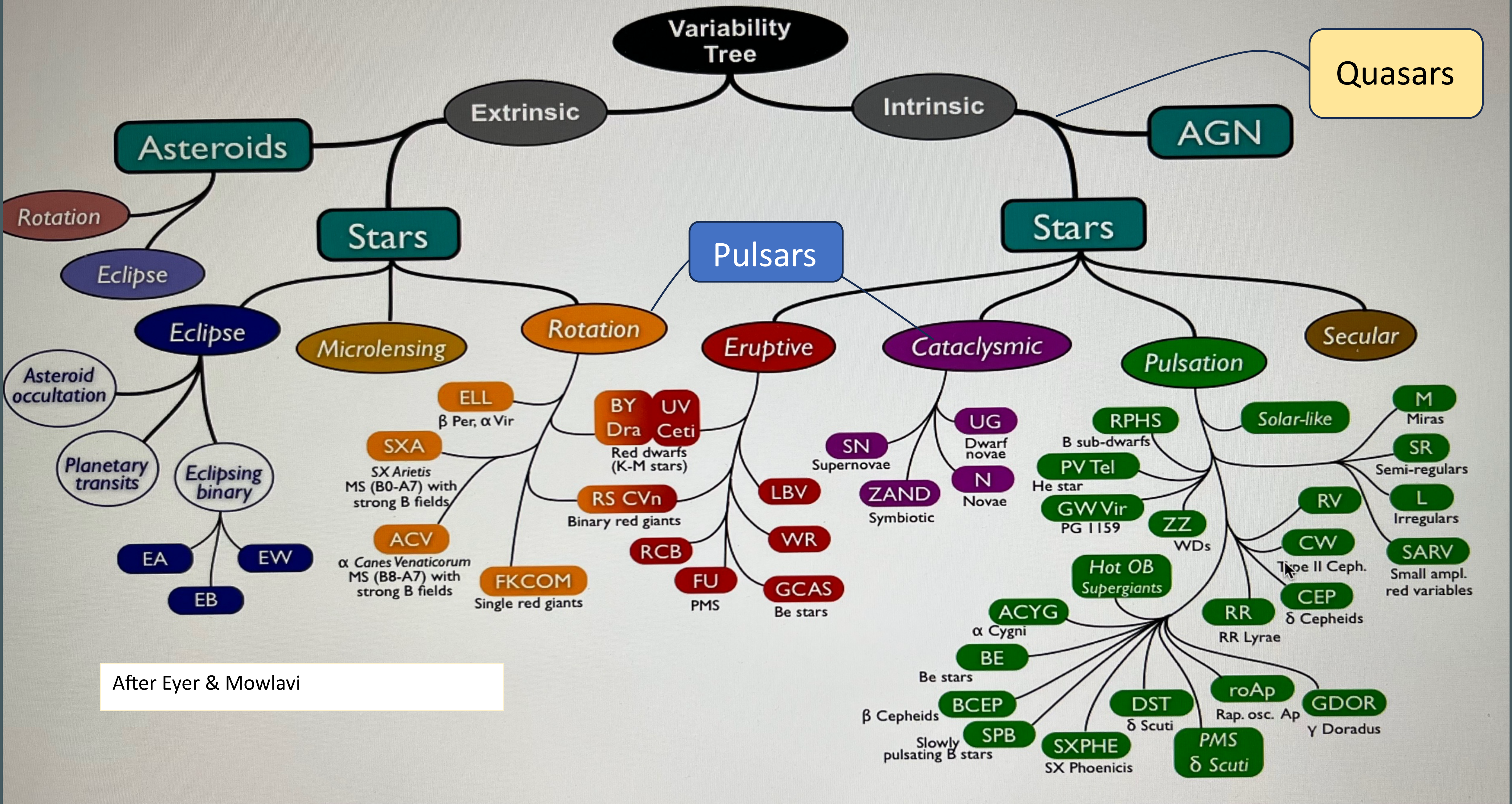
The Story of Variable Stars



"Family Trees" help explain relationships

Variable Star





After Eyer & Mowlavi

INTRINSIC

Variability corresponds to a star's internal nature

*Star Physics
*Stage of evolution
*Chemical composition

Pulsating Stars

Cepheid Variables

Class I Delta Cepheids

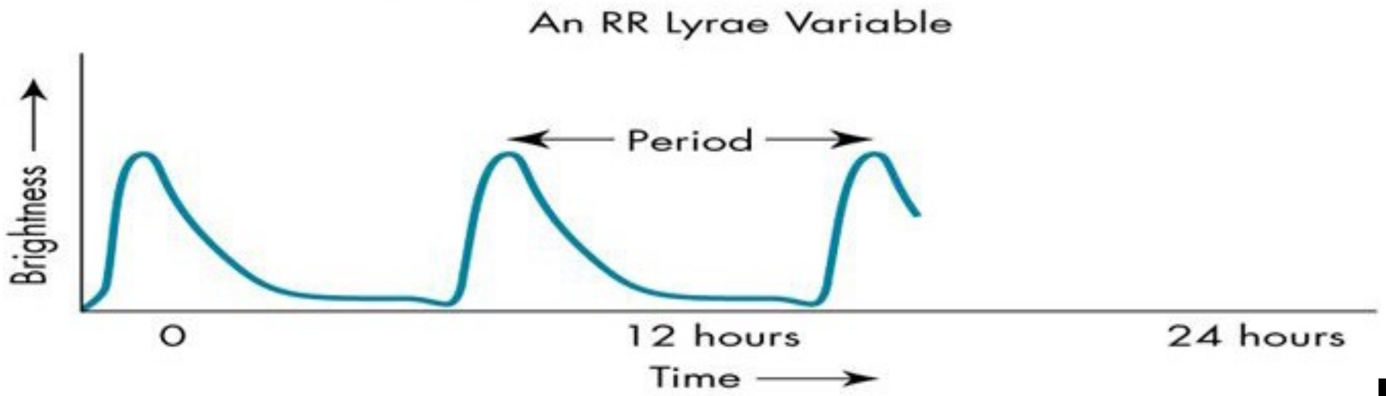
Class II Beta Cepheids

*Many subclasses, usually by periodicity

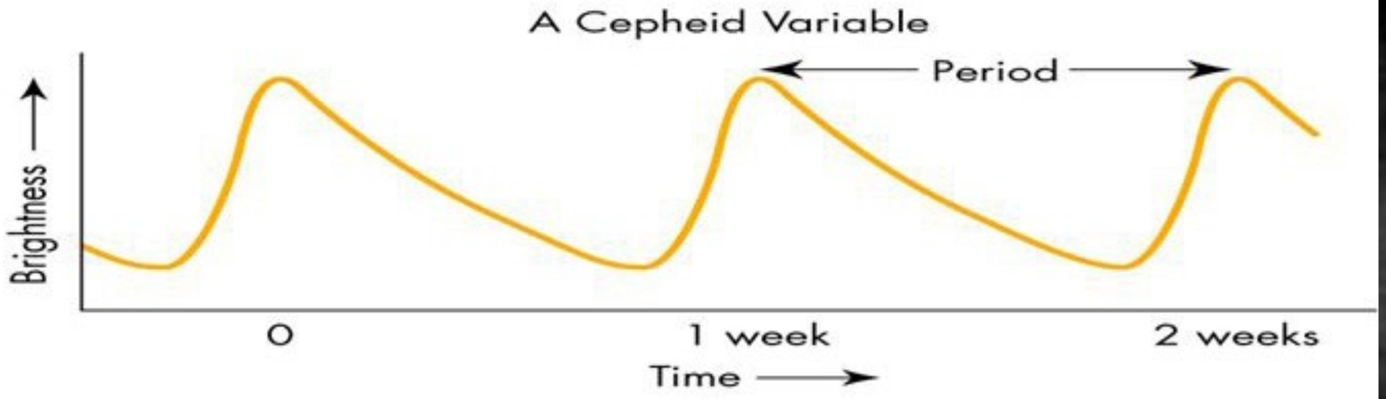
*Over 3000 now recognized

Light curves

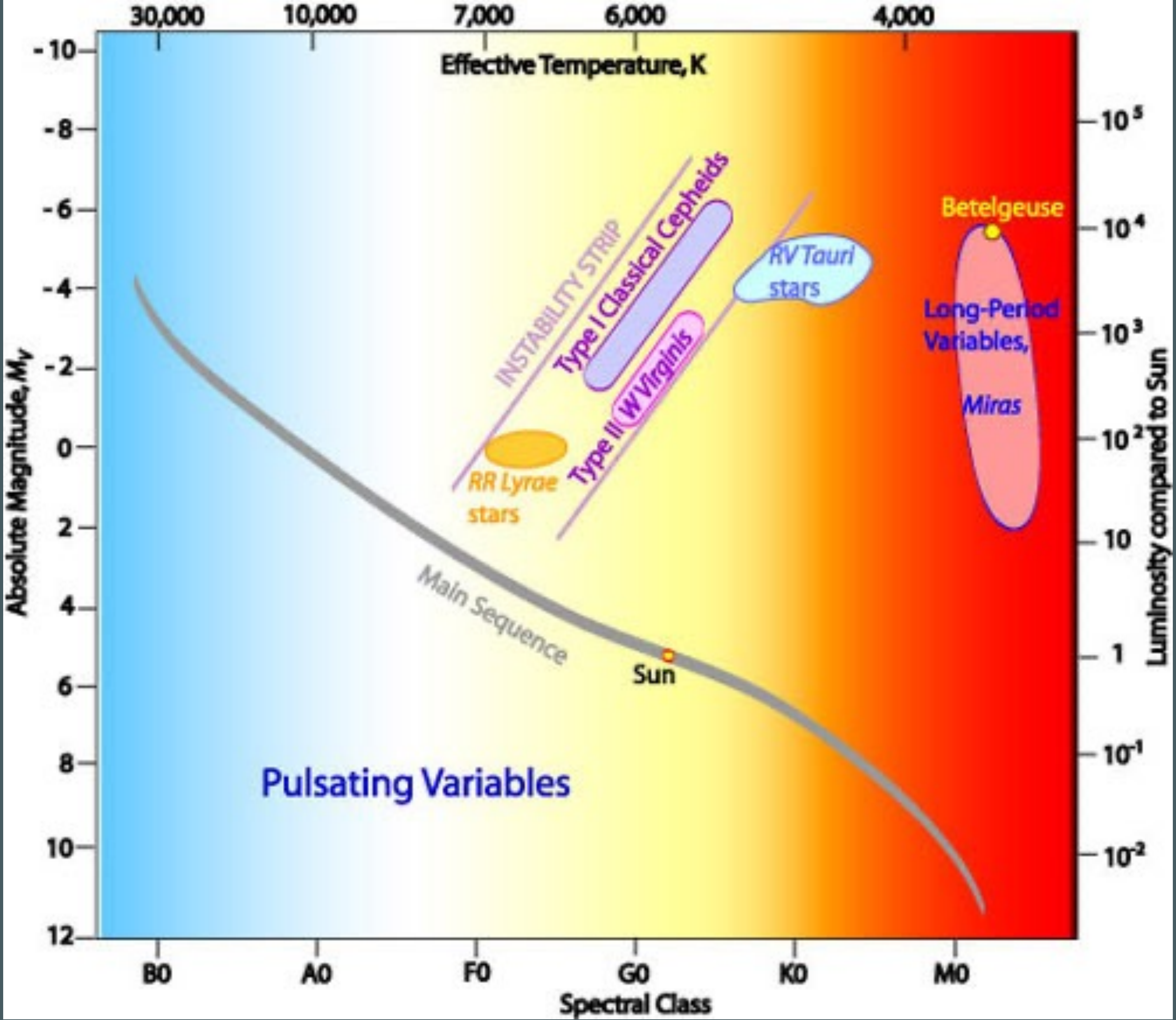
RR Lyrae



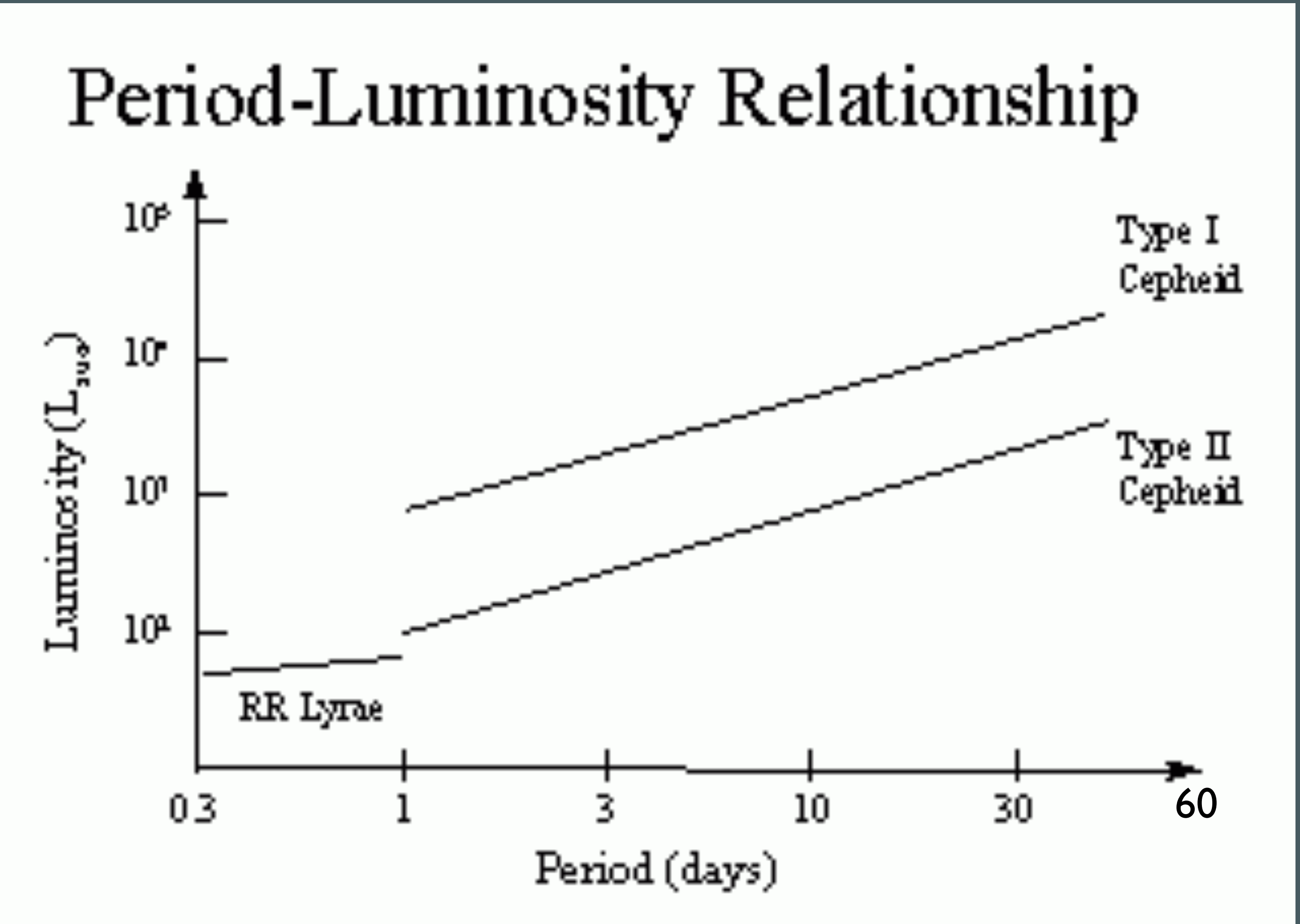
Cepheid



Henrietta Leavitt



30,000
10,000
7,000
6,000
4,000
Effective Temperature, K
Absolute Magnitude, M_V
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Luminosity compared to Sun
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
INSTABILITY STRIP
Type I Classical Cepheids
Type II W Virginis
RR Lyrae stars
RV Tauri stars
Betelgeuse
Long-Period Variables,
Miras
Main Sequence
Sun
Pulsating Variables
B0
A0
F0
G0
K0
M0
Spectral Class

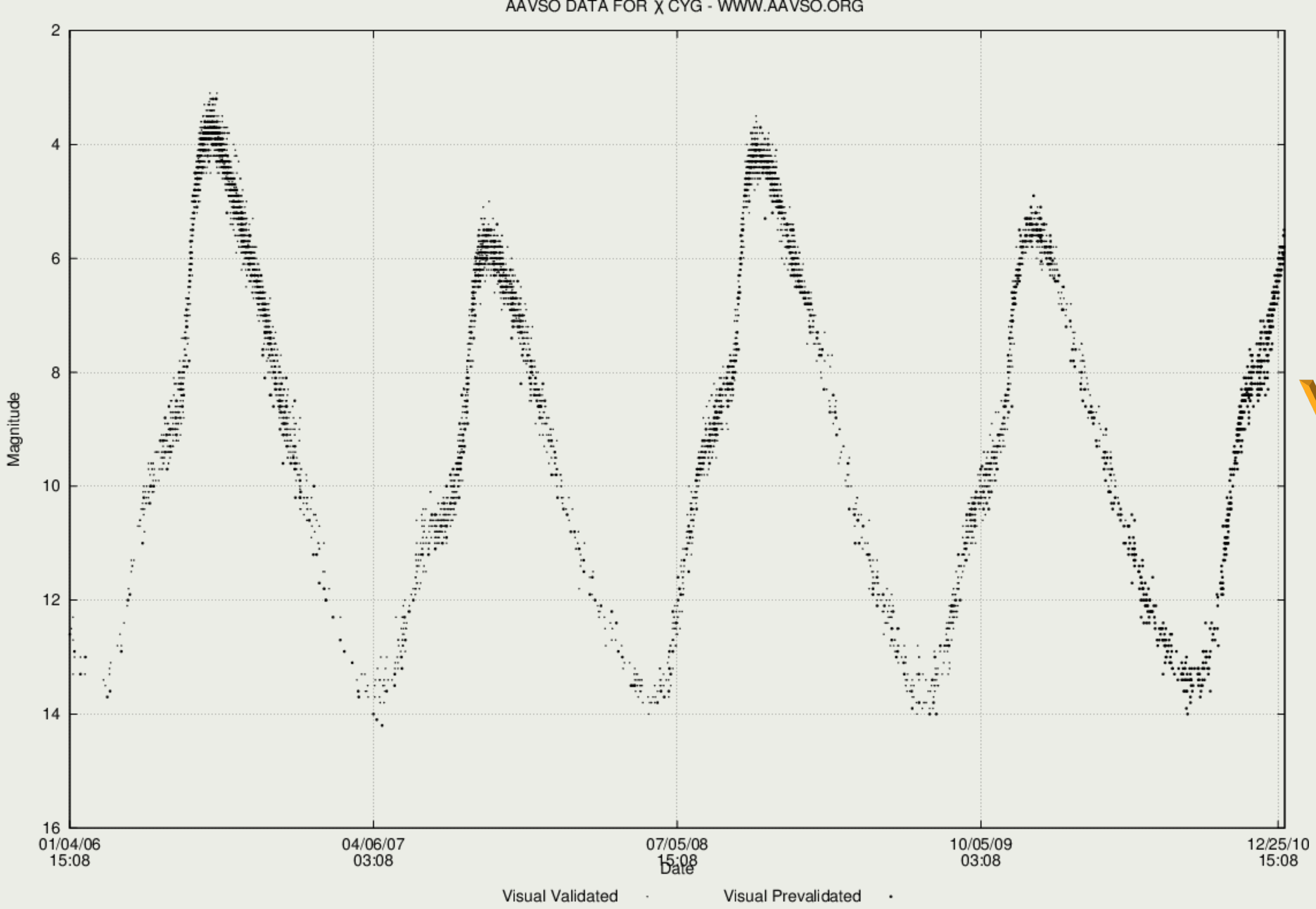


Brighter

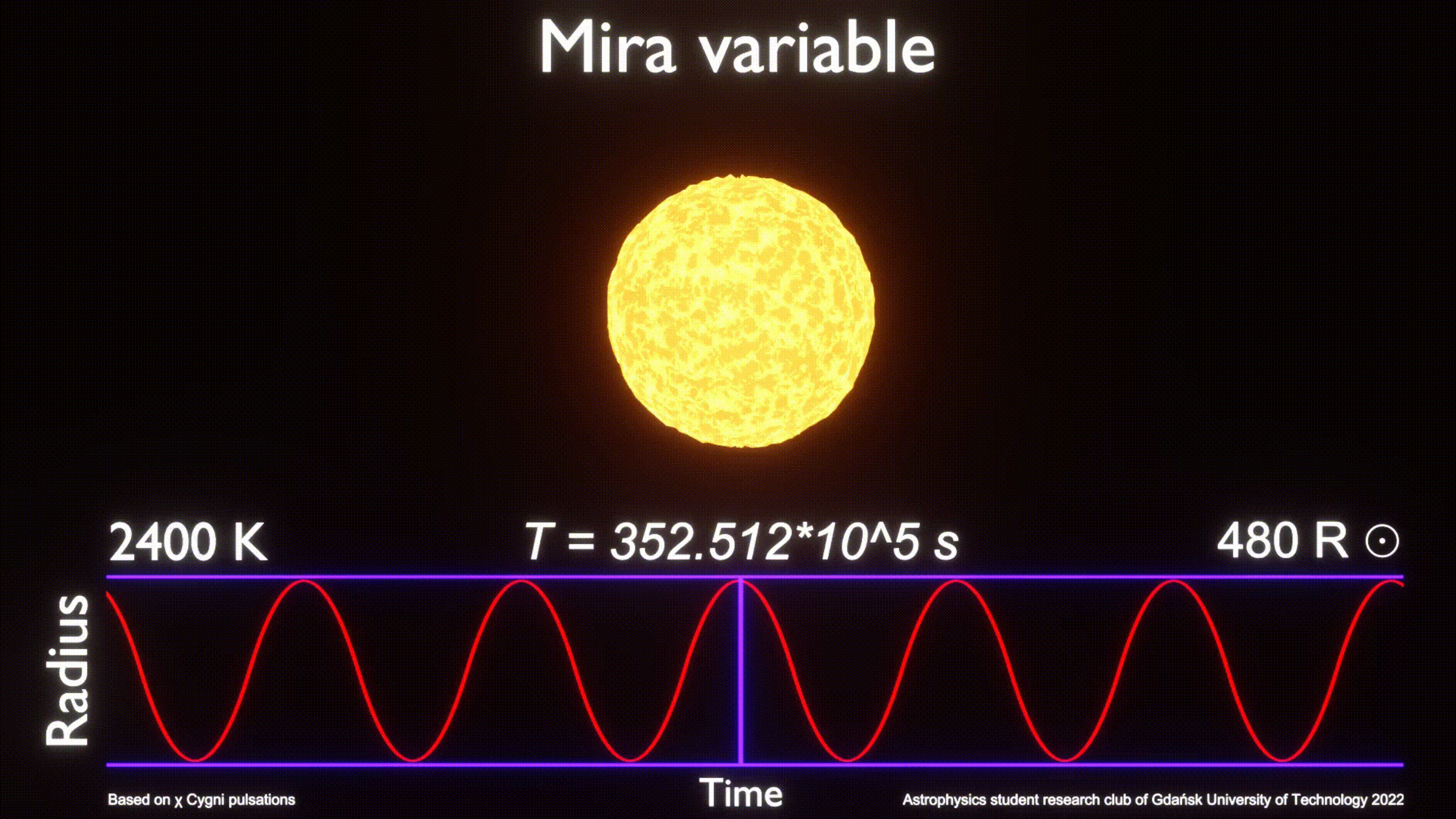
Dimmer

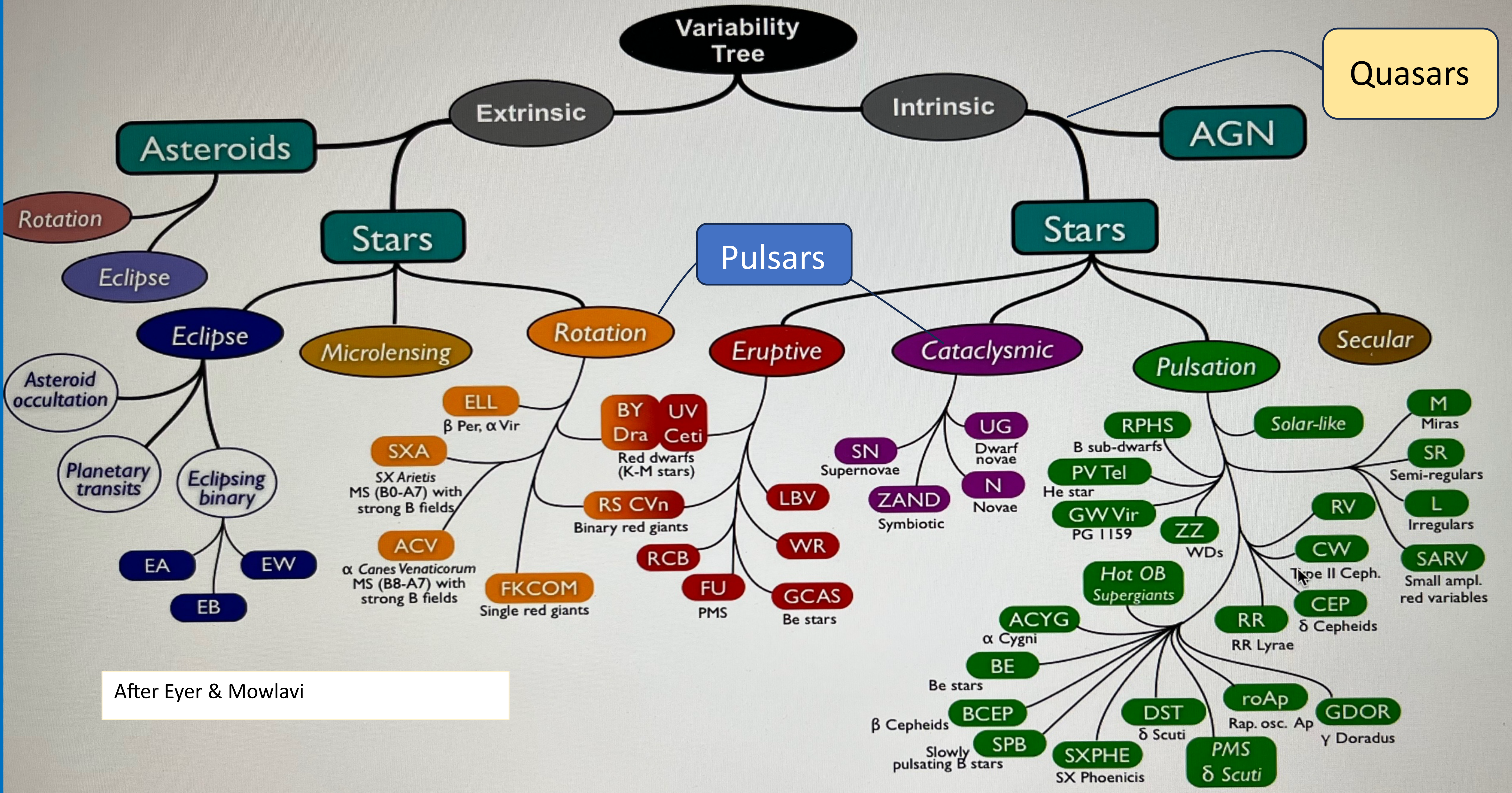
Related to the ratio of Singly ionized 1-He to Doubly ionized 2-He

3-30 Solar Masses



Long period Mira Variable >100 days


Mira variable
2400 K
T = 352.512*10^5 s
480 R ☉
Radius
Time
Based on χ Cygni pulsations
Astrophysics student research club of Gdańsk University of Technology 2022



After Eyer & Mowlavi

Cataclysmic Stars
Type II, IIb
Involving core collapse

*Novae

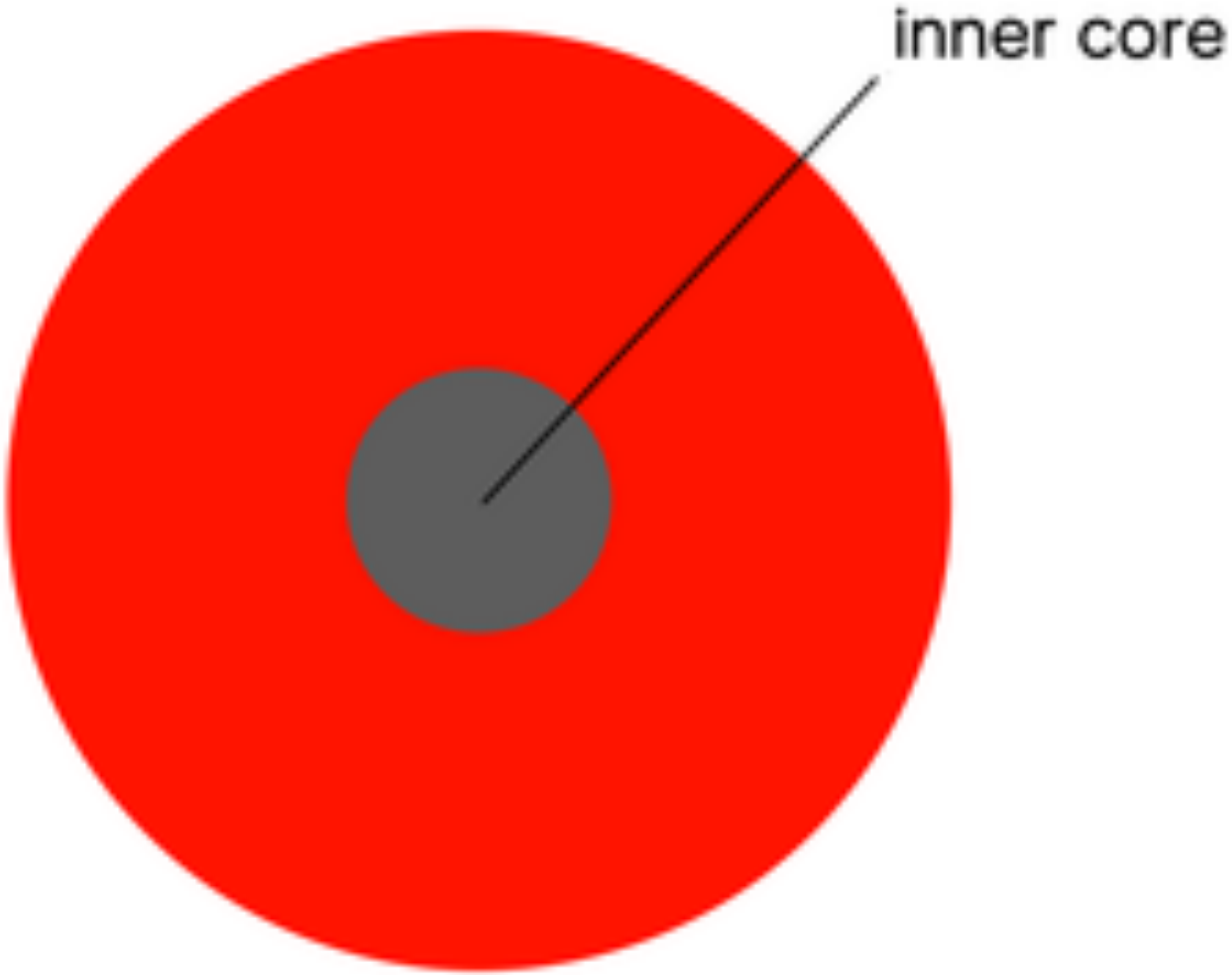
*Kilonovae

*Supernovae

*Hypernovae

NEUTRON STAR Formation

e- + p+ = n°



Massive Star: Usually 14-19 Solar Masses

NEUTRON STAR Formation

$e^- + p^+ = n^\circ$

Inner core implodes under gravity

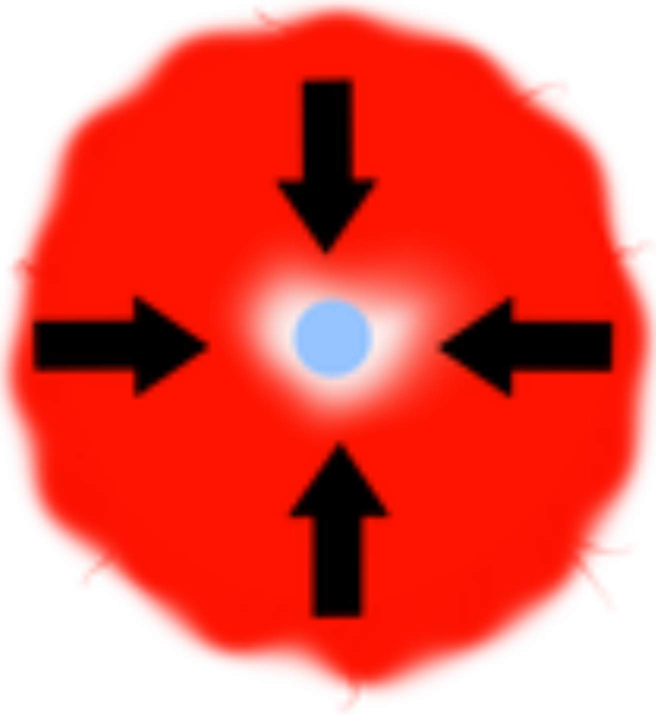
NEUTRON STAR Formation

e- + p+ = n°

Gravity smashes electrons and protons together, forming neutrons, and releasing a shower of neutrinos. Outer layers slosh violently from standing accretion shock instability.

NEUTRON STAR Formation

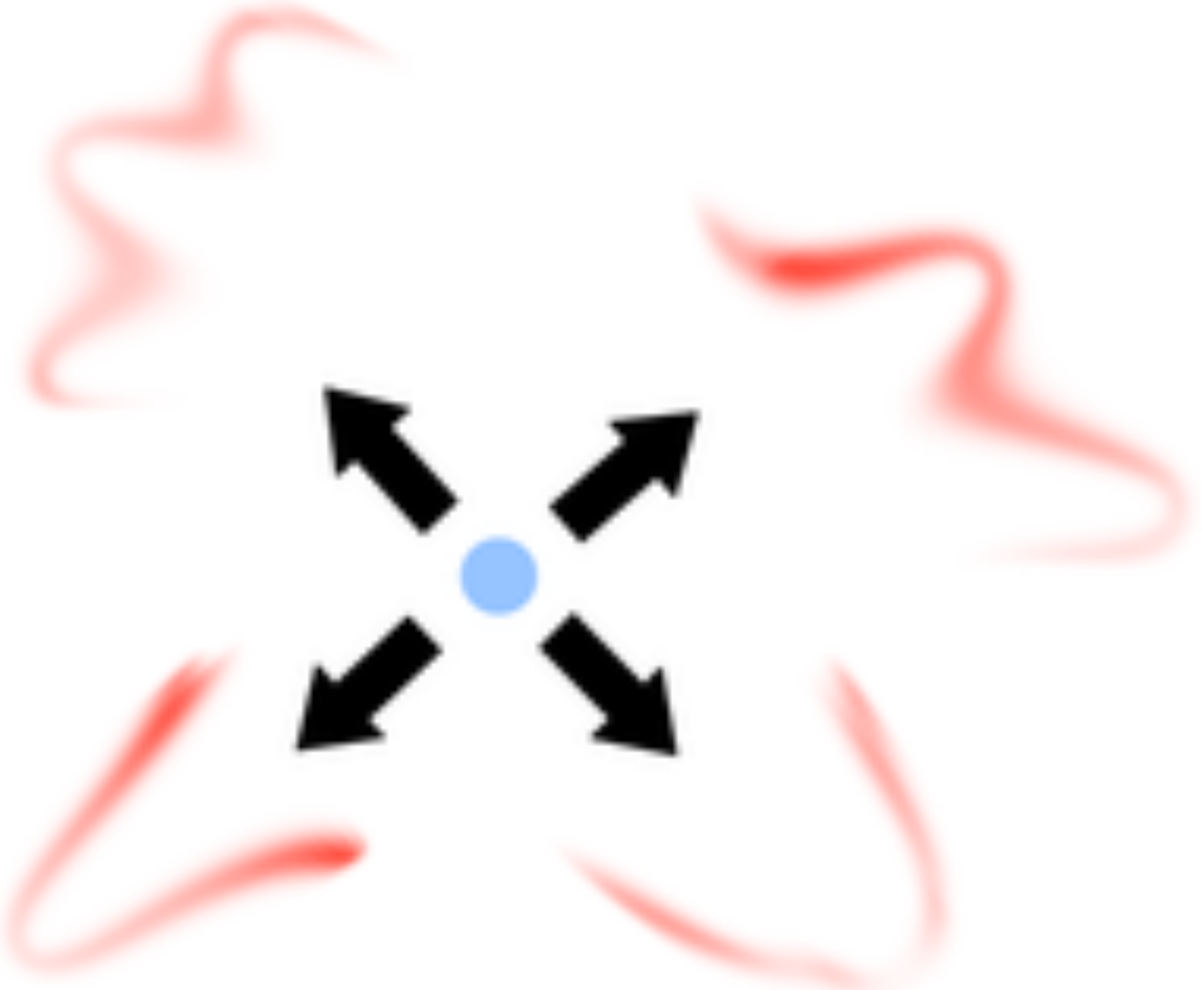
$e^- + p^+ = n^\circ$



Outer layers implode and collapse onto the inner core at 25% the speed of light.

NEUTRON STAR Formation

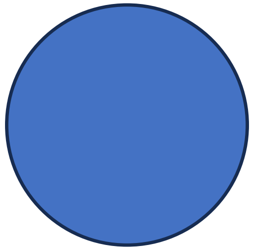
$e^- + p^+ = n^\circ$



Outer layers bounce off the dense core, now mostly neutrons, creating a Kilonovae, Supernovae or Hypernovae. Novae usually involves normal matter.

NEUTRON STAR Formation

$e^- + p^+ = n^\circ$



The resultant free core is a neutron star of 1.4-2.9 solar masses. Masses over 3 solar masses result in a Black Hole.

Kilonova:
GRB 200522A
Merger of Neutron stars with no Resulting Black Hole

Eruptive Stars
Type I, Ia, Ib, Ic
Symbiotic violent processes or Involving companion star(s)

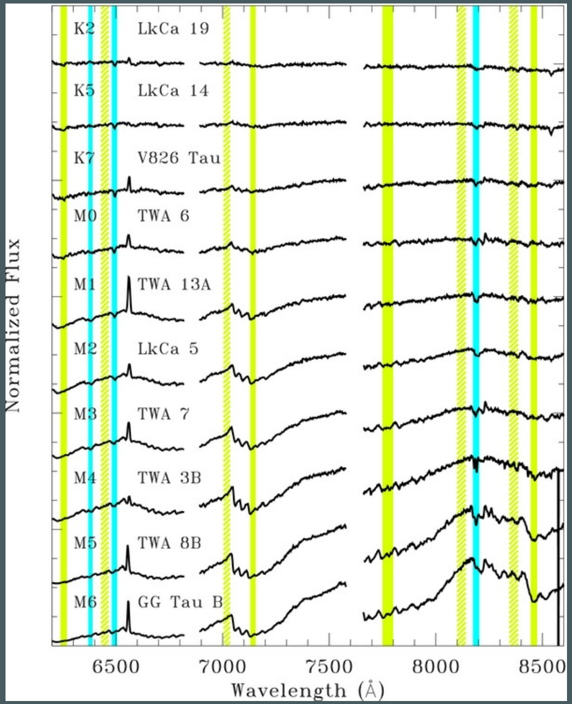
*Can involve a nebula
*Unexpected spectra (H, He)
*Supergiants
*Flare quickly or very gradually

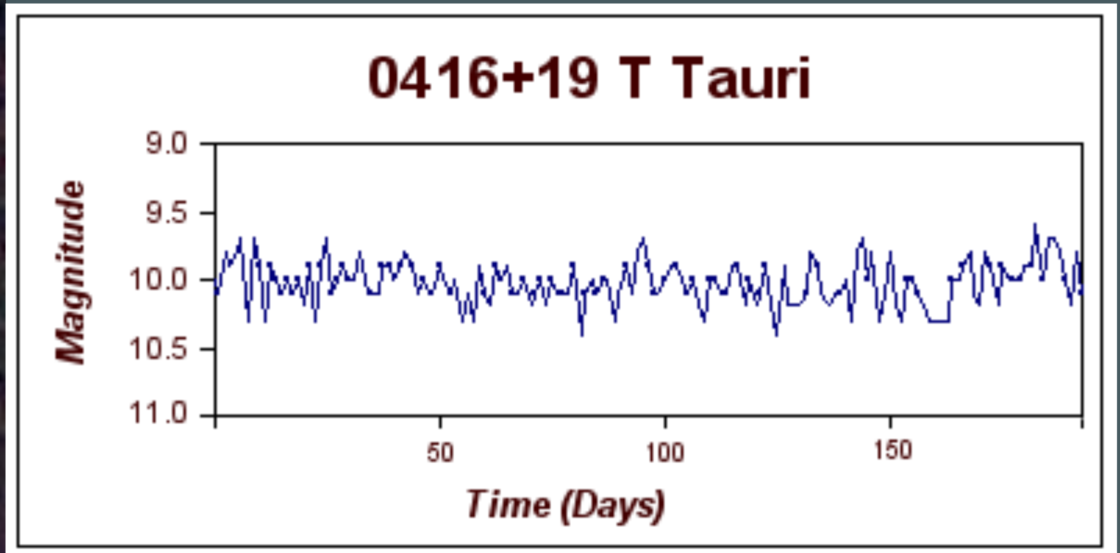
Betelgeuse: The 'Great Dimming' 2019/2020

Source: ESO/M. Montargès et al

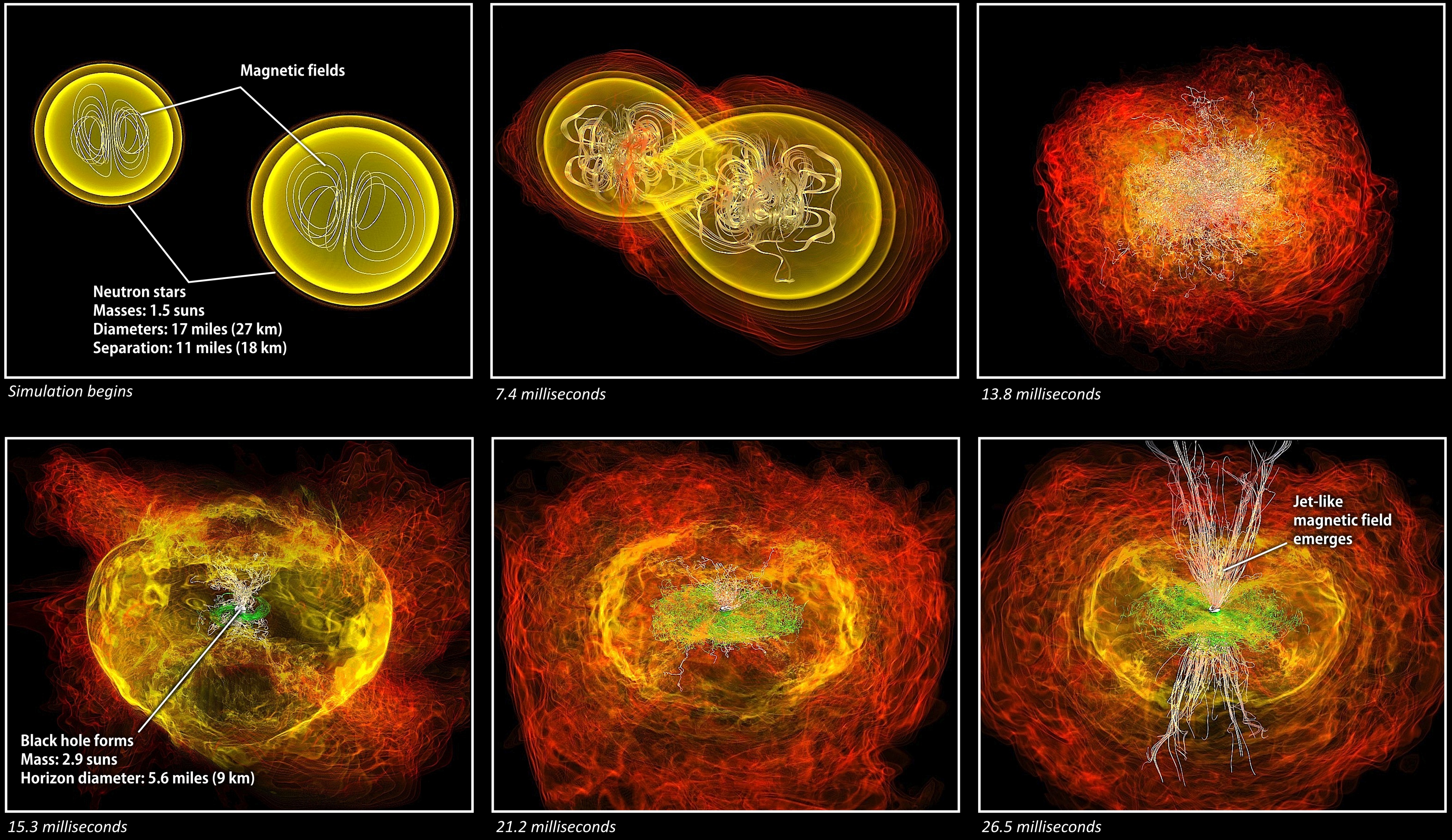
BBC

T Tauri
Variable Star
+/-200 day periodicity*

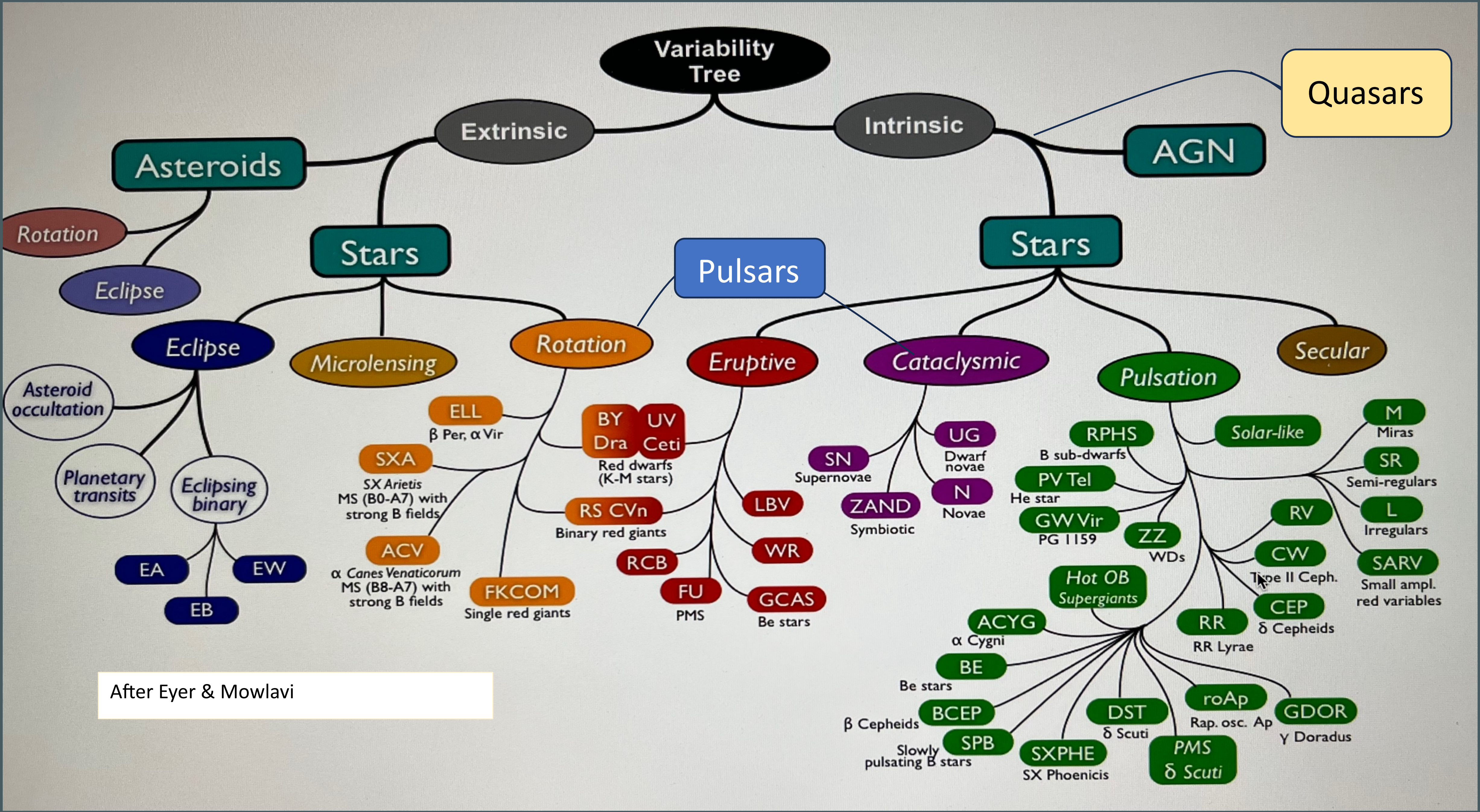




Crashing neutron stars can make gamma-ray burst jets

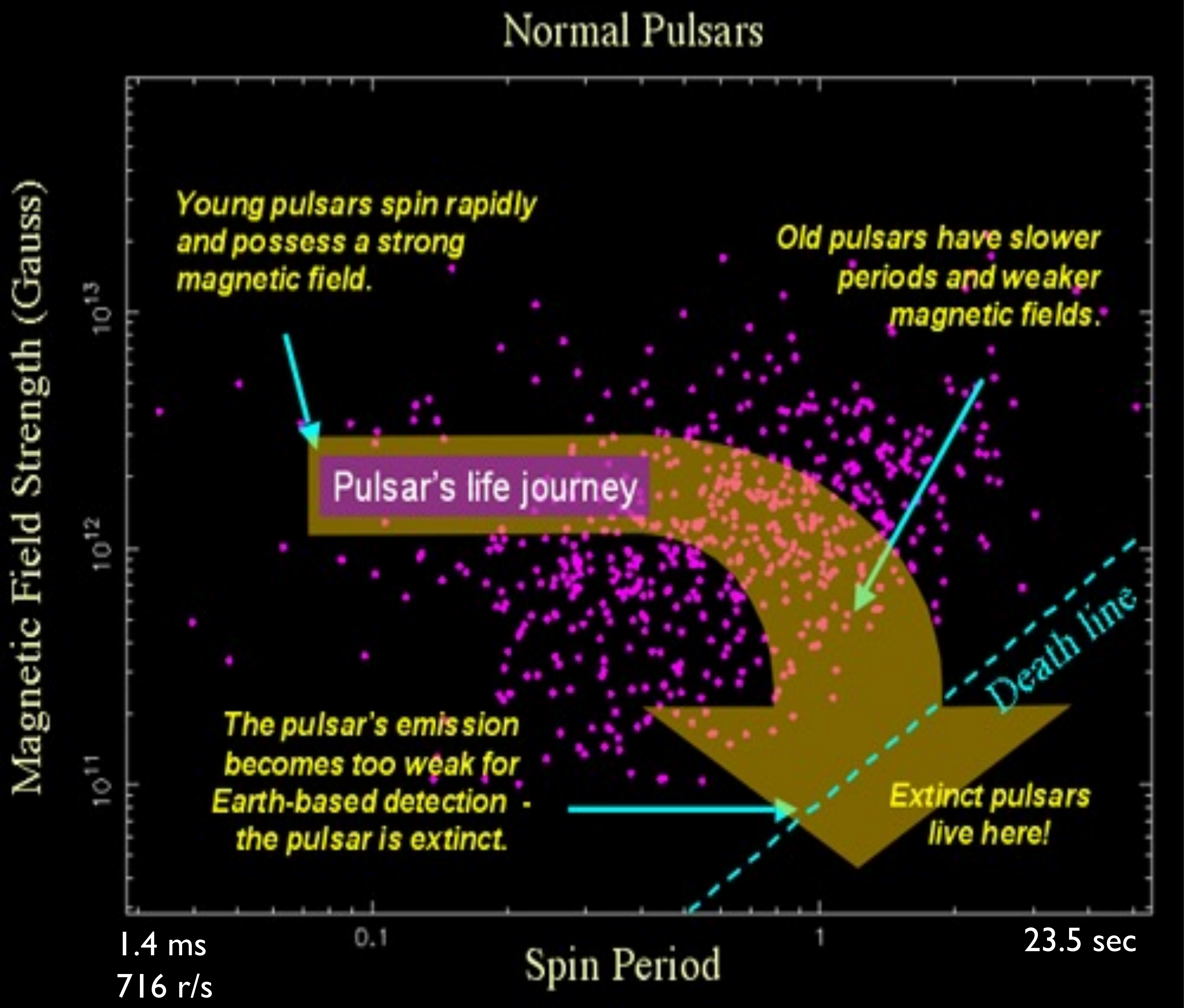


Credit: NASA/AEI/ZIB/M. Koppitz and L. Rezzolla



After Eyer & Mowlavi

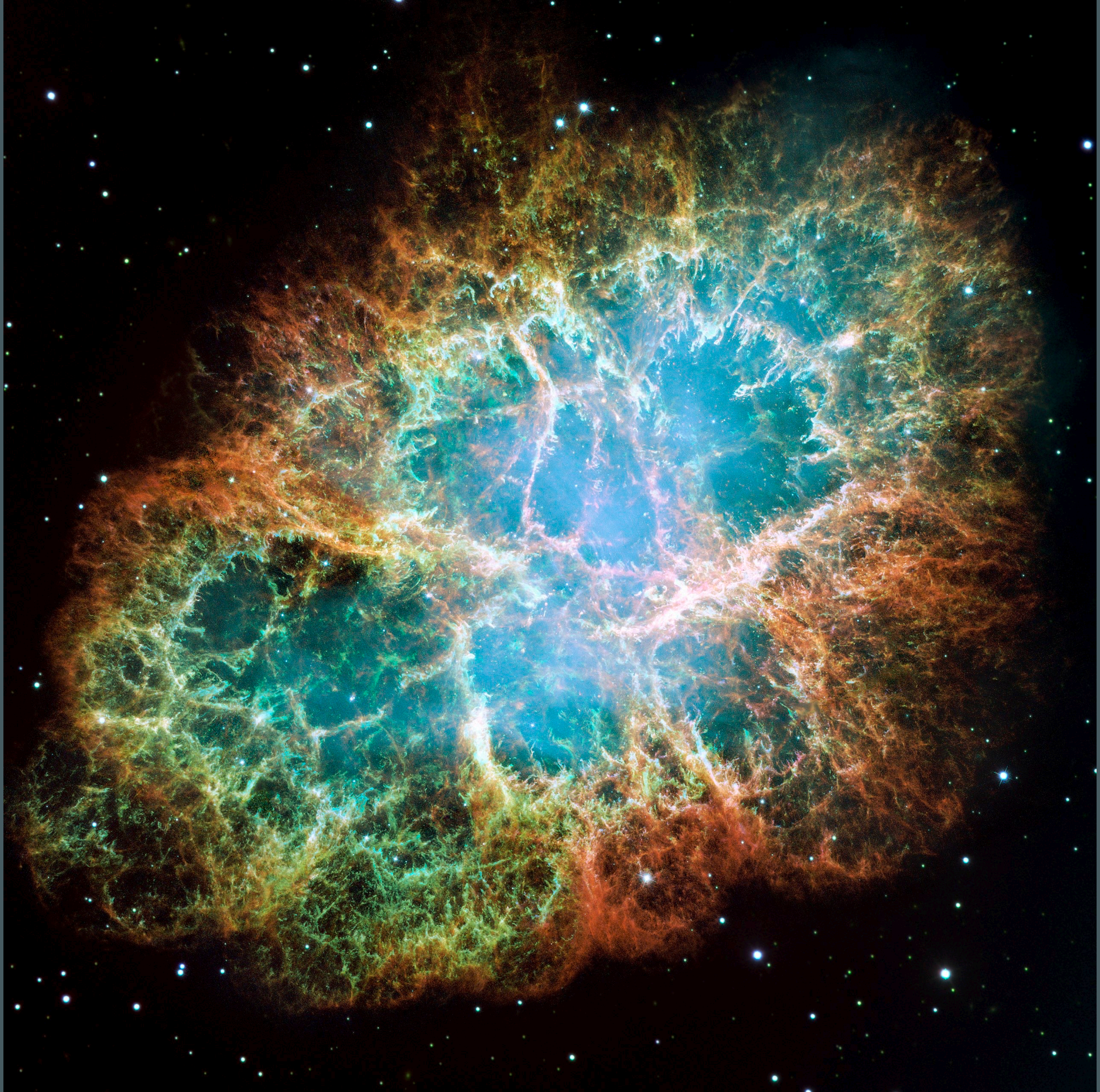
What is a Pulsar?



Pulsars are classified by their rotational rate, which changes over time.

Less then 10ms = Millisecond pulsar (MSR)

Swinburn Univ.

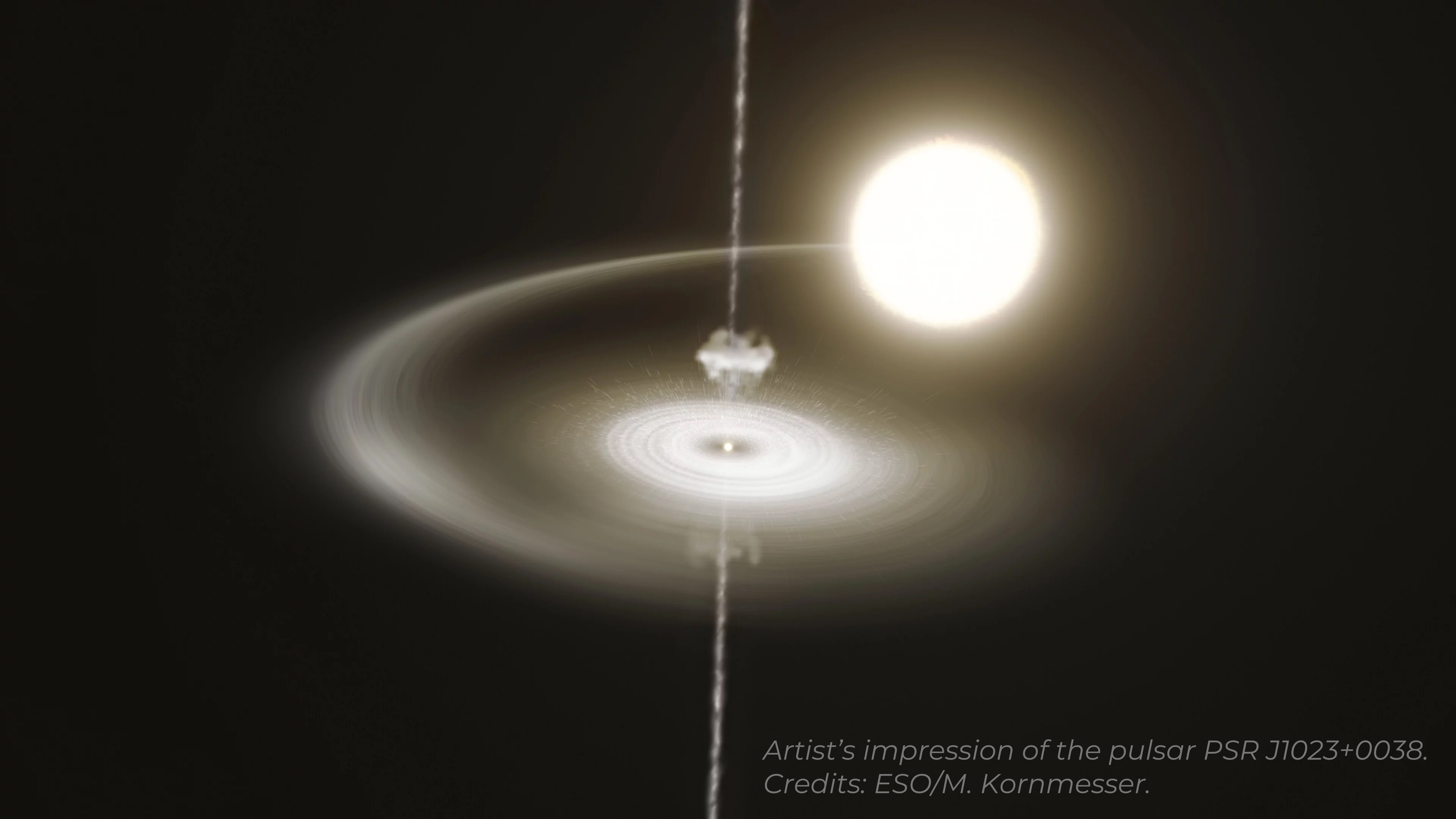


PULSARS in the news

SNR
M1 Crab
Nebula
NASA

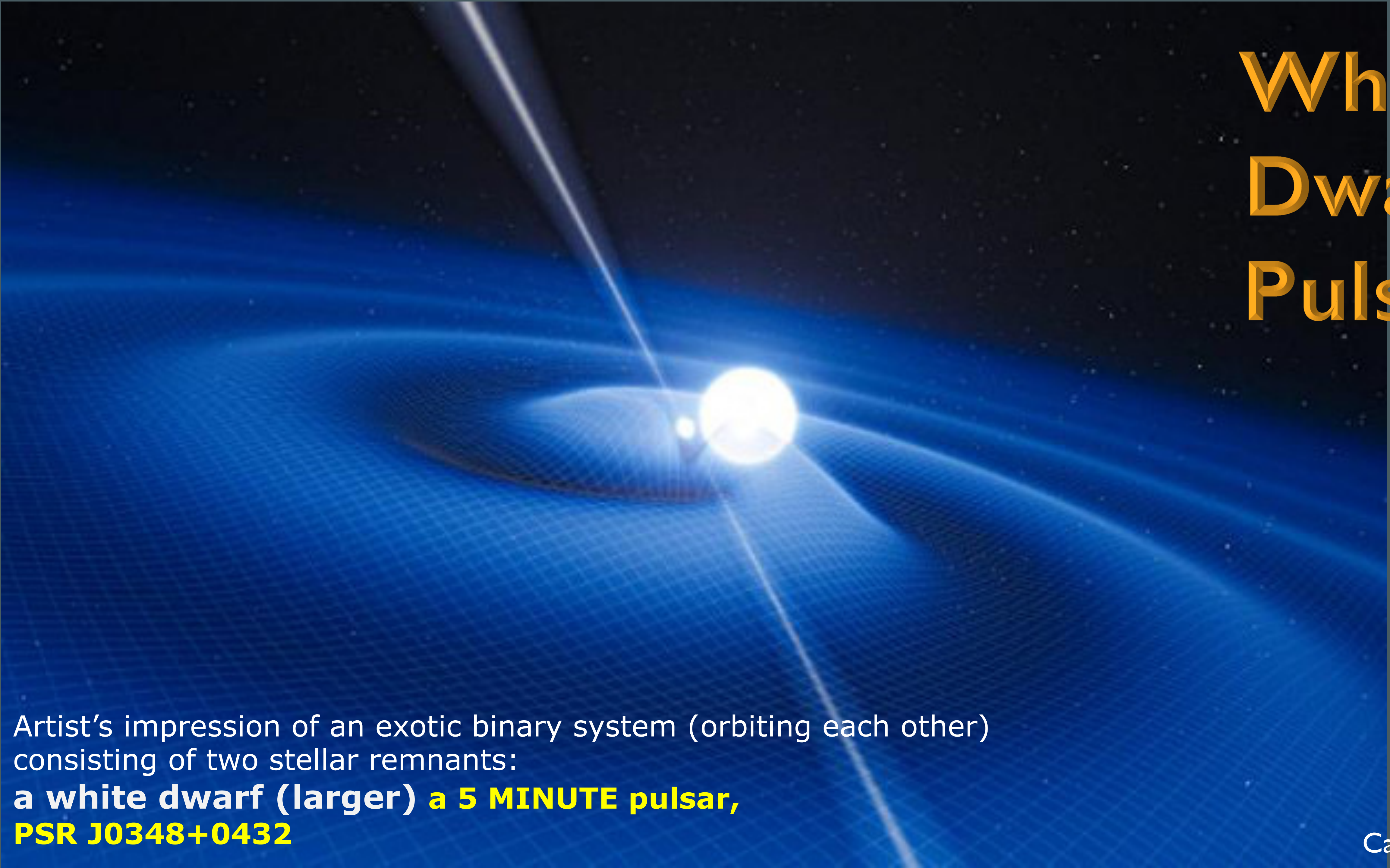
Crab Pulsar
SN1a
Collapsed
8-20 Ms star

Hubble, Chandra (xray)



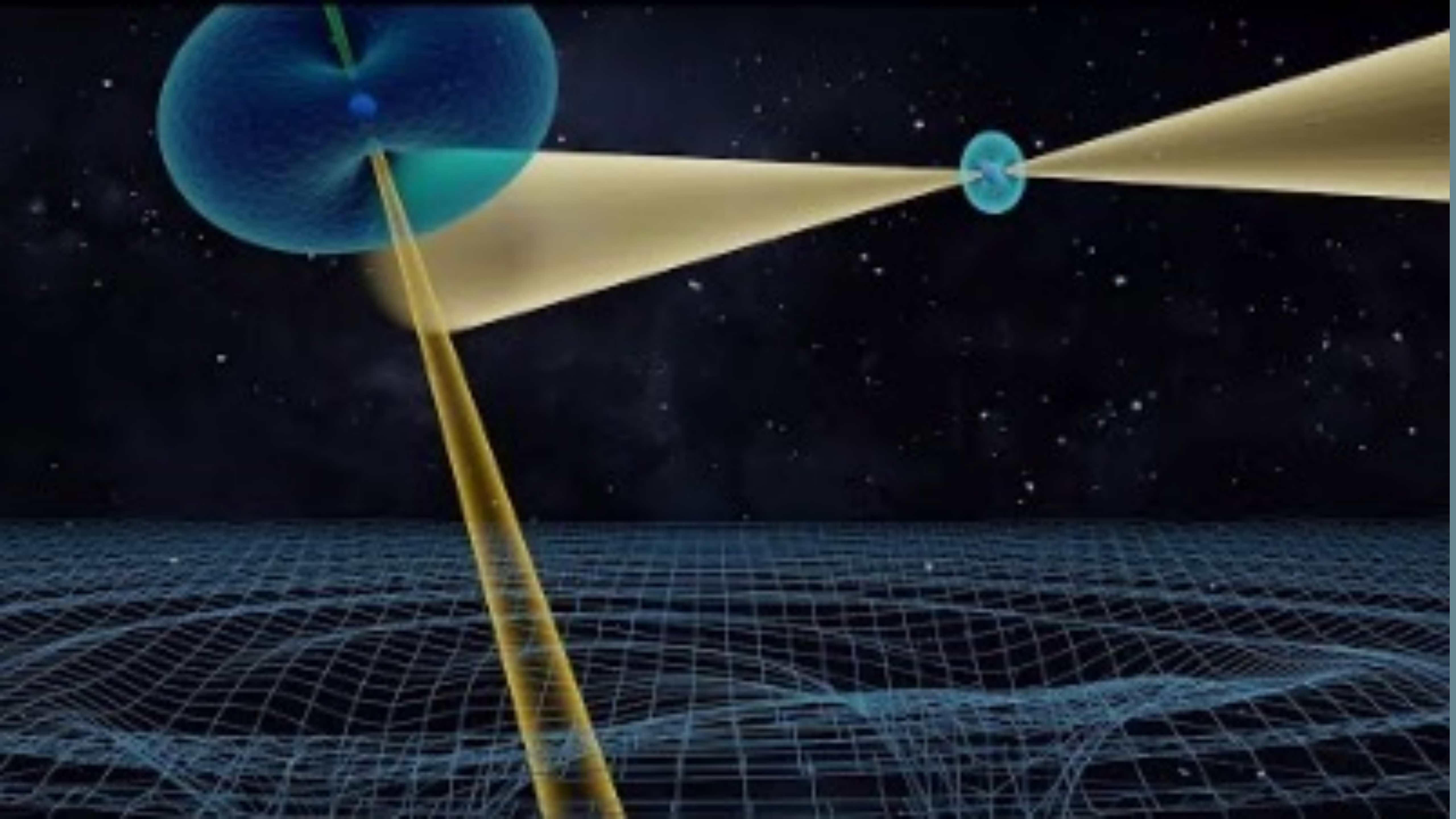
Artist’s impression of the pulsar PSR J1023+0038.
Credits: ESO/M. Kornmesser.

White Dwarf Pulsar

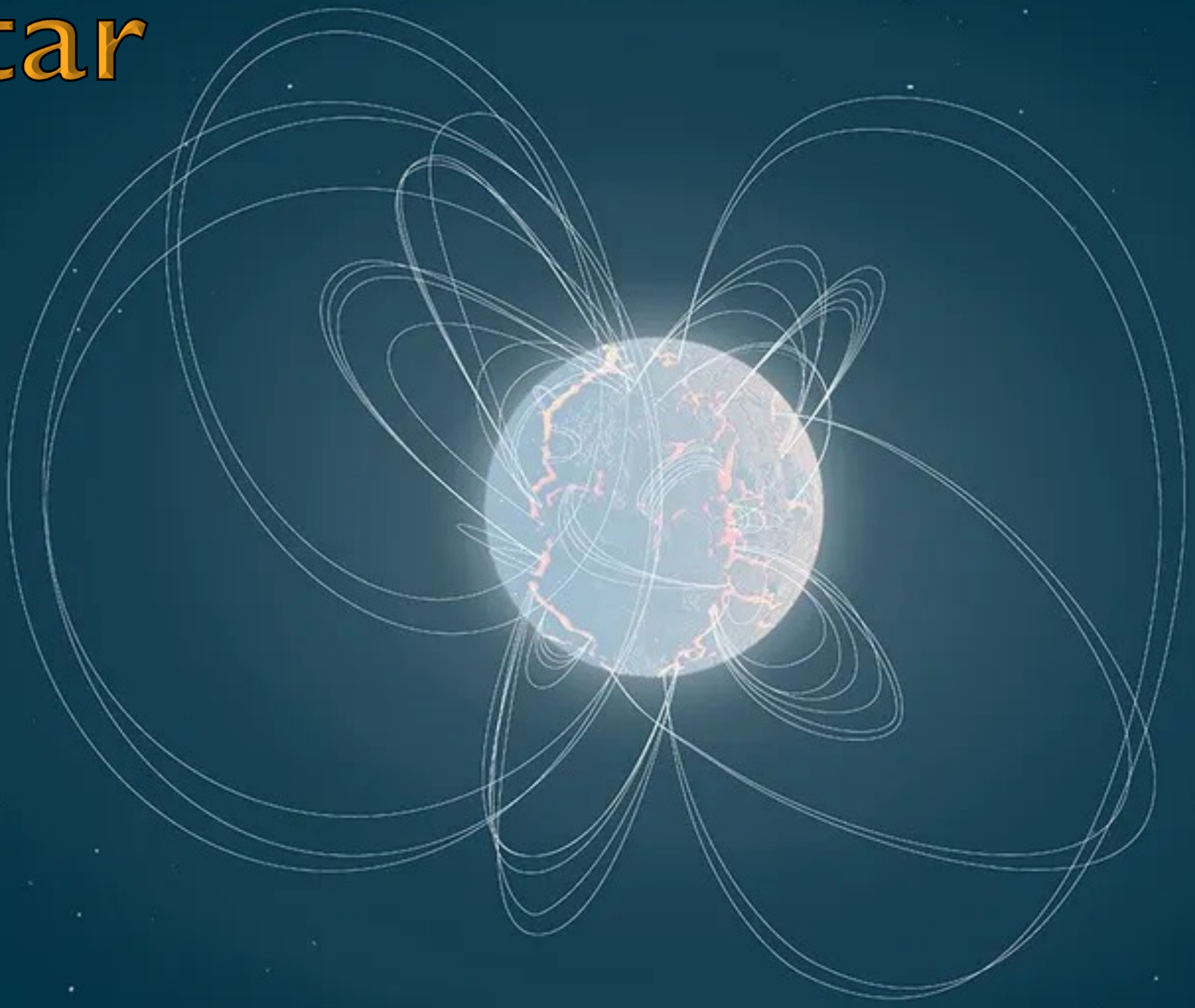


Artist’s impression of an exotic binary system (orbiting each other) consisting of two stellar remnants:
a white dwarf (larger) a 5 MINUTE pulsar,
PSR J0348+0432

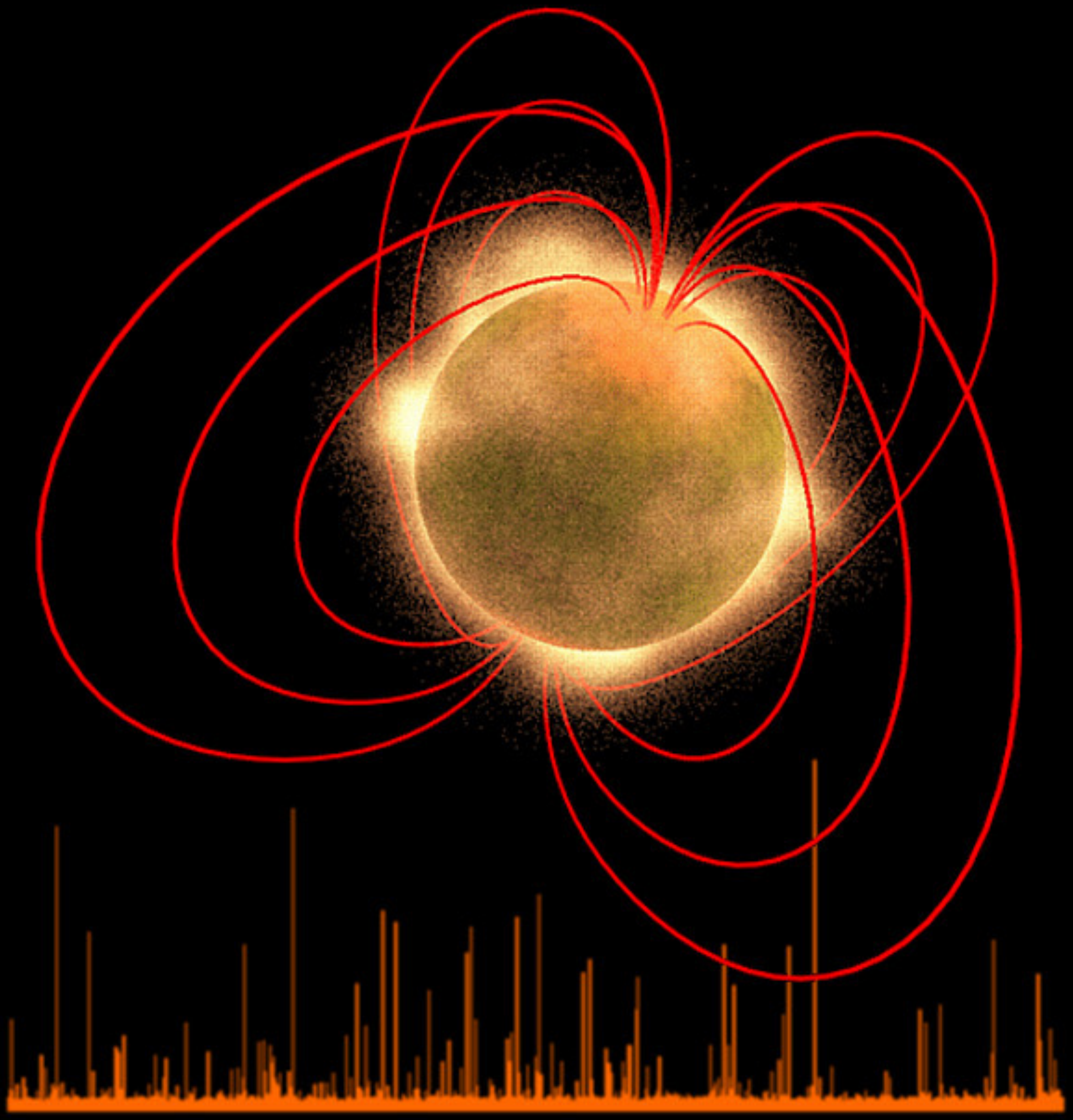
Calçada, ESO



Magnetar



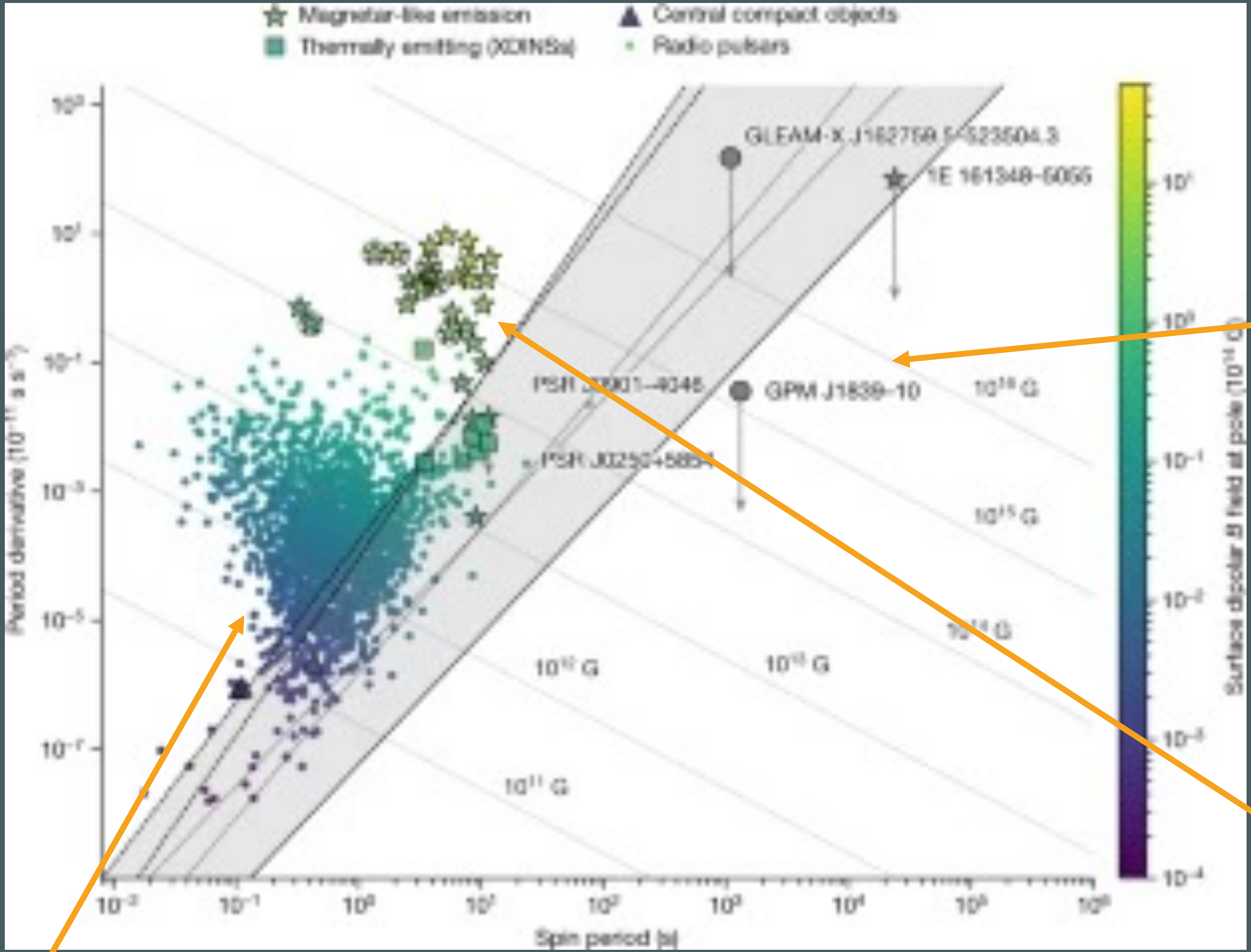
Illustration



Magnetar: Magnetic Star

*Evolutionary stage of some neutron stars

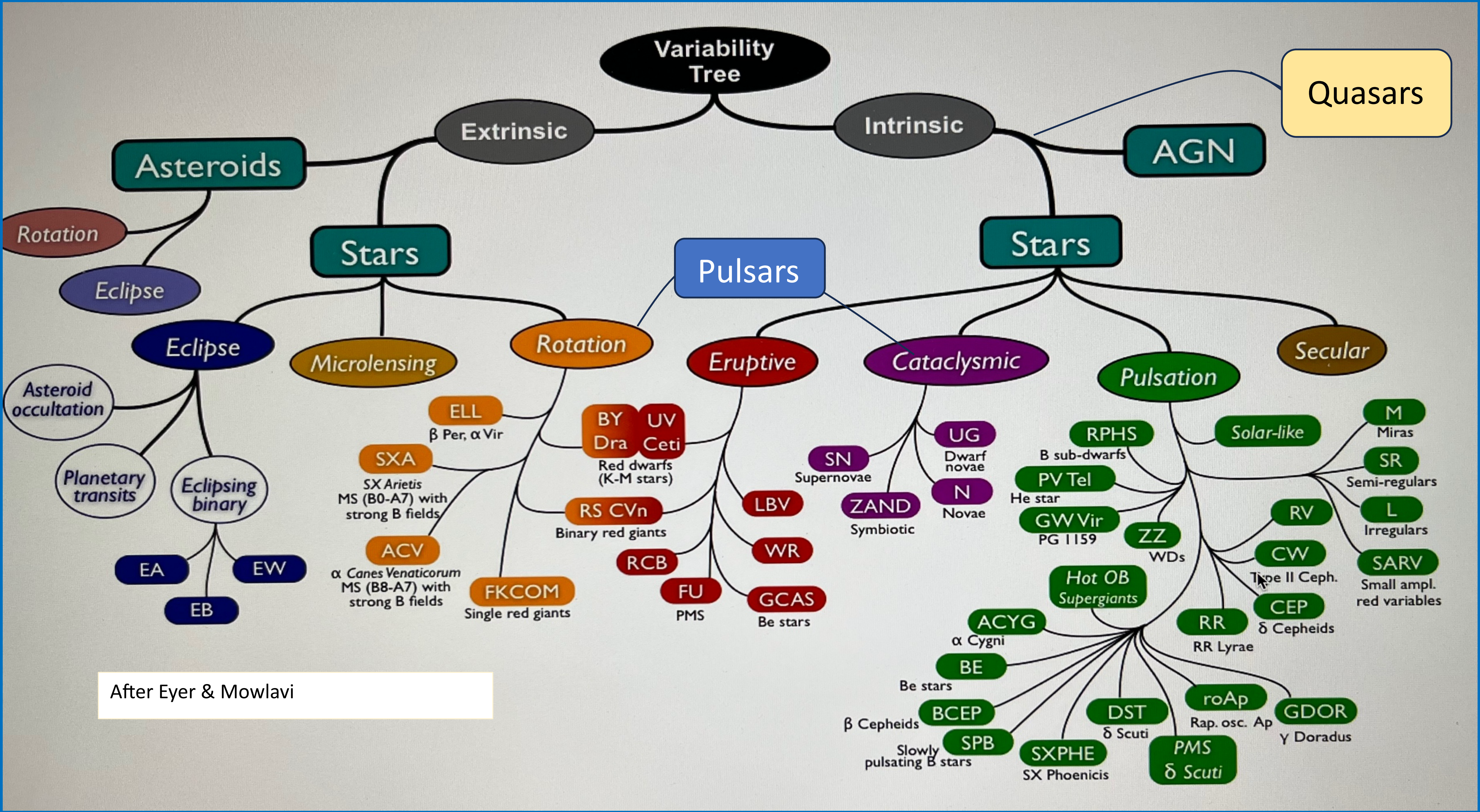
*Extreme magnetic field strength (trillion times that of the earth)



Magnetar
GPMJ1839-
10-22 minute
rotation

Magnetar
Usual
population

PULSARS



After Eyer & Mowlavi

EXTRINSIC

Variability corresponds to an environment

*Closeness to other stars
*Dynamic Interaction with other stars
*Disruption of natural rotation

Types of Binary Stars

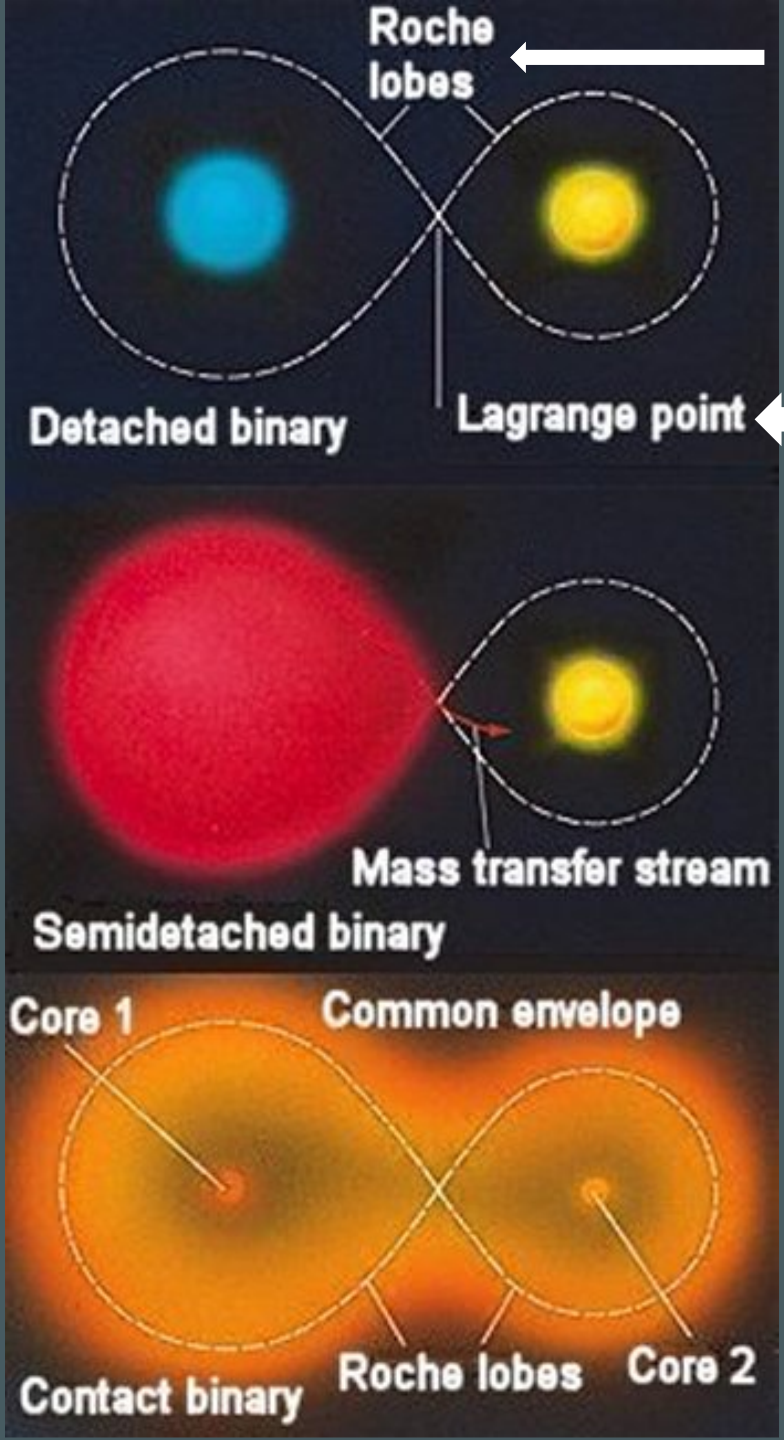
<u>Visual Binaries</u>

Usually cannot be observed without a telescope.

<u>Eclipsing Binaries</u>

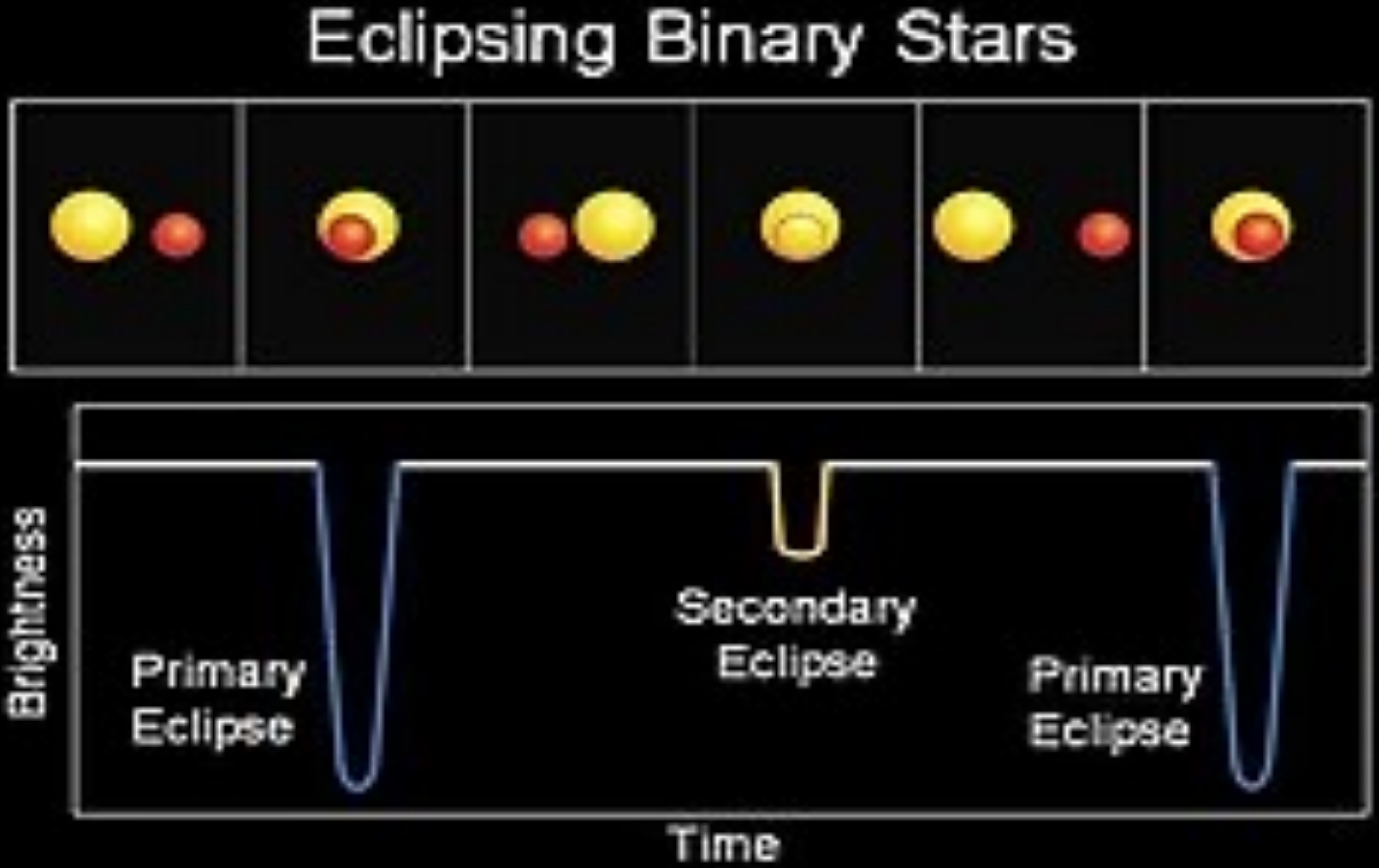
<u>Spectrographic Binaries</u>

Cannot be seen as individual stars. The light curve, color and spectra will change as they eclipse or rotate.



Material envelope that is bound to the star due to gravity

Rotational axis of both stars



Assuming the red star is less bright than the yellow star