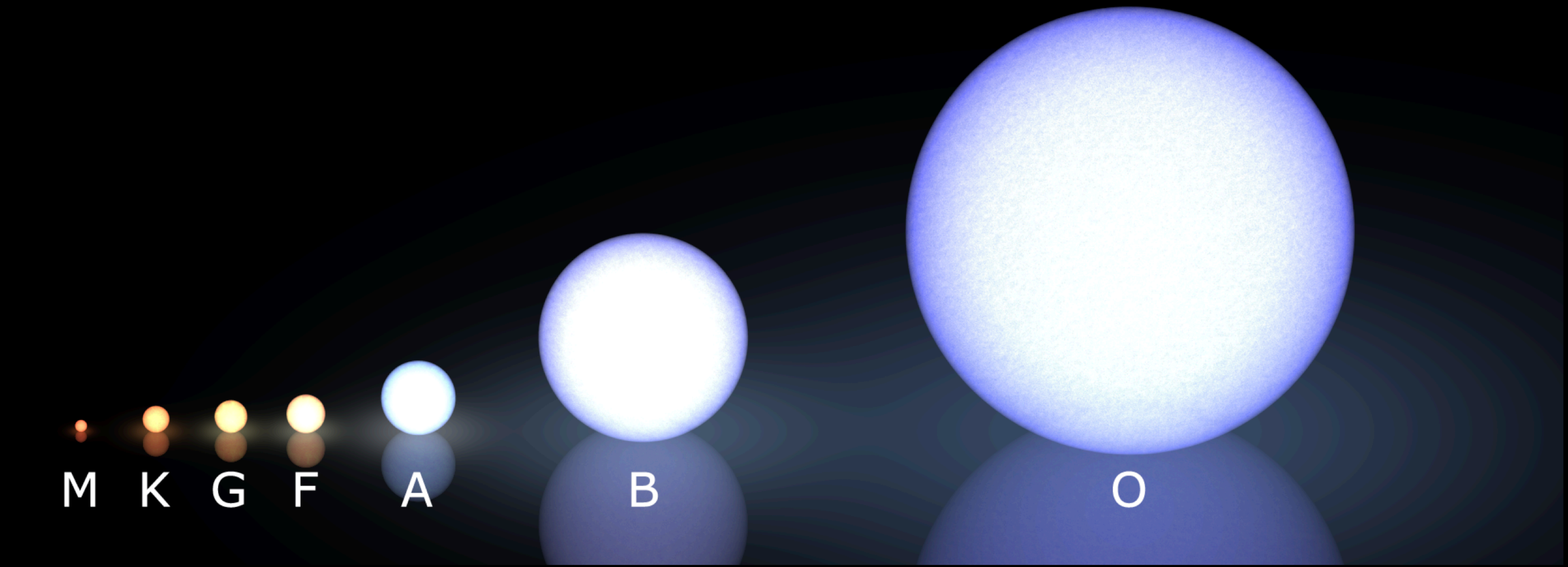
Image: National Observatory of Japan /EOS

Stellar evolution

Stellar Classification



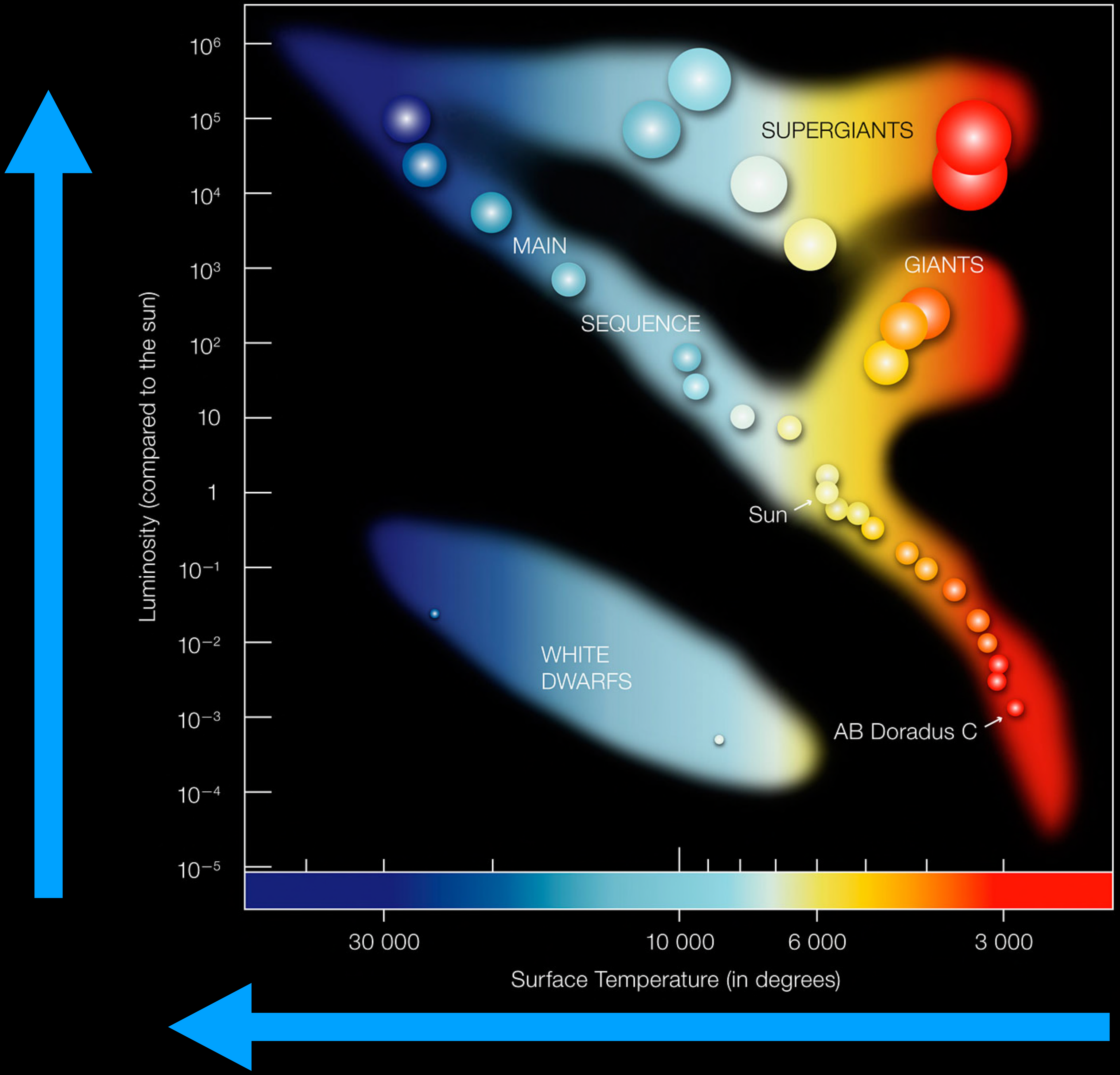
Class	Temperature	Apparent color
O	≥ 30,000 K	blue
B	10,000–30,000 K	blue white
A	7,500–10,000 K	white to blue white
F	6,000–7,500 K	white
G	5,200–6,000 K	yellowish white
K	3,700–5,200 K	yellow orange
M	≤ 3,700 K	orange red

We can classify stars using:

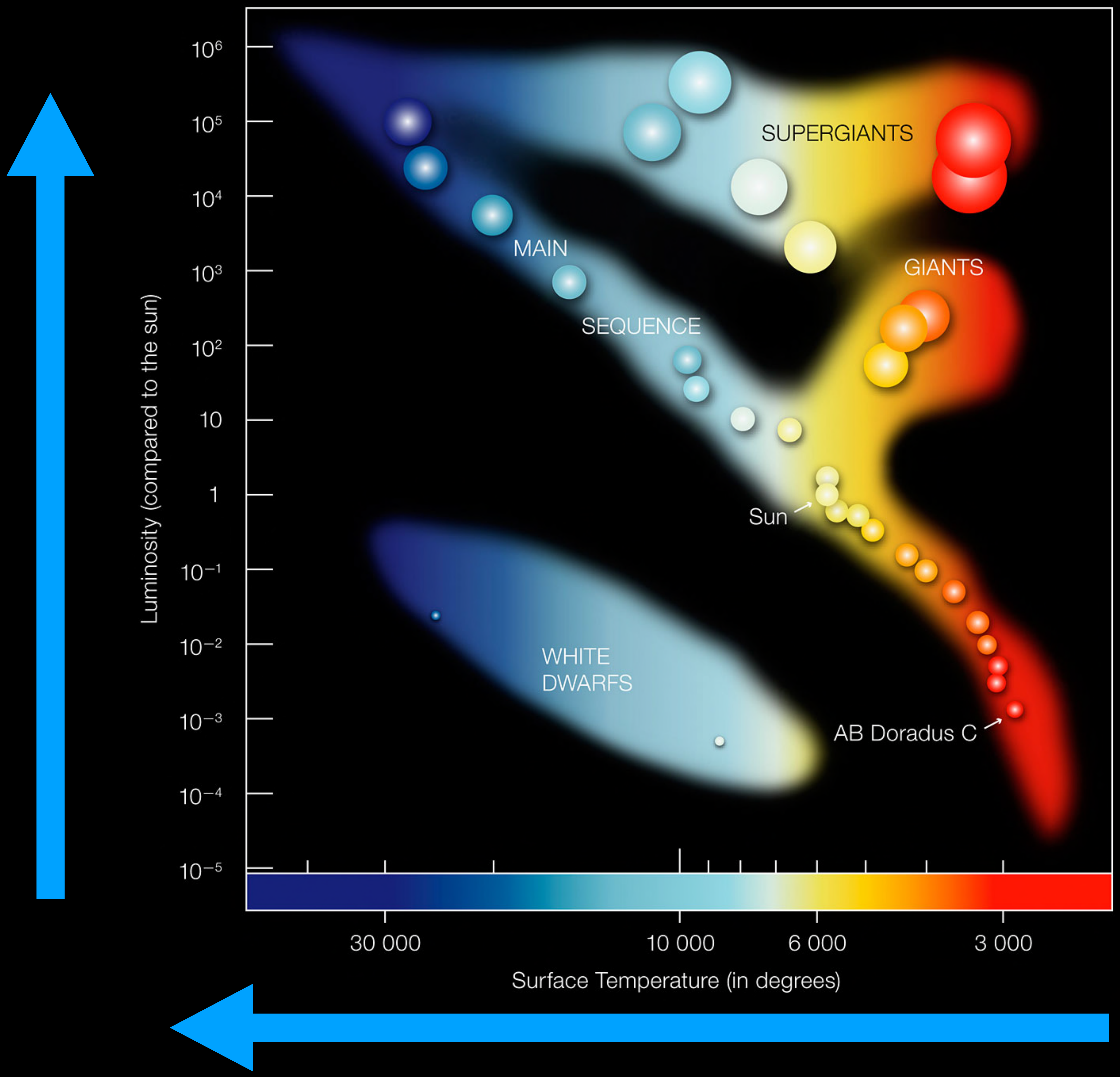
- Temperature
- Color

Stellar evolution

The HR Diagram



Stellar evolution

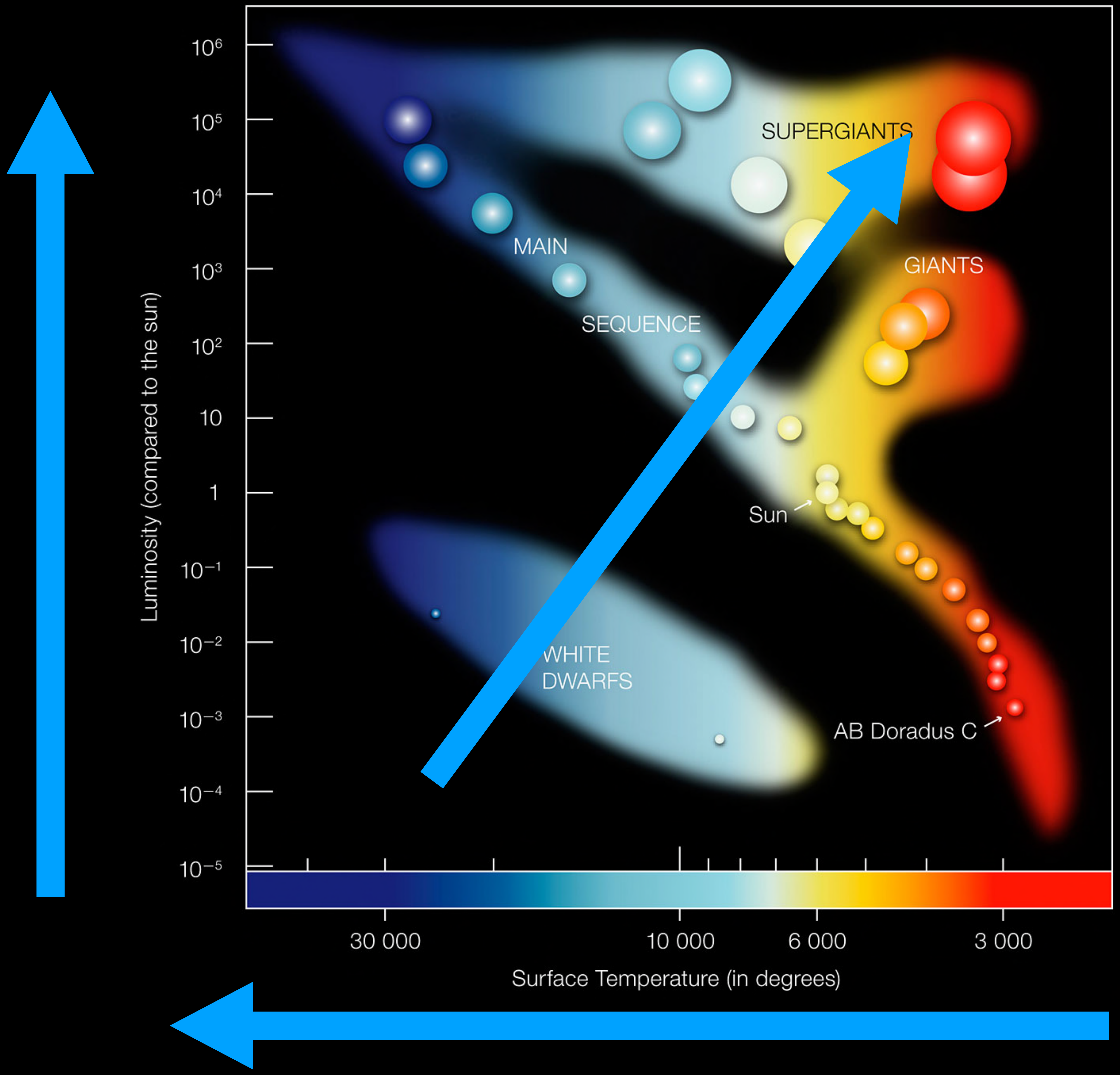


The HR Diagram

Luminosity increases as we go “up” the HR diagram.

Temperature increases from right to left.

Stellar evolution



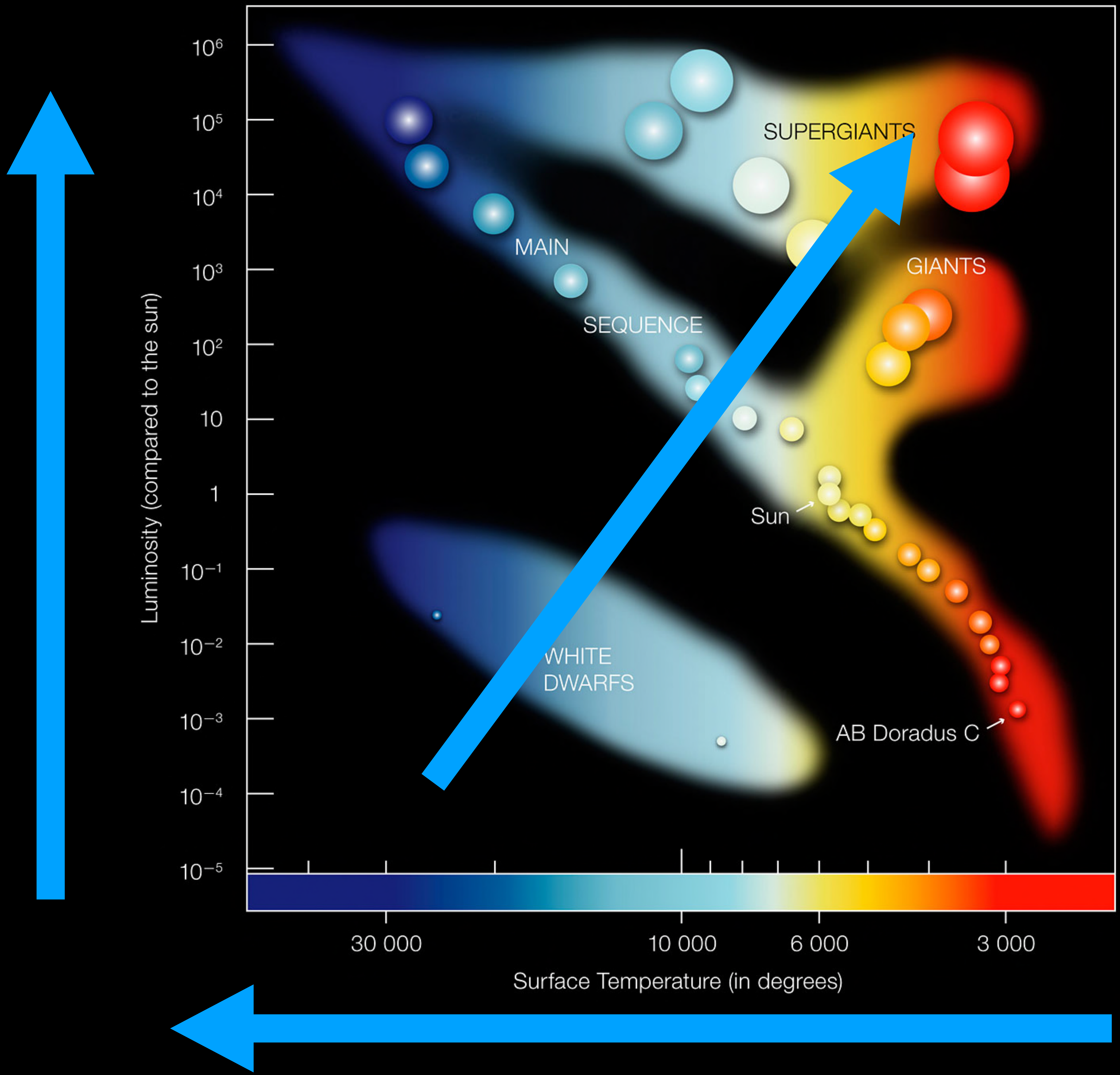
The HR Diagram

Luminosity increases as we go “up” the HR diagram.

Temperature increases from right to left.

What do we notice increases diagonally “upward” from left to right??

Stellar evolution



The HR Diagram

Luminosity increases as we go "up" the HR diagram.

Temperature increases from right to left.

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Radius

Stellar evolution

For a star like our sun, its “corpse” will be a white dwarf

Evolution of the Sun

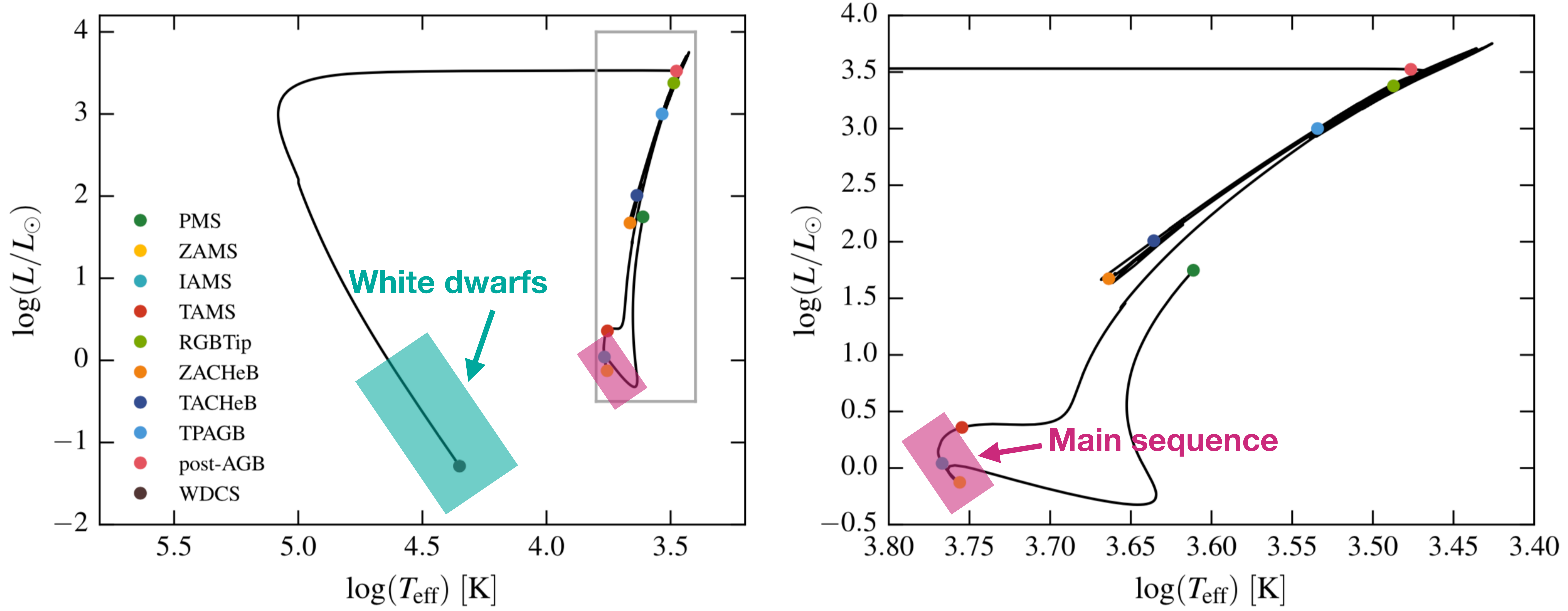

Figure 3. Left: an example $1\ M_\odot$ evolutionary track in the equivalent evolutionary point (EEP) format, with the locations of the primary EEP points marked by colored circles. The gray box marks the zoomed-in region shown in the right panel. Right: a zoomed-in view of the track.

Choi et al. (2016)

Stellar evolution

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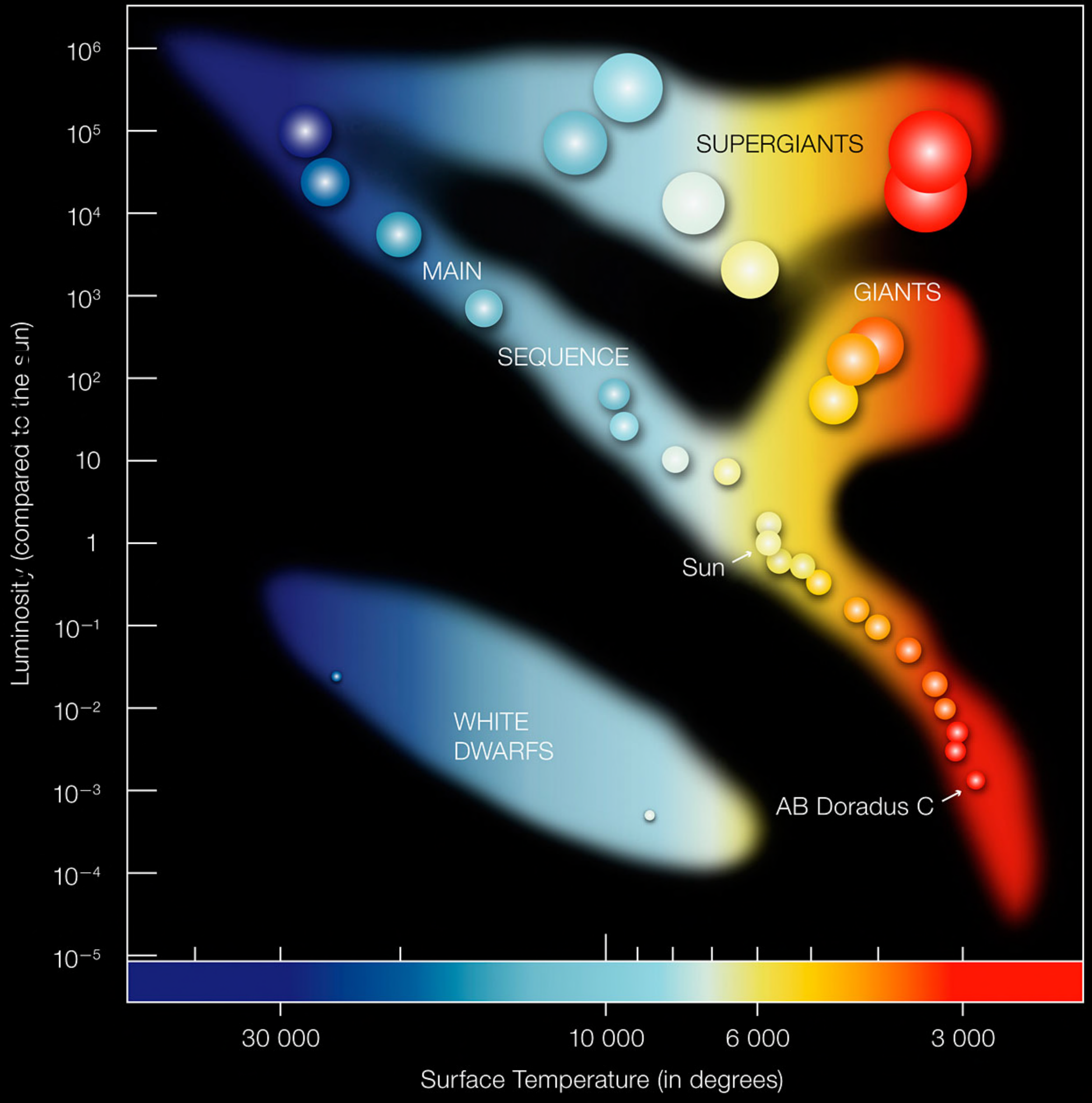
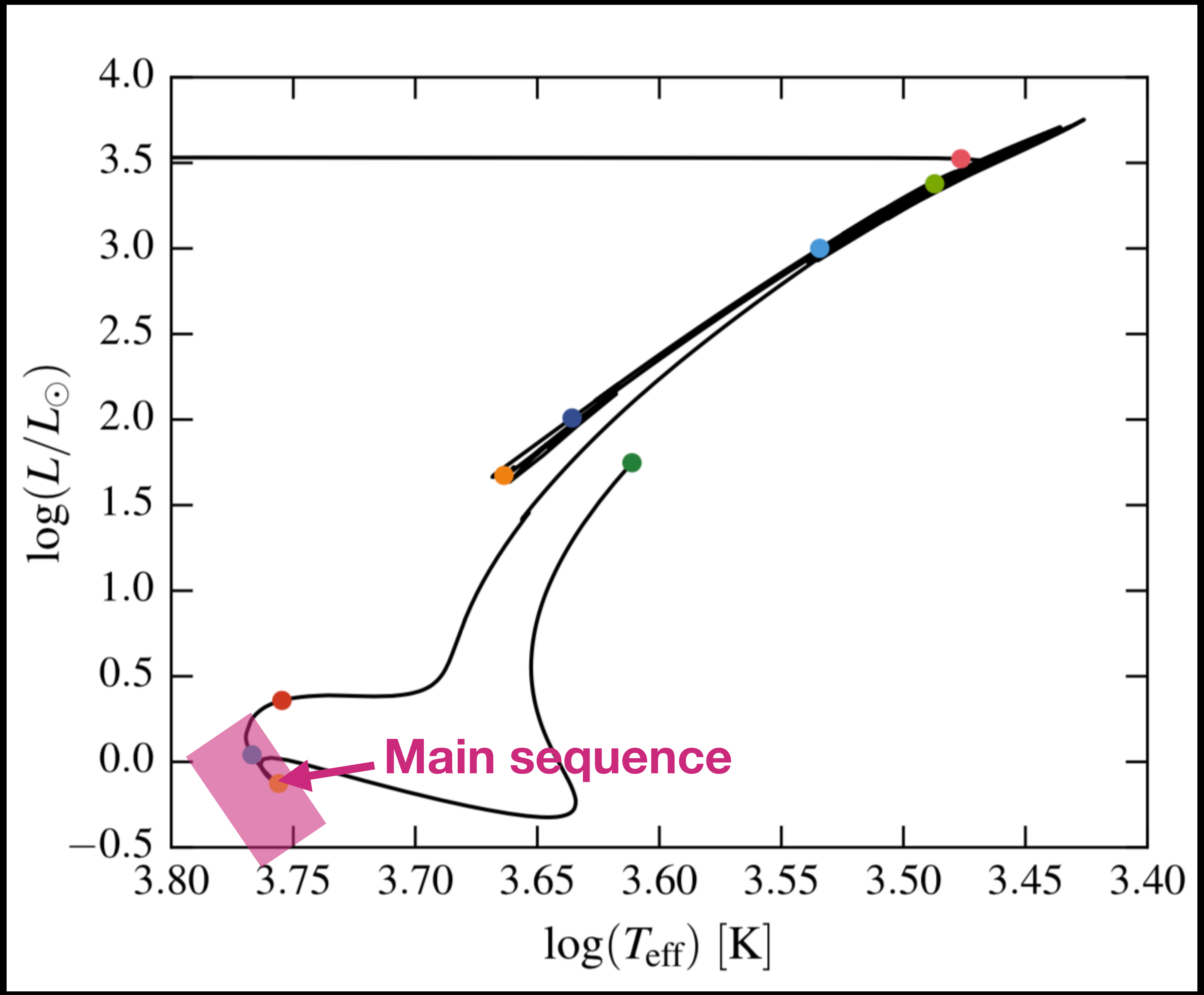
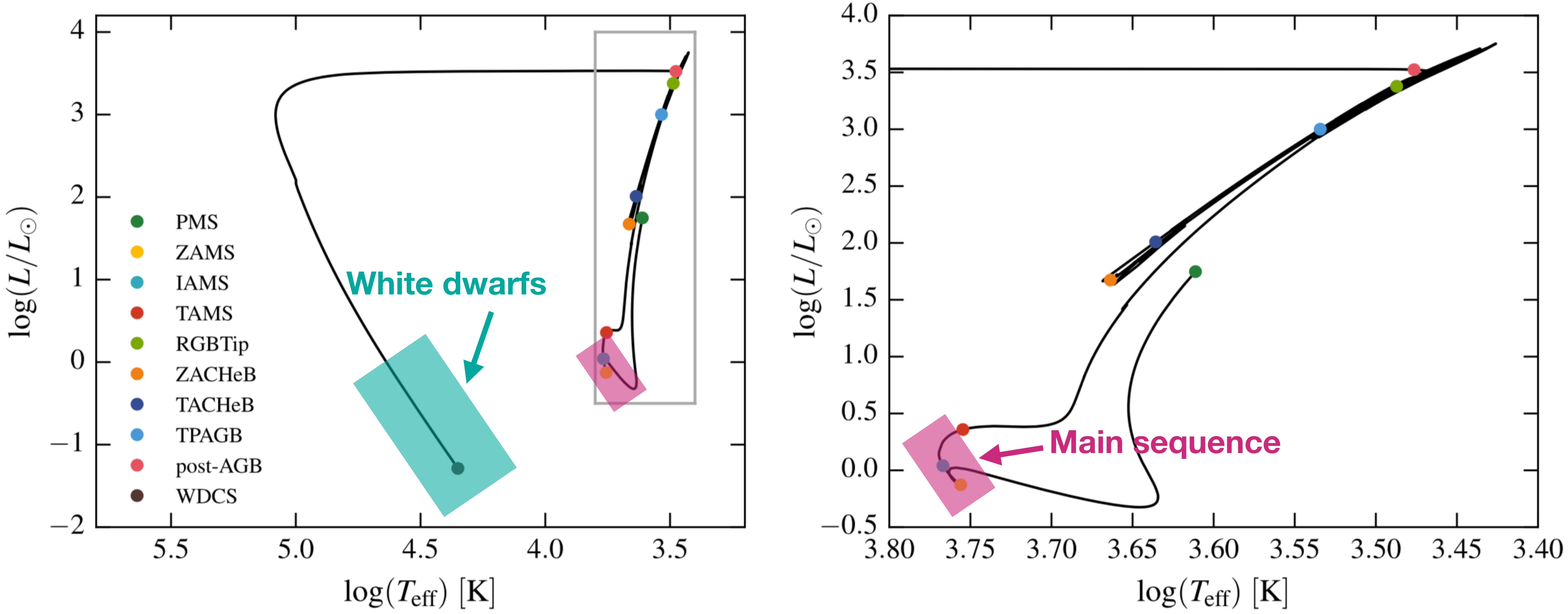




Stellar evolution

For a star like our sun, its "corpse" will be a white dwarf

Evolution of the Sun



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Choi et al. (2016)

Stellar evolution

Flux and Luminosity

Flux depends on the **distance** from a source

Luminosity is an **intrinsic** physical property

Flux at the surface of the sun depends on the solar luminosity.

$$F_\odot = \frac{L_\odot}{4\pi R_\odot^2}$$

Flux received from the sun on Earth also depends on the solar luminosity.

$$F_\oplus = \frac{L_\odot}{4\pi d^2}$$

Stellar evolution

Magnitudes

Magnitude is a measure of a star’s flux from Earth.

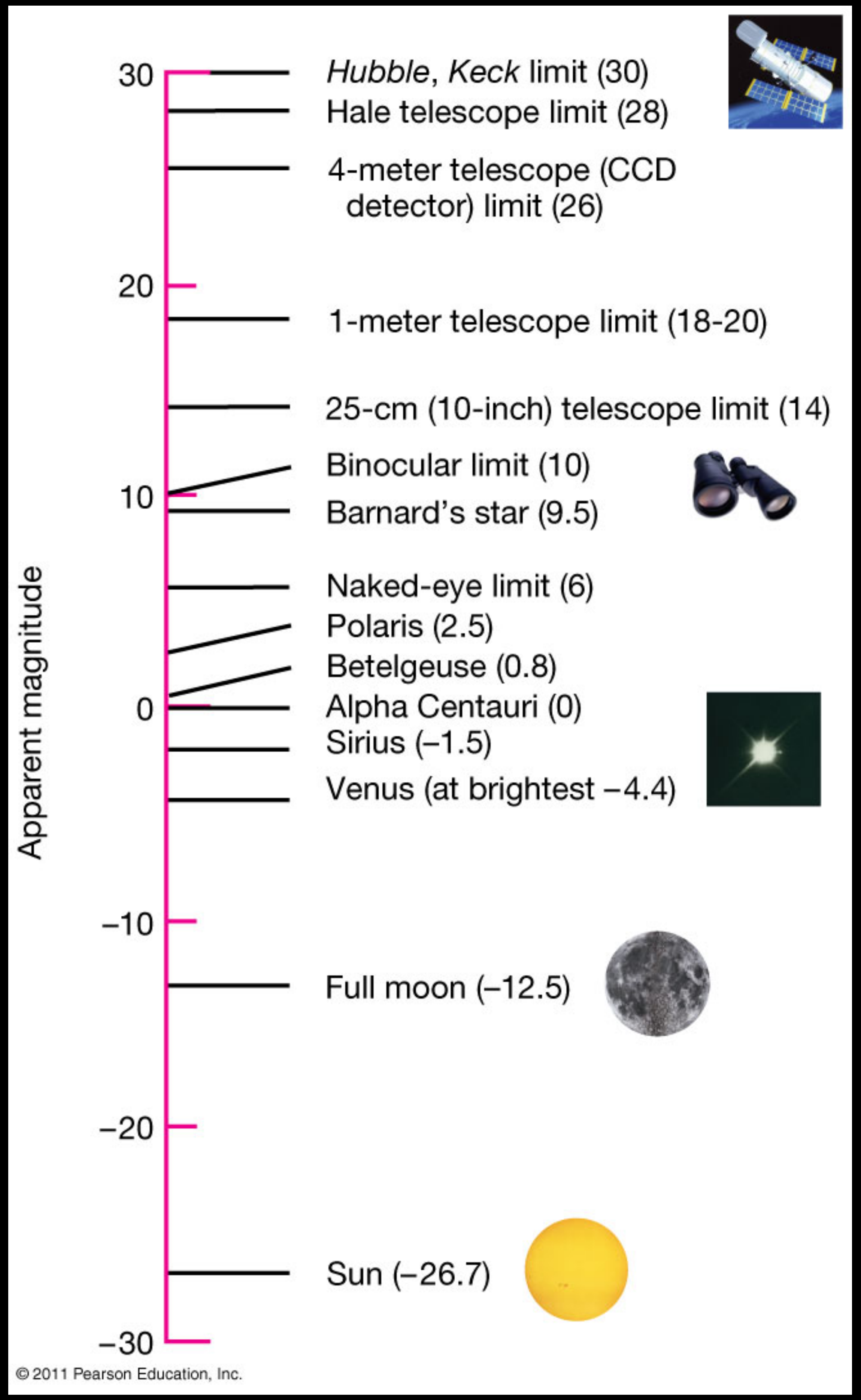
Apparent Magnitude:

Originally based on a ranking system of the brightness (as determined by the human eye) of stars compared to Vega.

Brighter objects have more negative magnitude.

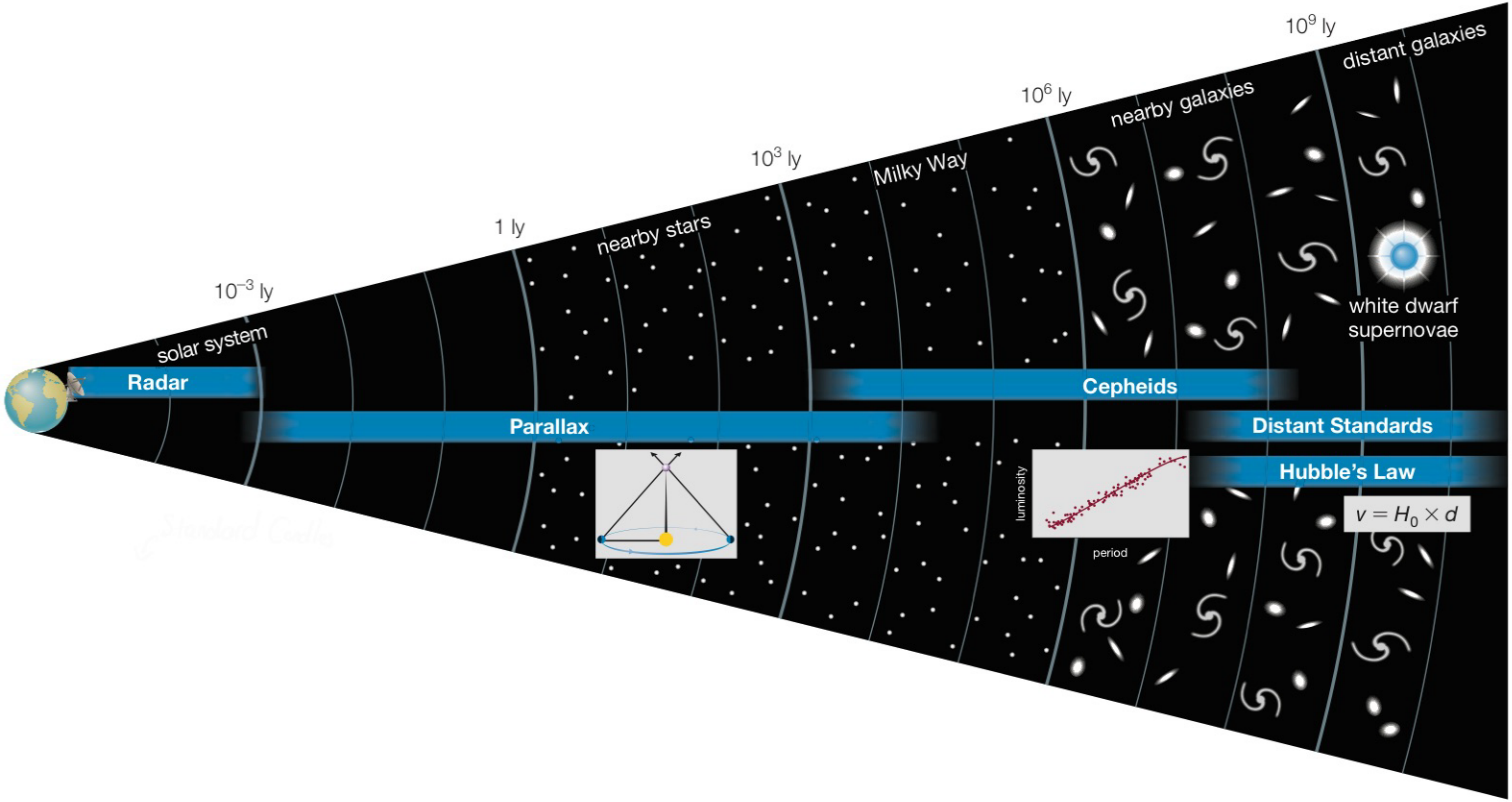
We define the difference in apparent magnitudes between two stars as:

$$m_1 - m_2 = 2.5log_{10}(F_1/F_2)$$

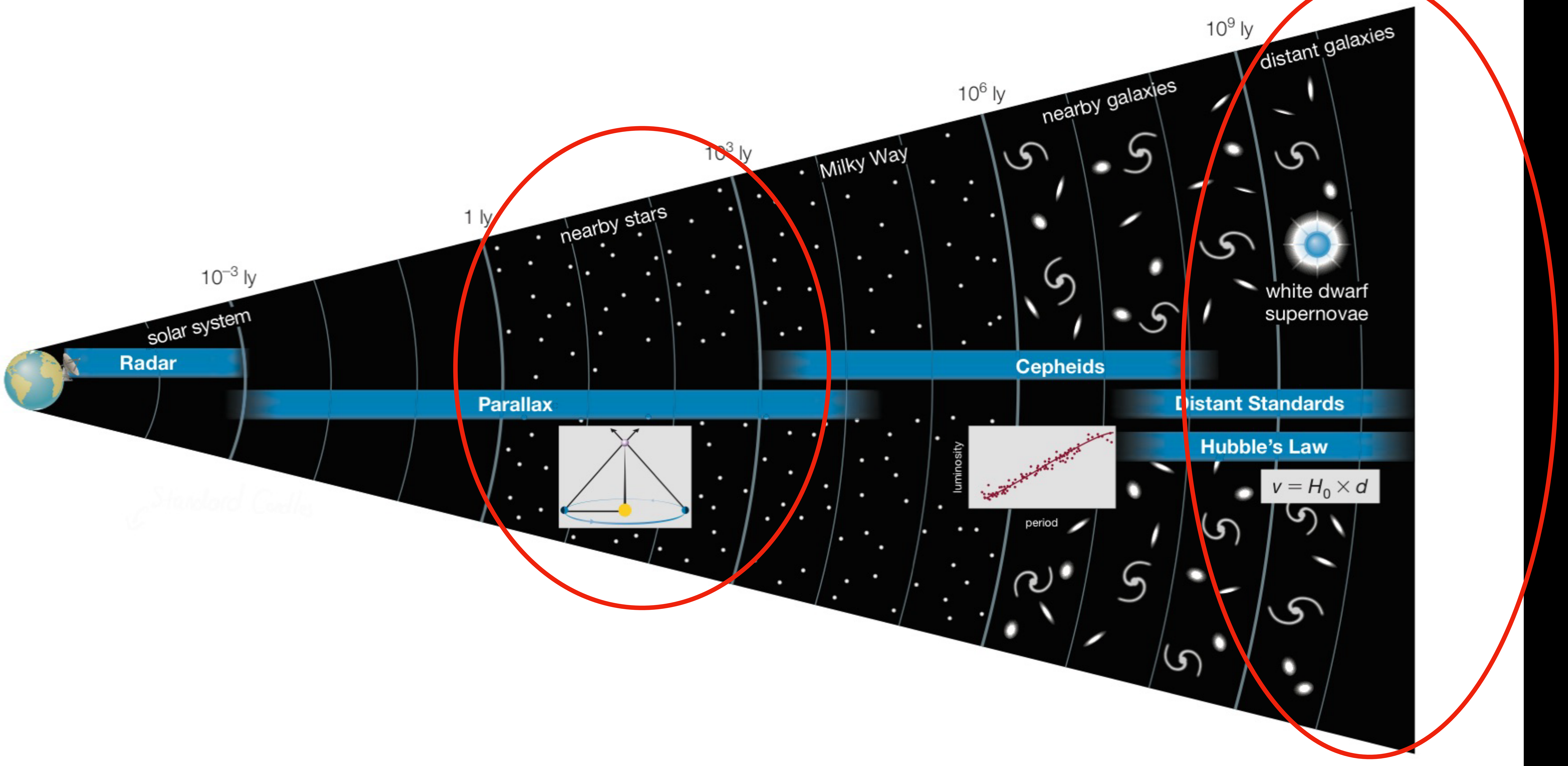


The cosmic distance ladder

The cosmic distance ladder



The cosmic distance ladder



Parallax

Parallax

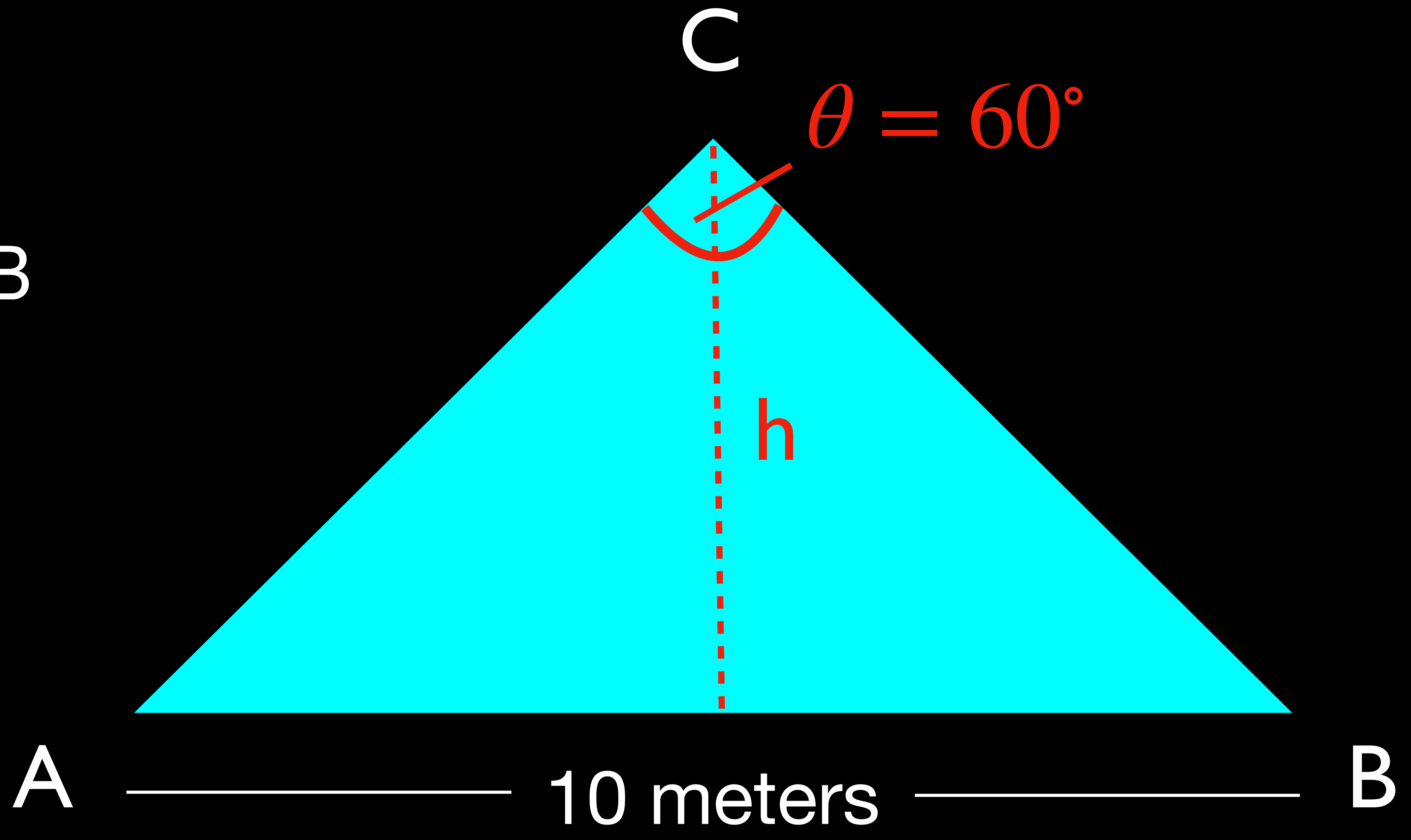
One method to measuring large distances hat we can't physically reach is *triangulation*

I want to find the distance, h.

I know the *baseline* distance from A to B

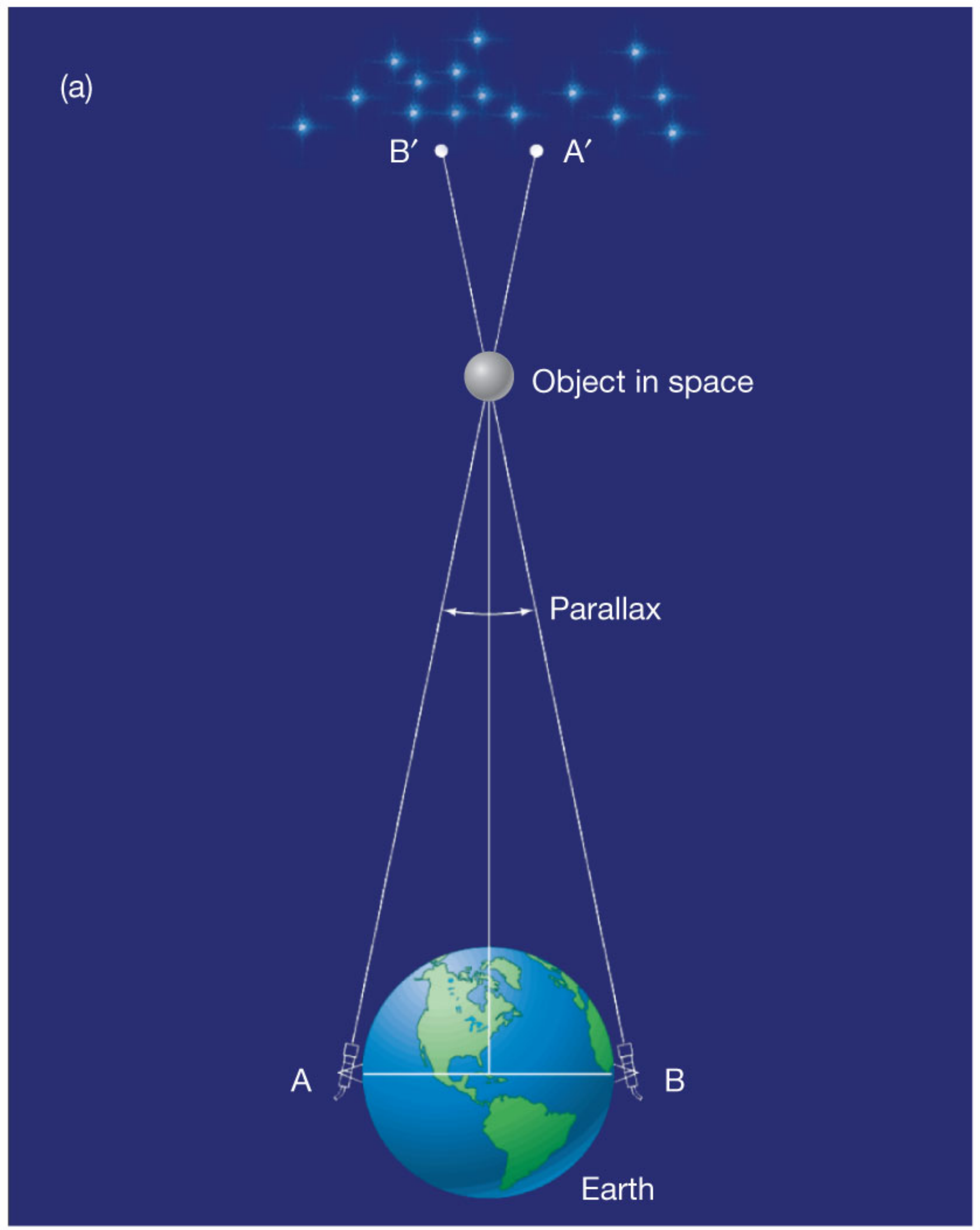
And I know the *angle*, θ

I can use geometry to find h!

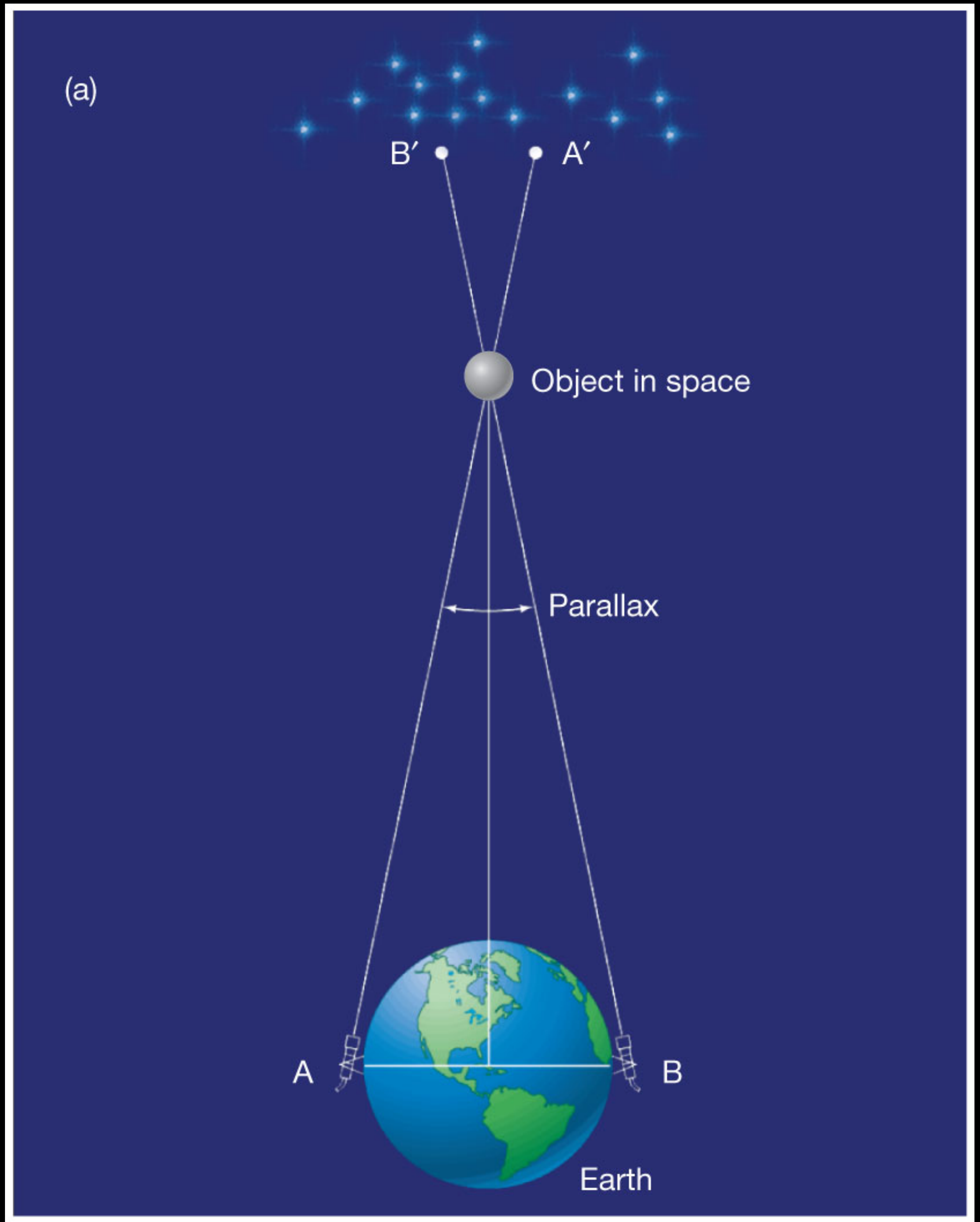


Parallax

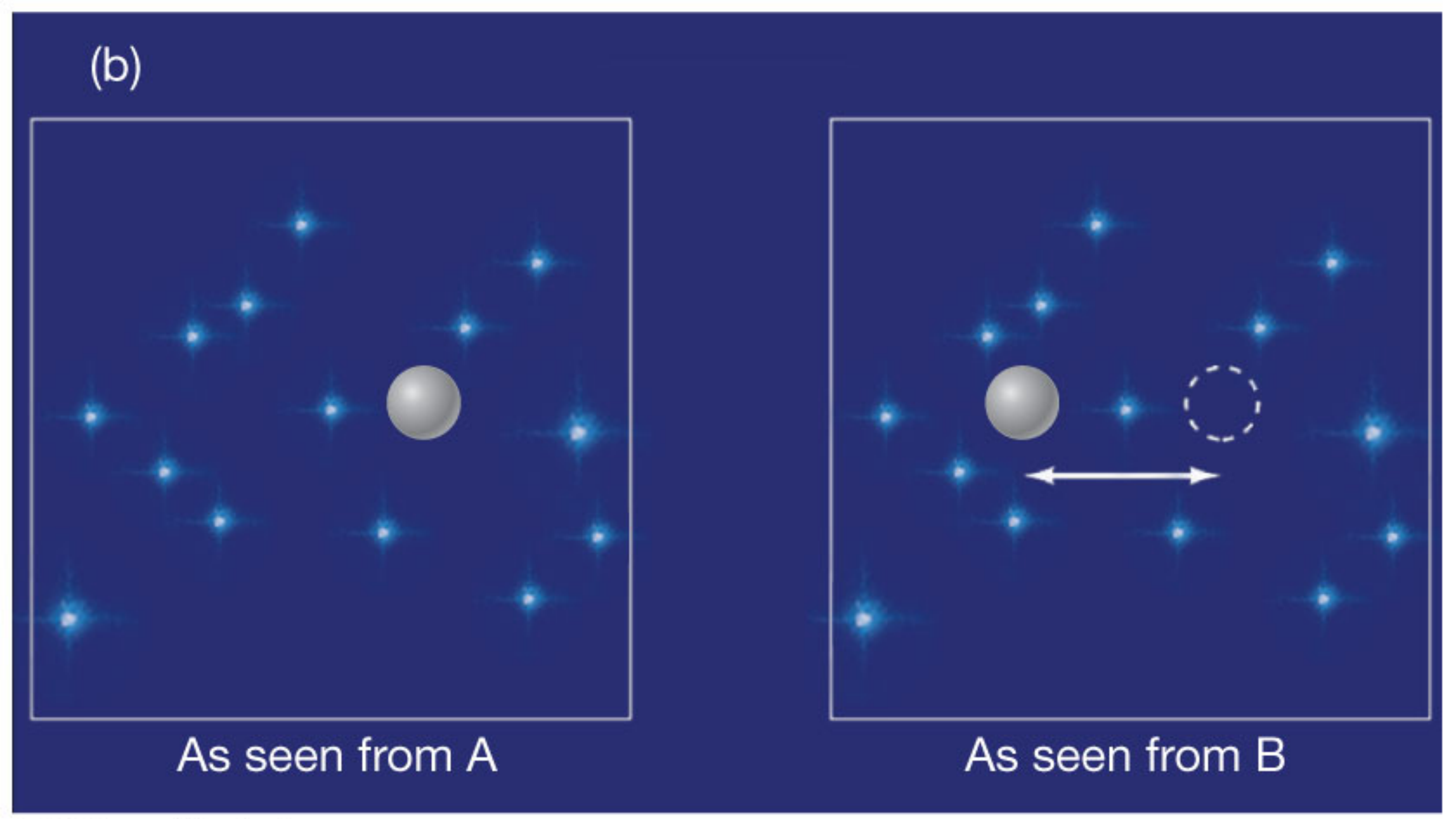
We use parallax to create triangles between us and an object projected on the sky!



Parallax



The key to successful parallax measurement is that the foreground object must move *compared to the fixed background stars*.



Parallax

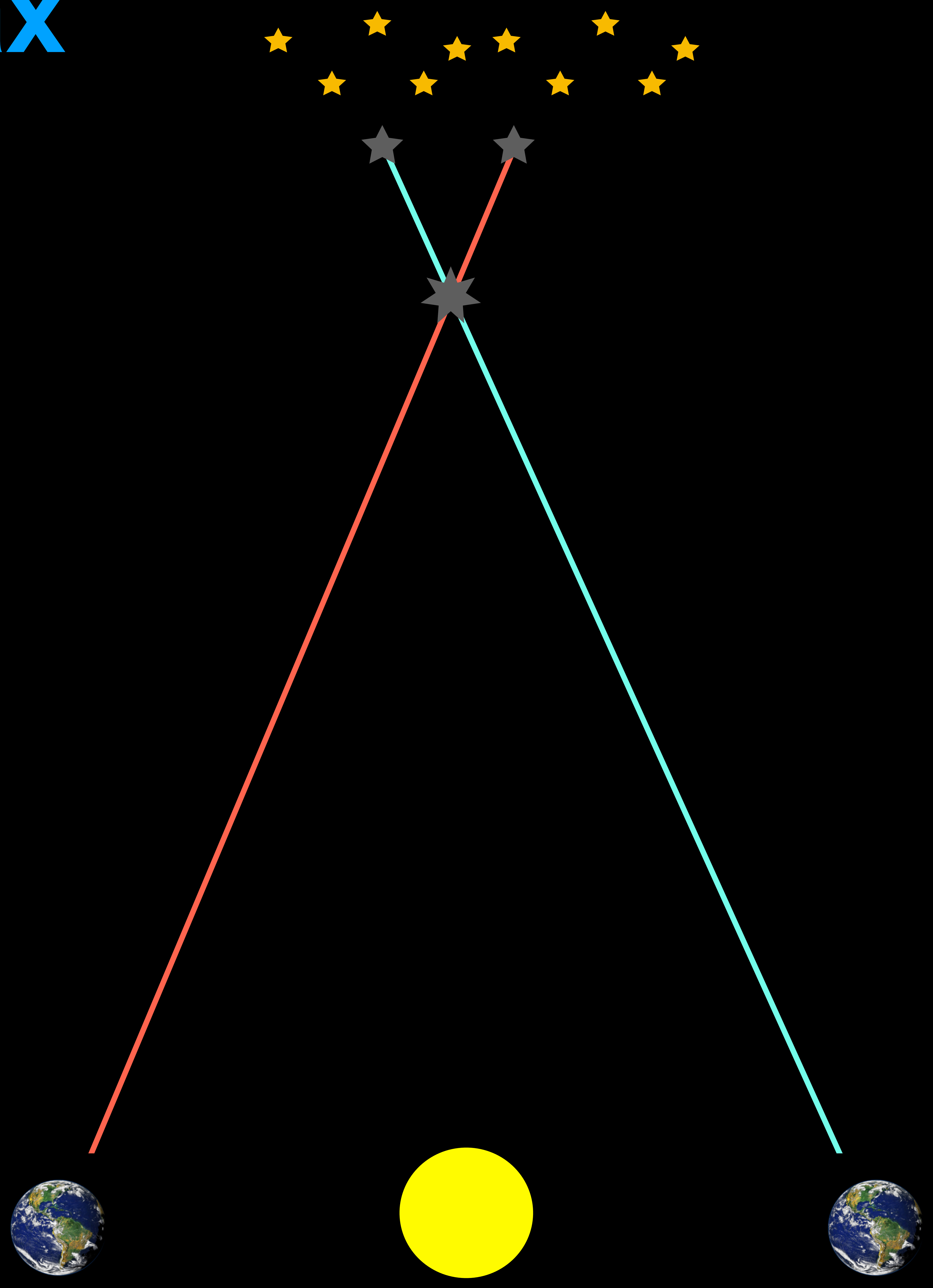
Let’s use parallax to measure the approximate lengths of our own arms without a ruler!

You’ll need a background of “fixed stars”.

The average human eyes are 2 inches apart

Parallax

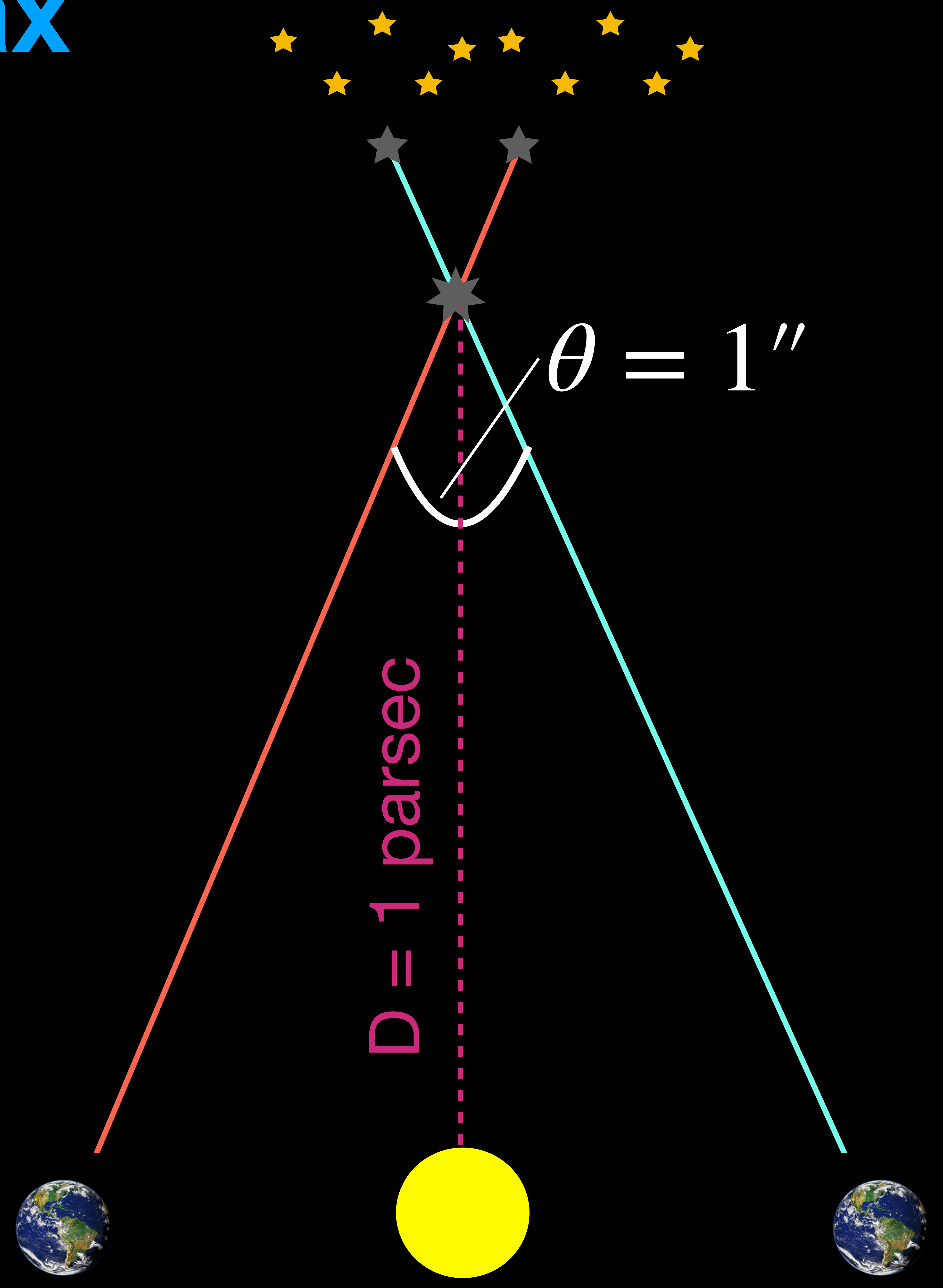
The largest baseline we can make from Earth is on opposite ends of our orbit around the sun!



Parallax

The *parsec*

The distance defined by one parsec, is the distance to an object that has a parallax of 1” (1 arcsecond) hence parallax-second

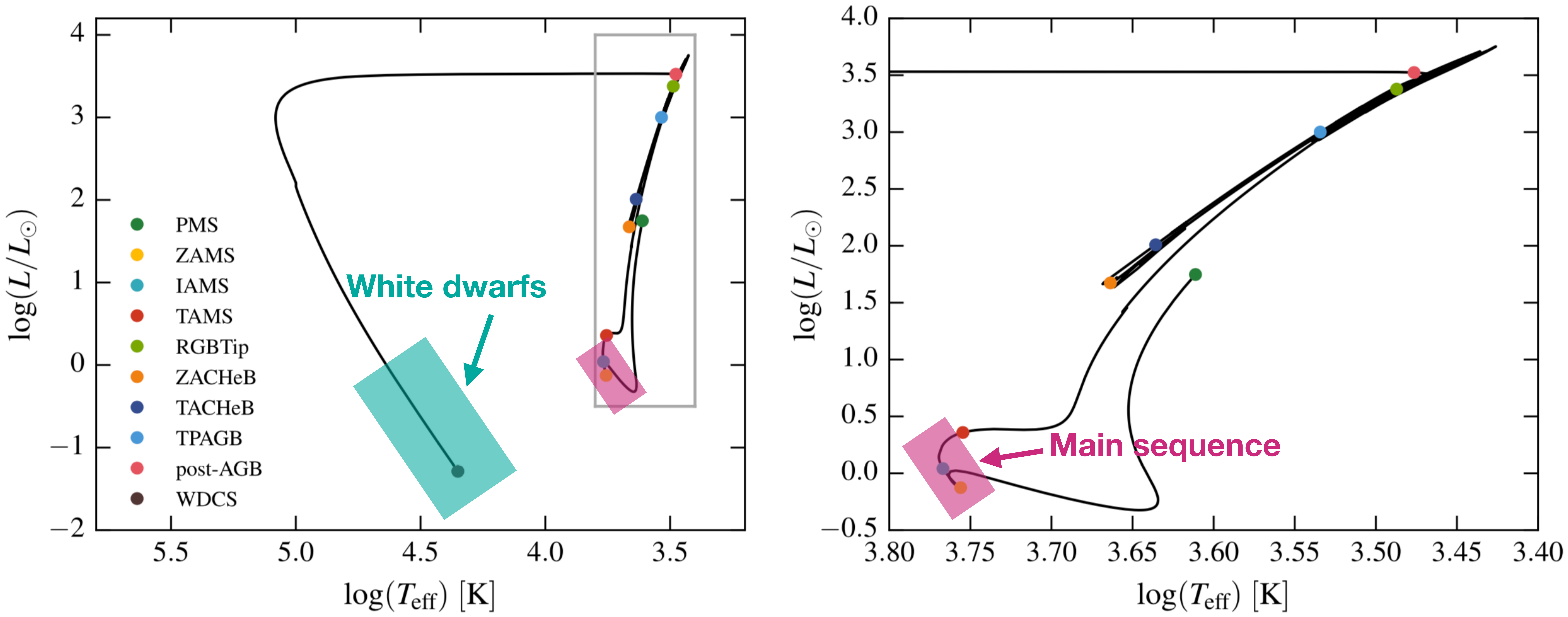


Type 1A Supernovae

Stars like our sun become white dwarfs

For a star like our sun, its “corpse” will be a white dwarf

Evolution of the Sun



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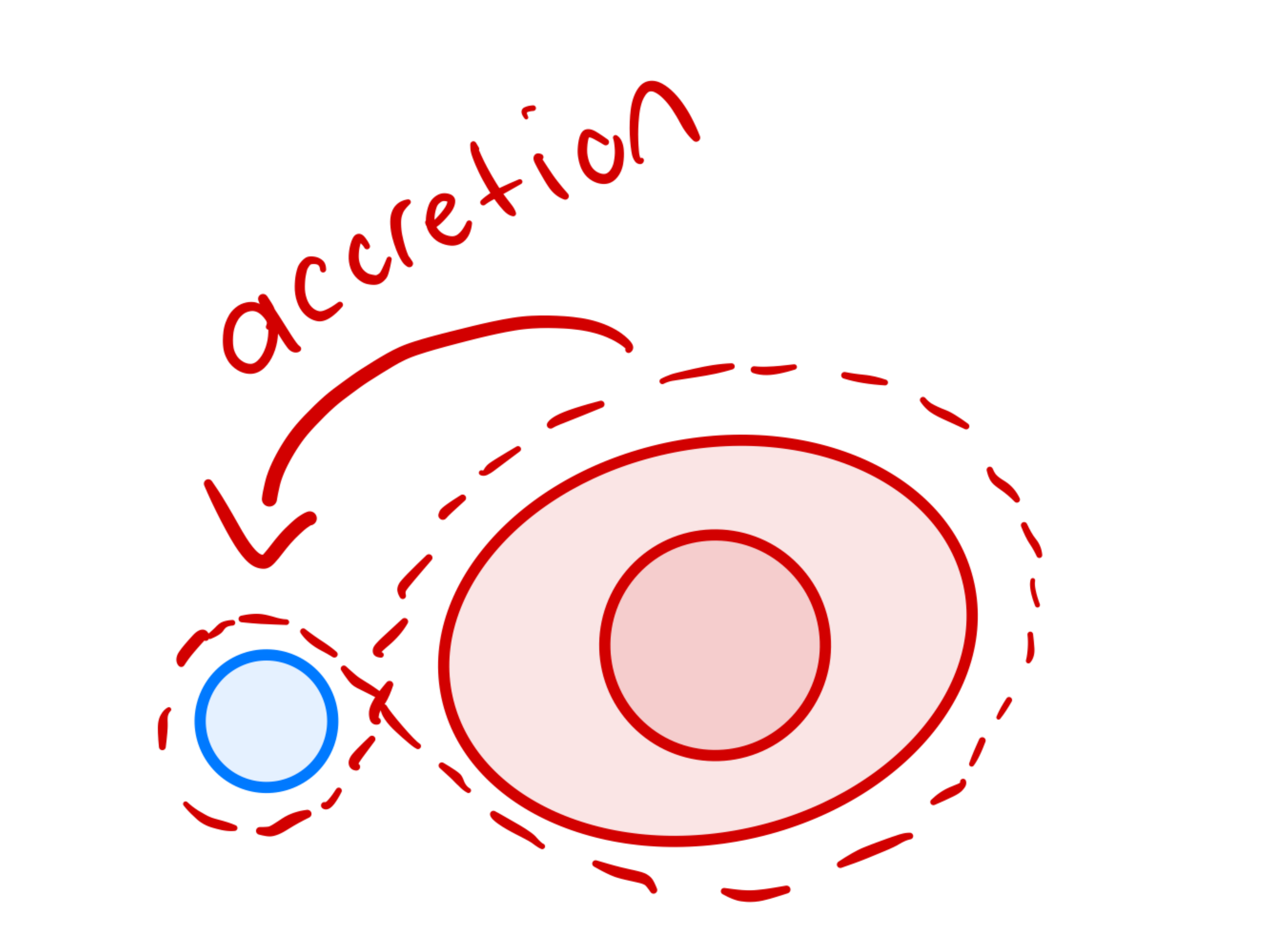
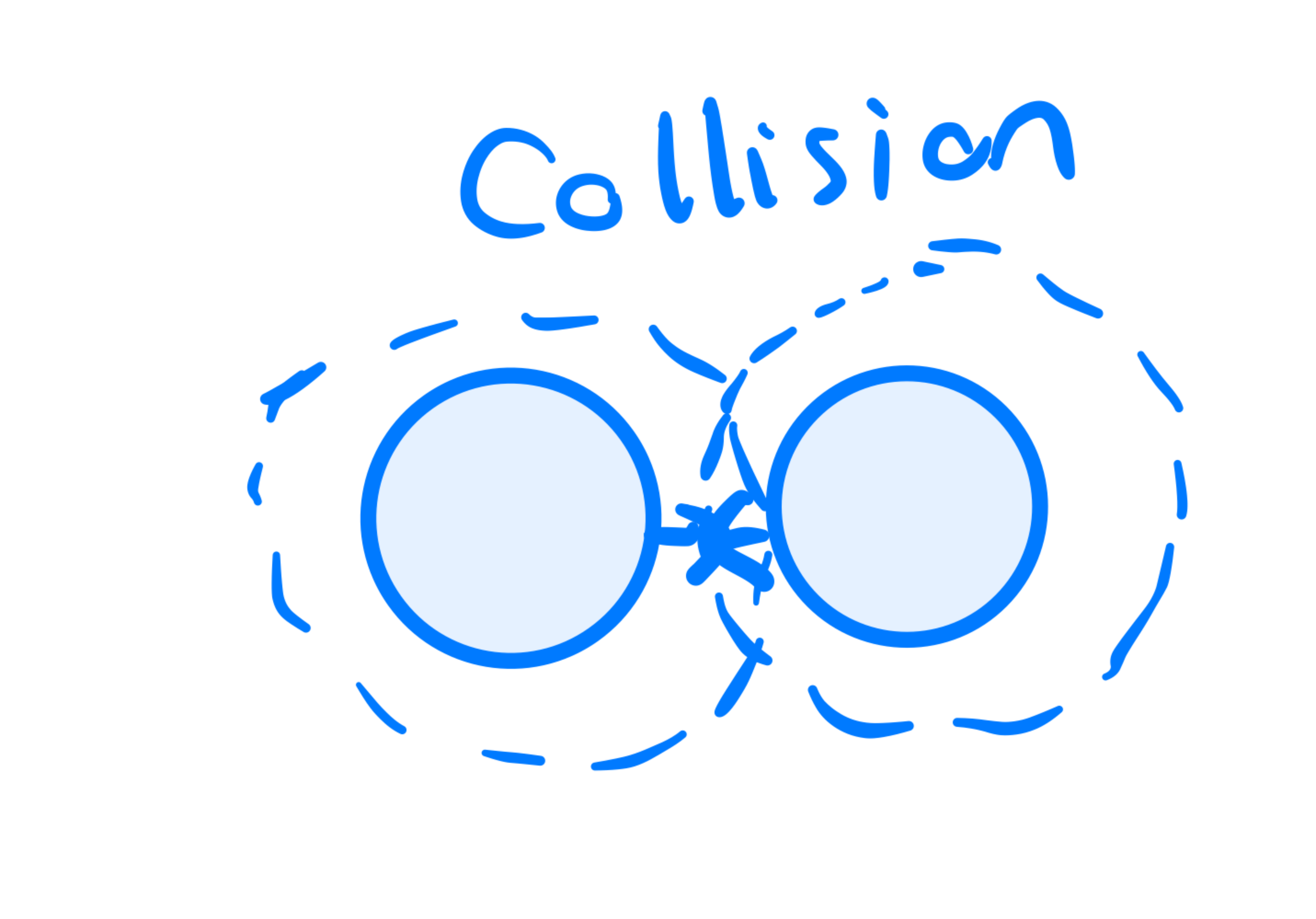
Choi et al. (2016)

Type 1A Supernovae

One white dwarf and one red giant.



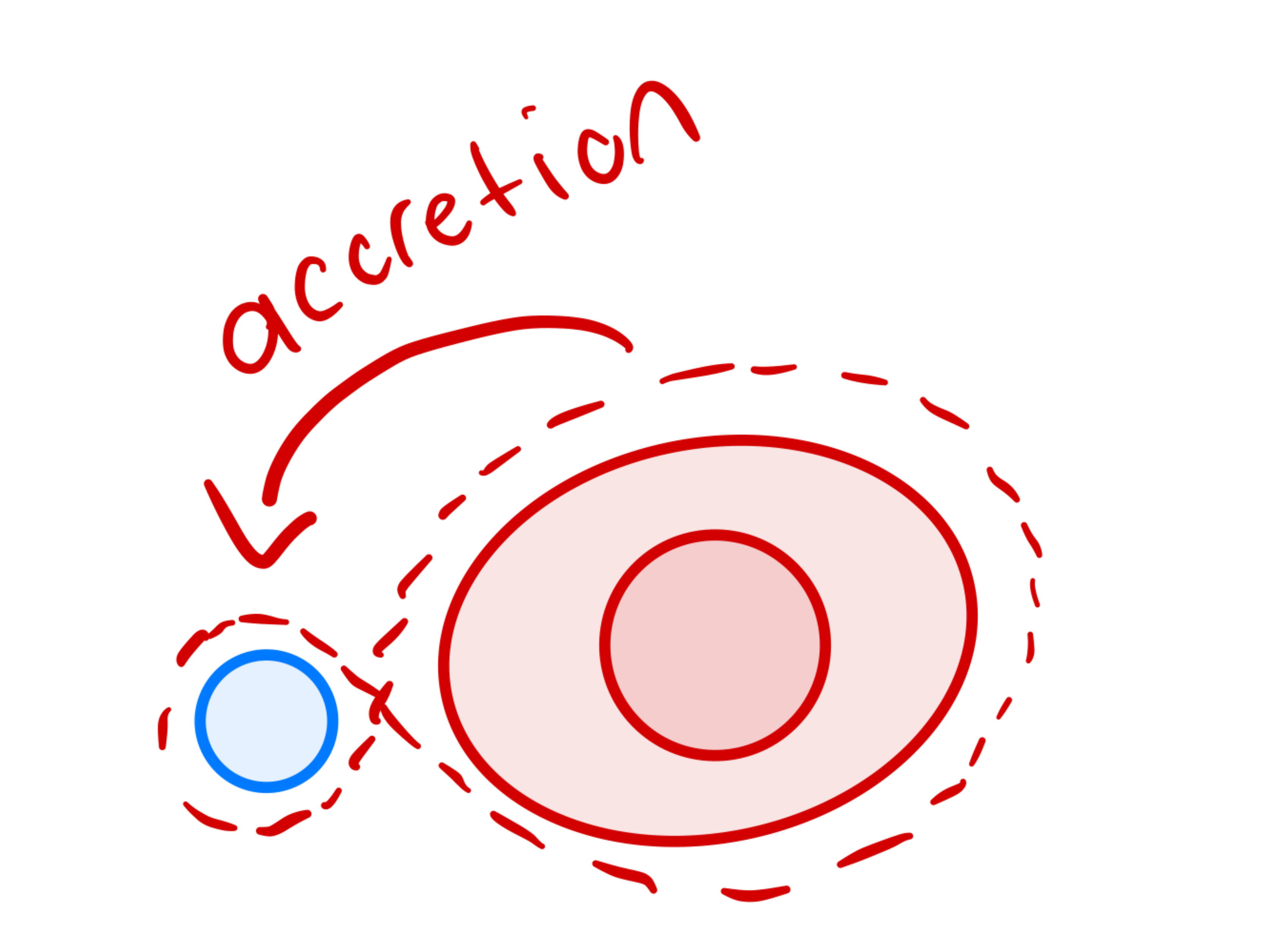
Two white dwarfs



Type 1A Supernova

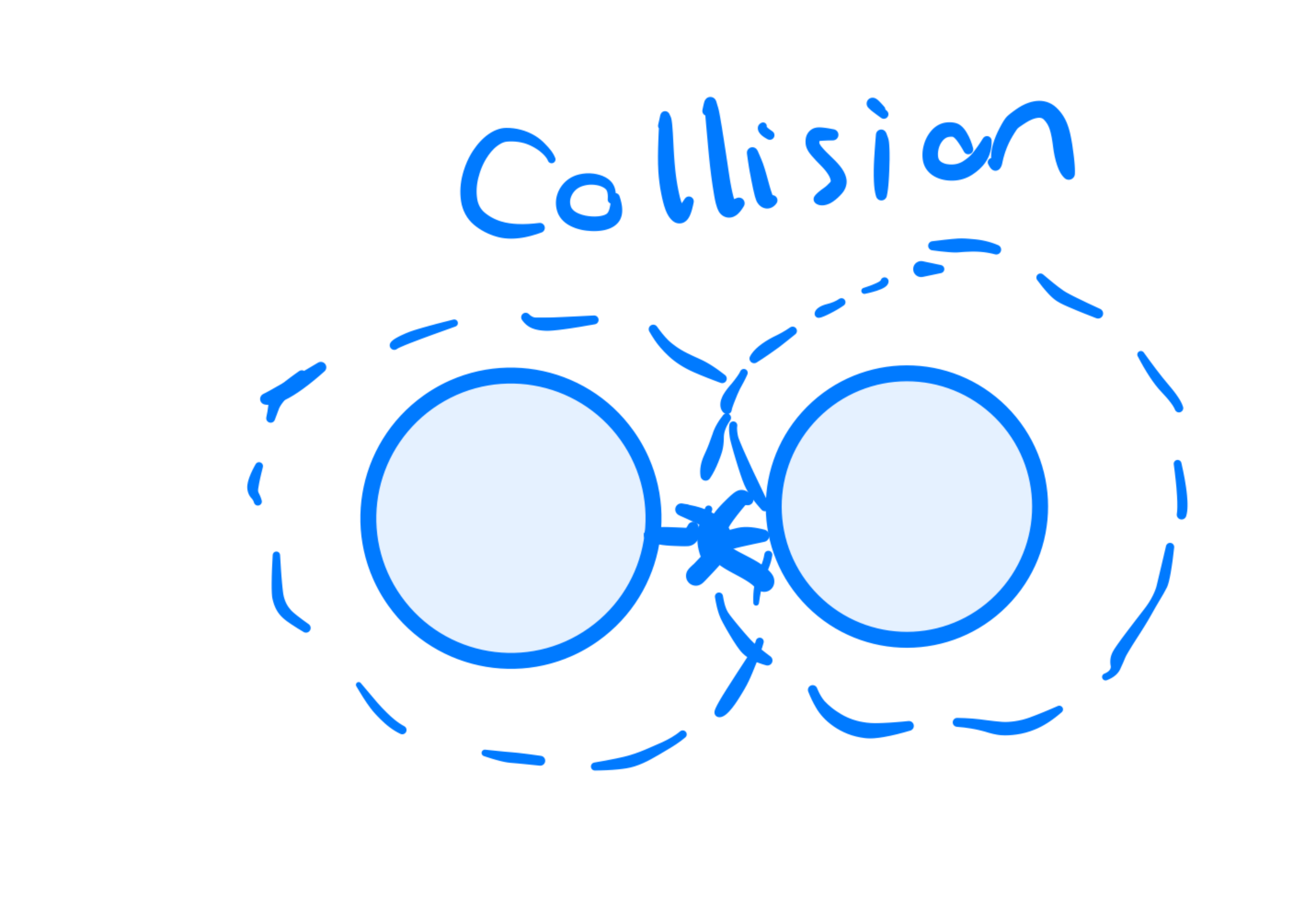
One white dwarf and one red giant.

If the white dwraf accretes enough mass…



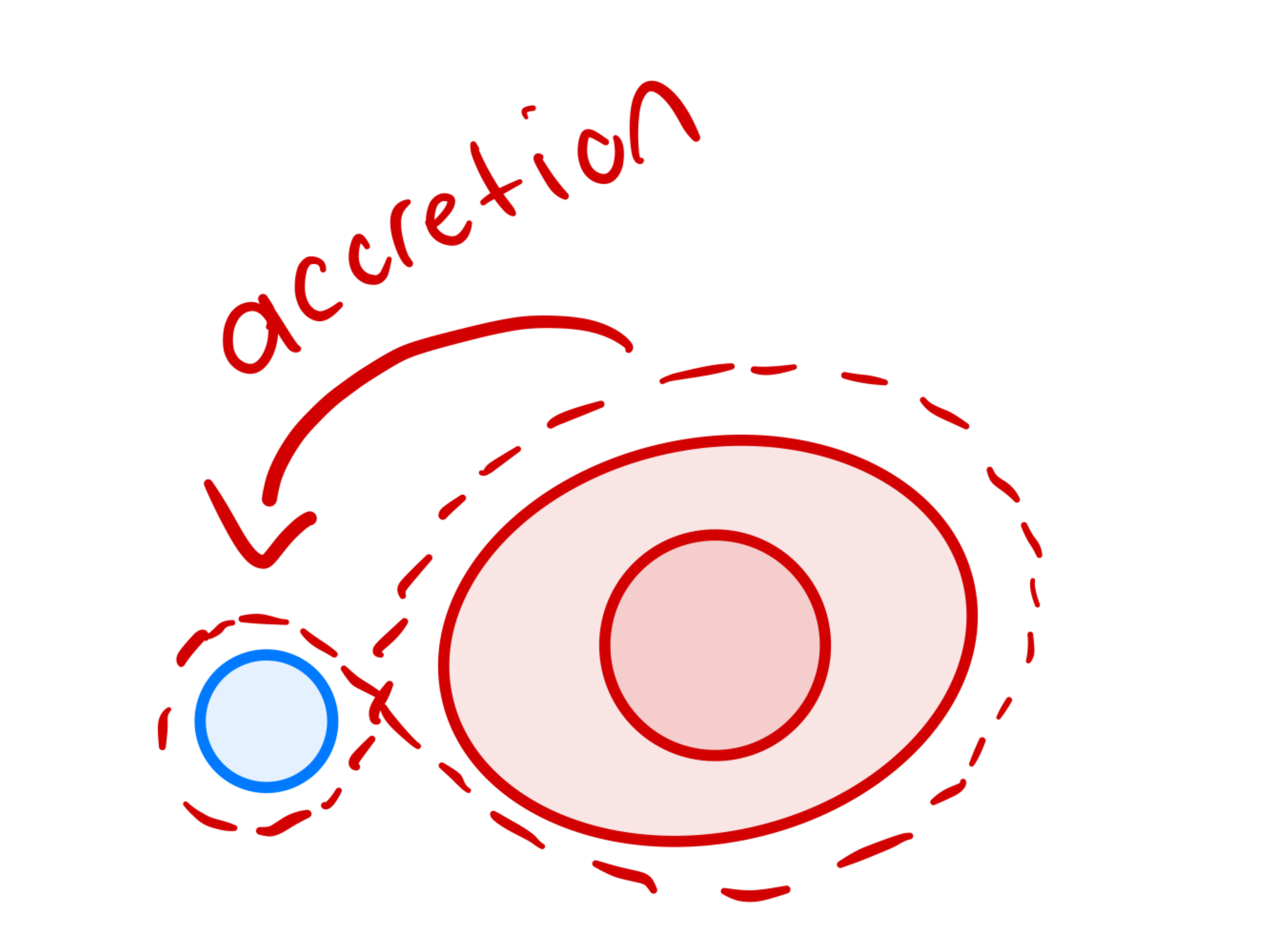
Two white dwarfs

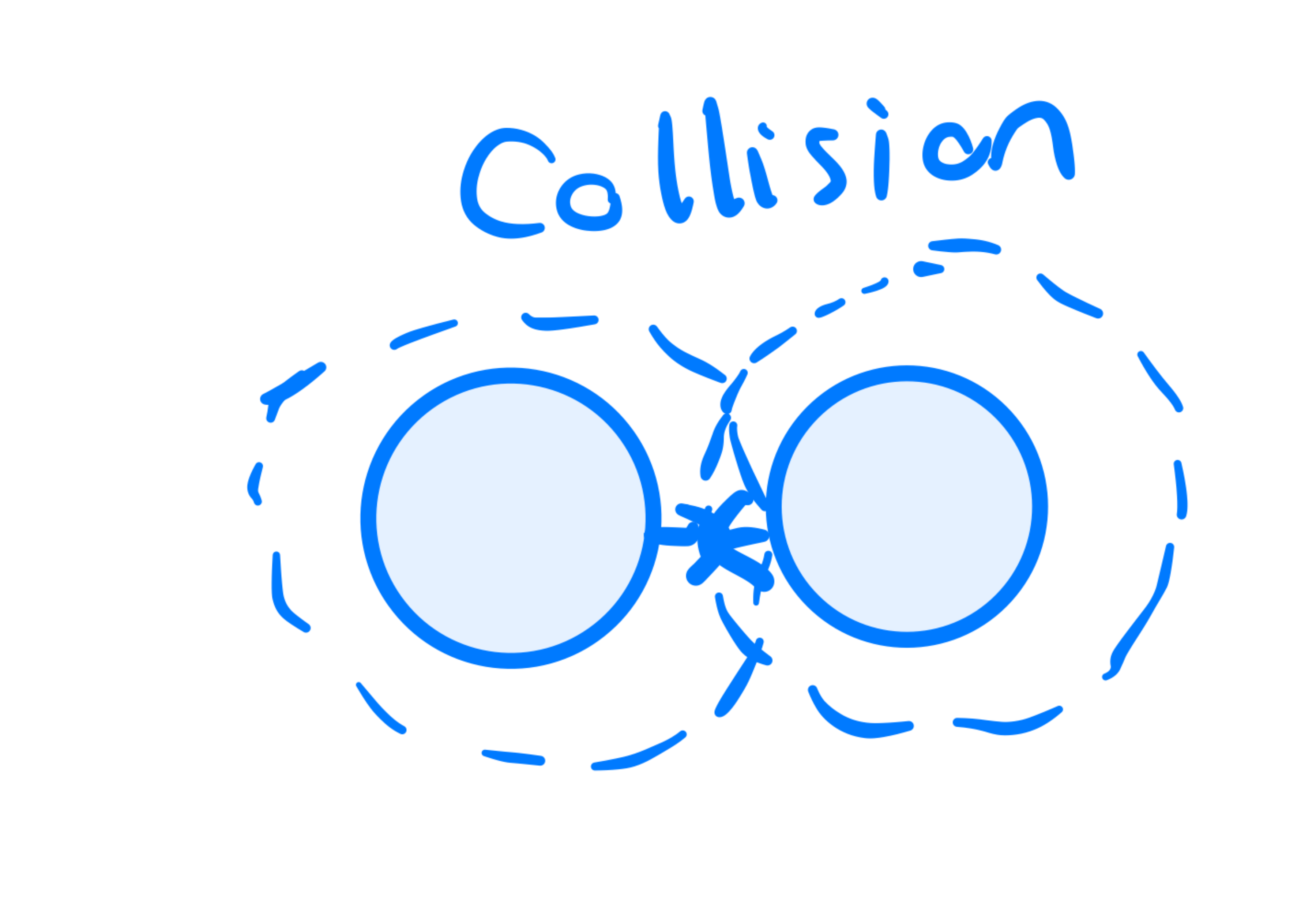
If the two white draws collide…



Type 1A Supernovae

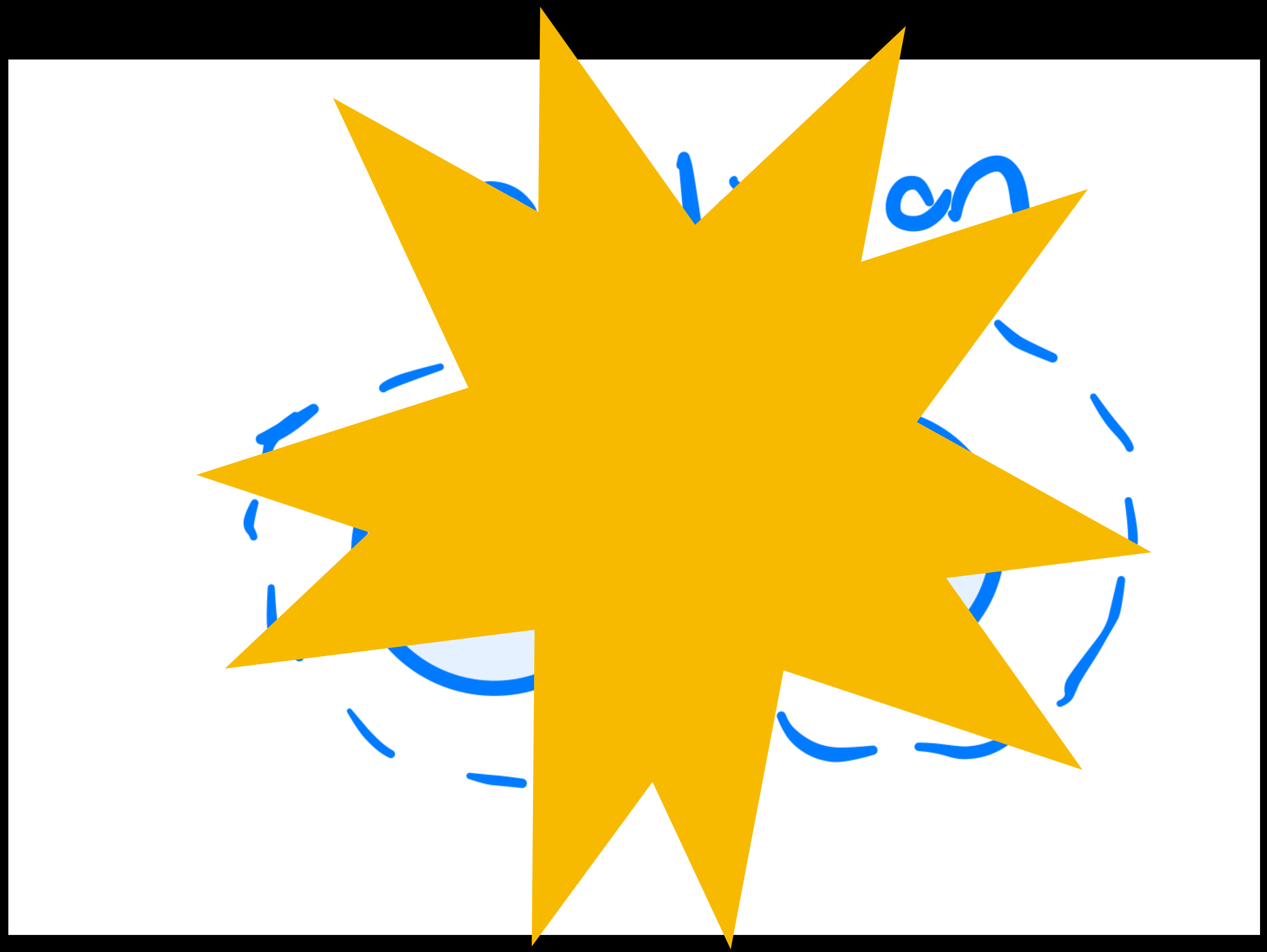
Such that the white dwarf reaches the Chandrasekhar mass (~1.4 solar masses)





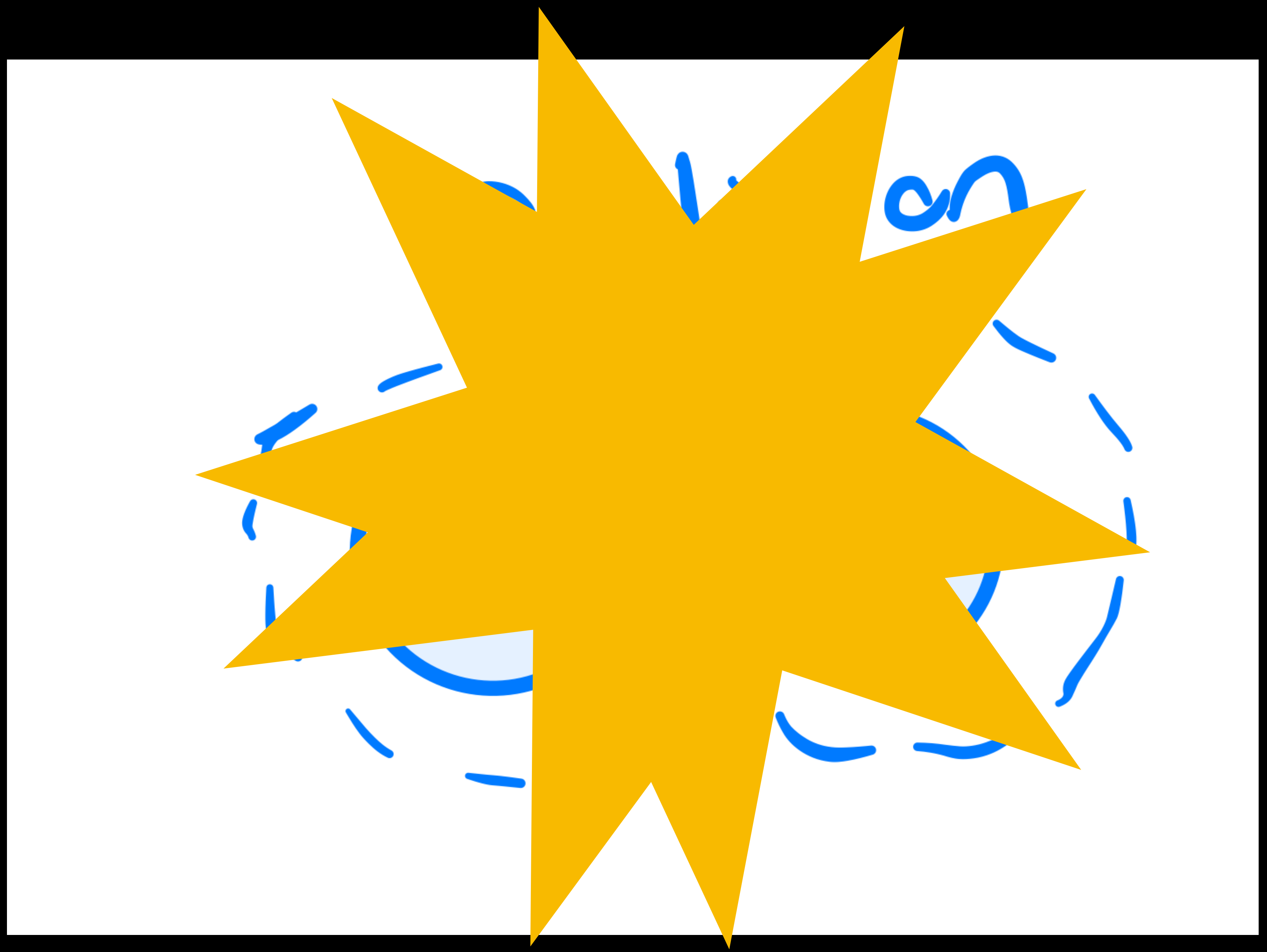
Type 1A Supernovae

The white dwarf explodes in a Type 1A supernova!



Type 1A Supernovae

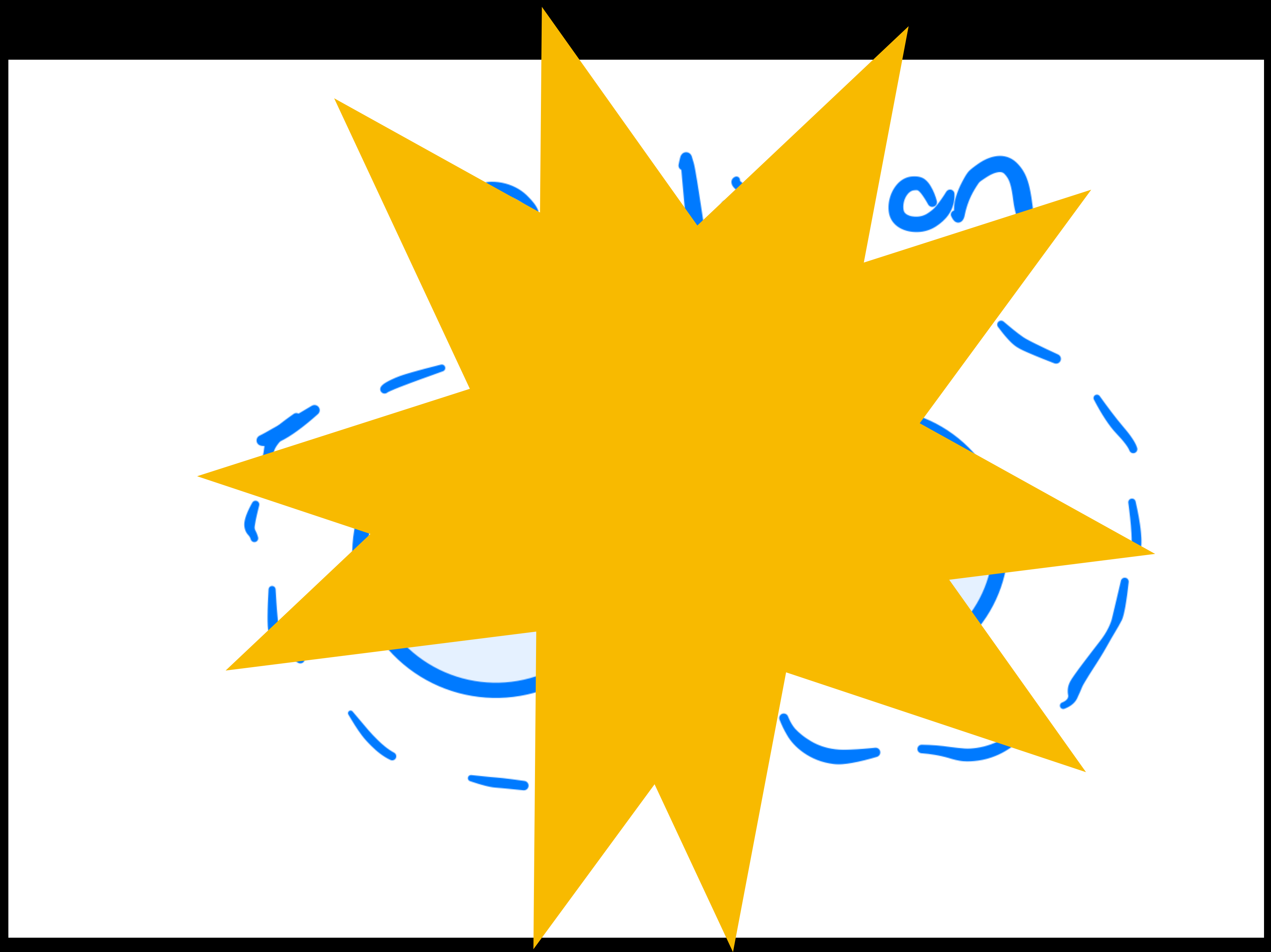
Because we know the intrinsic properties of this type of phenomenon, we know it’s intrinsic luminosity….



Type 1A Supernovae

$$F_{\text{received}} = \frac{L_*}{4\pi d^2}$$

We call these *standard candles*



The cosmic distance ladder