Group

AL	**Hunt**	Paige	**Quinn**	Jamie	**Devkota**	Bishwash
AR	**Prater**	Zane	**Fernandez**	Elizabeth	**Schott**	Connor
BL	**Smith**	Jaihan	**Fernandez**	Corey	**Thompson**	Natalie
BR	**Tlustos**	Travis	**White**	Erin	**Wood**	Noelle
CL	**DeMeyer**	Lauren	**Oconnor**	McKenna	**Burdette**	Lily
CR	**Gunalan**	Vishnu	**Shrimplin**	Skylar	**Morris**	Riley
DL	**Golovin**	Anita	**Pappageorge**	Lauren	**Mongillo**	Hailie
DR	**Lee**	Tony	**Gregory**	Brinley	**Beezley**	Claire
EL	**Tomczyk**	Aaron	**Ehardt**	Bella	**Adkins**	Leo
ER	**Desmond**	Sarah	**Aleman**	David	**Davis**	Jackson
FL	**Holtgrewe**	Emily	**McGeough**	Natasha	**Stringer**	Jason
FR	**Shell**	Brookelynn	**Green**	Kailey	**Ausler**	Kiara
GL	**Keeney**	Alex	**Takeuchi**	Fuka	**Brown**	Tatianah
GR	**Byrum**	Faith	**Evans**	Hannah	**Ziff**	Caitlin
HL	**Jones**	Justice	**Rosentreter**	Riley	**Tucker**	Kali
HR	**Swartz**	Alicia	**Barr**	Abigail	**Ashlin**	Bradley

AL	**Knight**	Cassidy	**Bourcier**	Savannah	**Pike**	Alena
AR	**Stirewalt**	Robert	**Ellis**	Alexander	**Roberts**	Jay
BL	**Stinnett**	Nic	**Hunter**	Kris		
BR	**Still**	Martin	**Price**	Elijah		
CL	**Kolath**	Caroline	**Petinaris**	Joanna		
CR	**Davis**	Samantha	**Brown**	Quincy		
DL	**Stiers**	Alexis	**Bayer**	Caeden		
DR	**Hunt**	Taylor	**Chabino**	Conner		
EL	**Yoss**	Aaron	**Czeschin**	Kyle		
ER	**Lambeth**	Gabe	**Cherukumilli**	Shan		
FL	**Ayers**	Carley	**McBurney**	Sullivan		
FR	**Bowe**	Ava	**Adams**	Autumn		
GL	**McPike**	Aiden	**Bradshaw**	Jenny		
GR	**Todd**	Ana	**Maune**	Cole		
HL	**Saucedo**	Brithny	**Sauceda**	Emma		
HR	**Coomes**	Austin	**Govero**	Brady		

Stars do not all appear the same

We want to know:

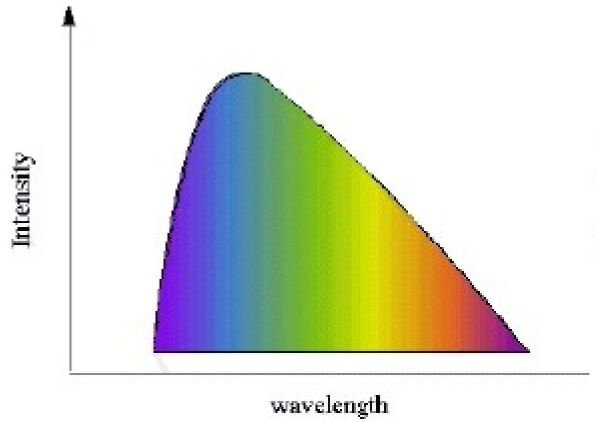
- How hot are stars? — $T = 2.9x10^6/\lambda$
- How BIG are stars (size)? — parallax
- How massive are stars?
- What are stars made of? — Spectral lines: H then He
- How much energy do stars emit — Luminosity
- Where does that energy come from — Fusion: $E=mc^2$
- How far away are stars — Parallax
- Are they in motion? — Yes. Proper motion & radial velocity

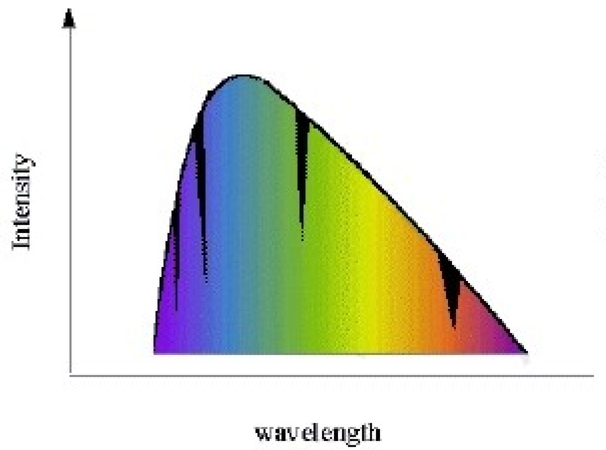
How to make a star brighter

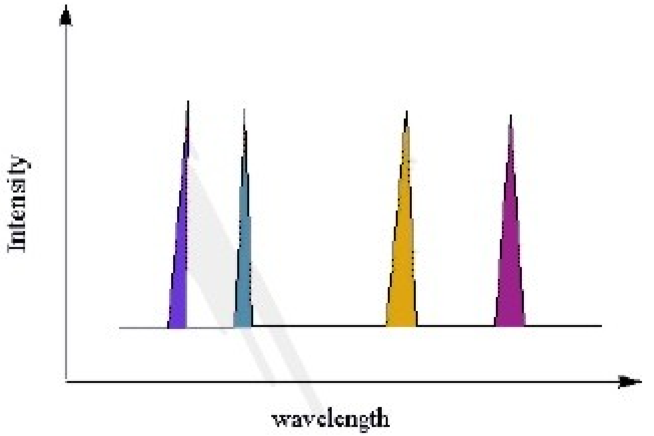
- Make it hotter: $L_{ap} \sim T^4$
- Make it bigger: $L_{ap} \sim R^2$
- Make it closer: $L_{ap} \sim 1/d^2$

Hotter is most powerful.

So now we have 3 types of spectra





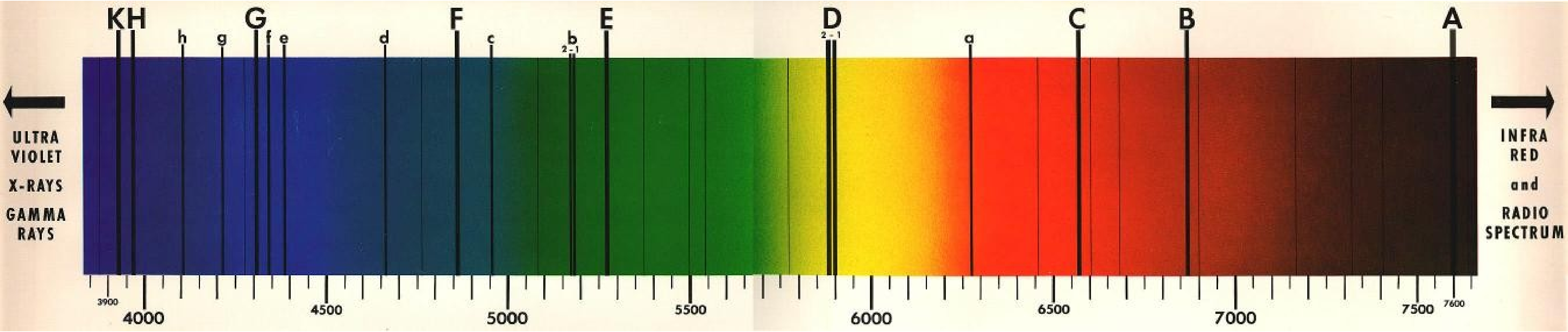


Continuous spectra are made by objects under high pressure (like solids)

Absorption line spectra are made by cool (comparatively) low pressure gases.

Emission line spectra are made by (comparatively) hot, low pressure gases.

A spectrum of our Sun:



The lines give us composition! So we can see what our Sun is made of !

Nearly all stars....

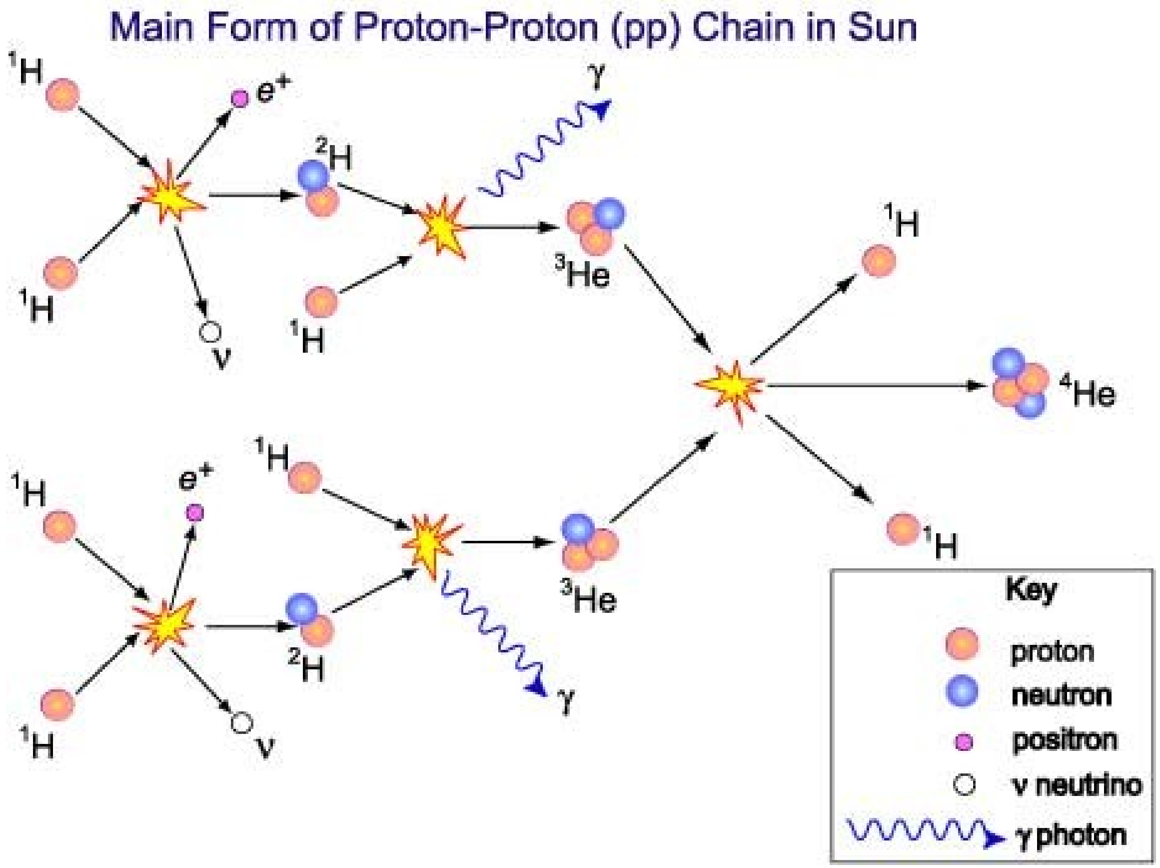
- Are ¾ H and ¼ He with a trace (<3%) 'metals' (everything else).

Now we can ask, What provides the energy our Sun emits?

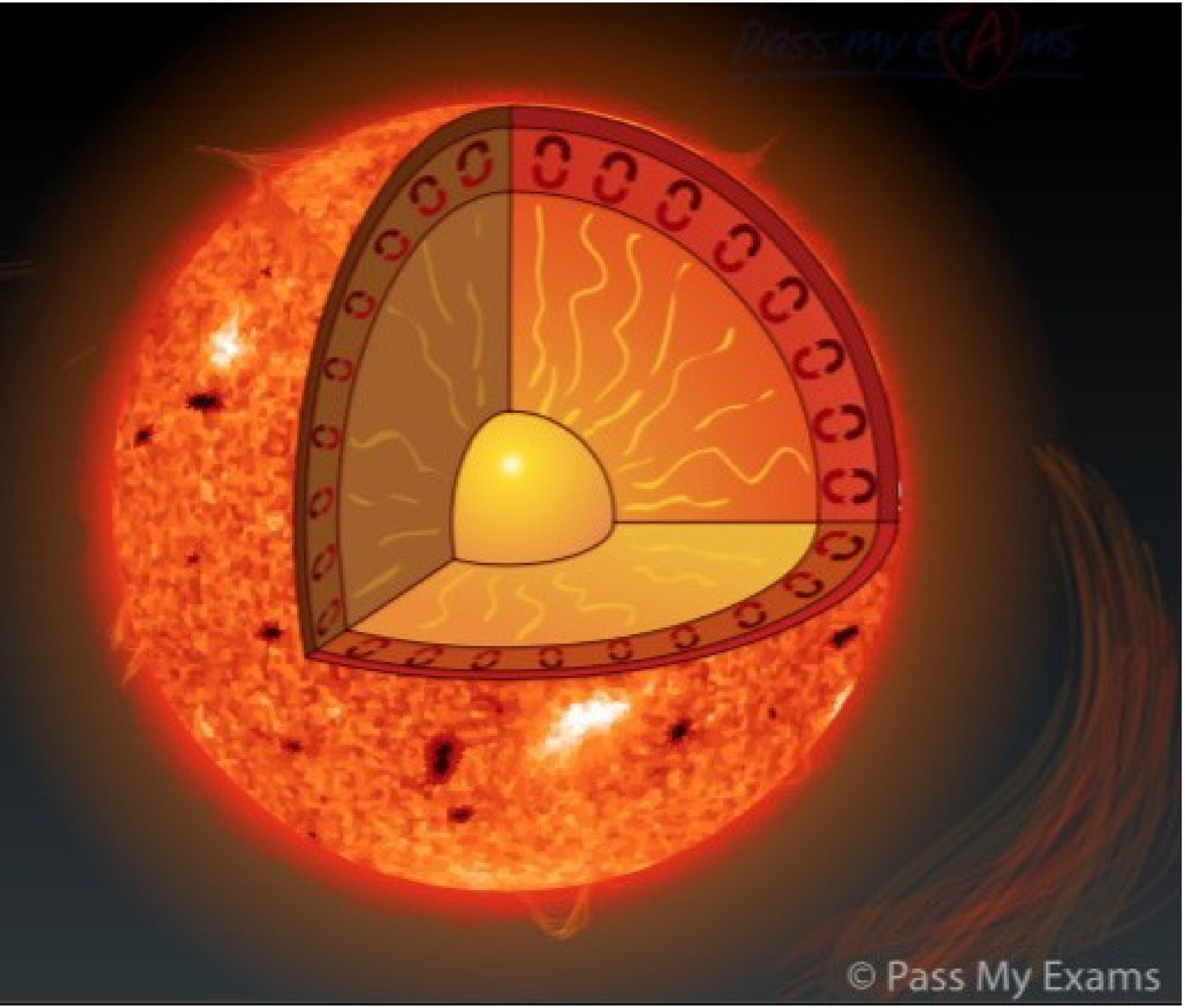
the Sun radiates $L=3.9x10^{26}$ W

The Sun emits a million billion tons of TNT worth of energy each second.

By converting hydrogen to helium: **<u>nuclear fusion</u>**.

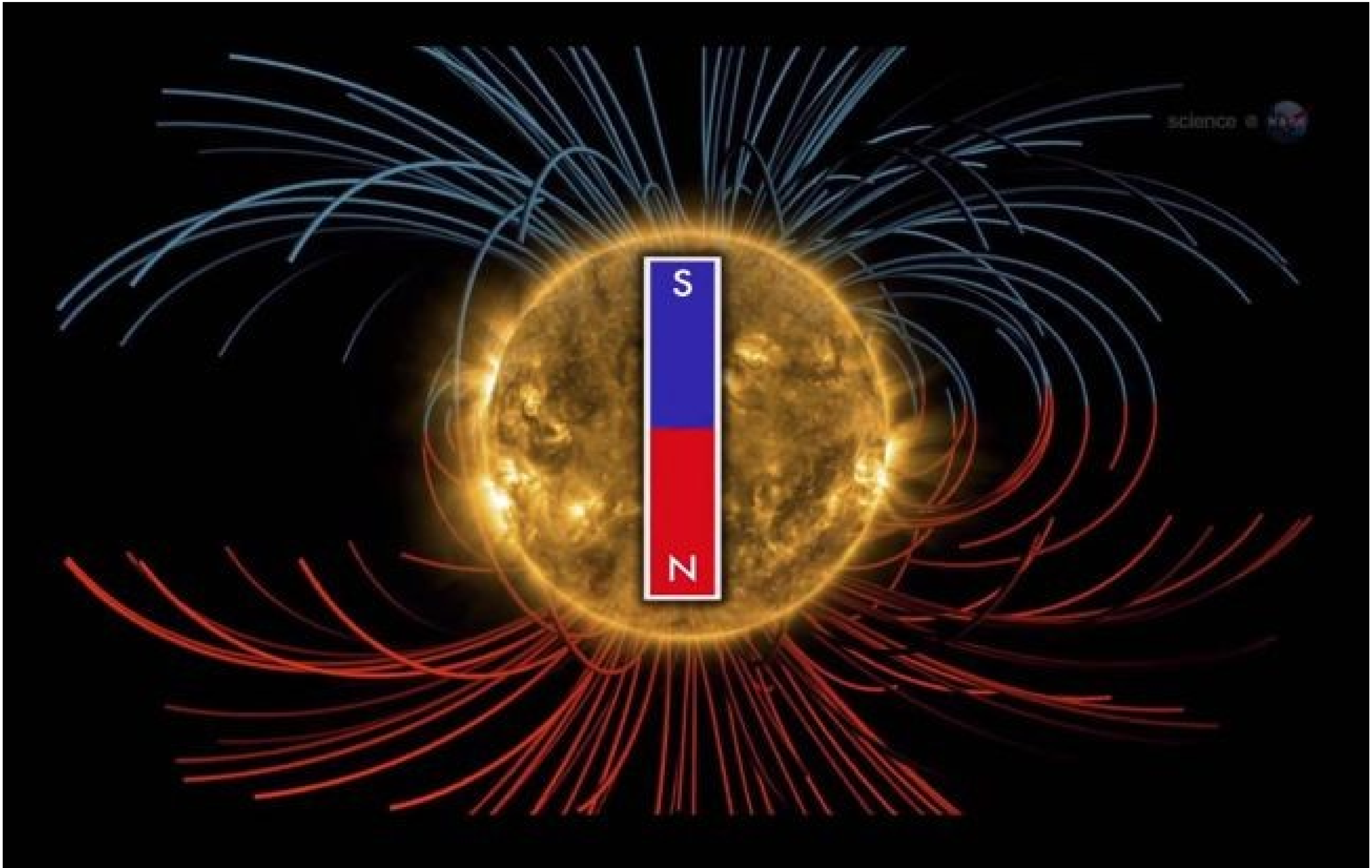


The Sun's structure

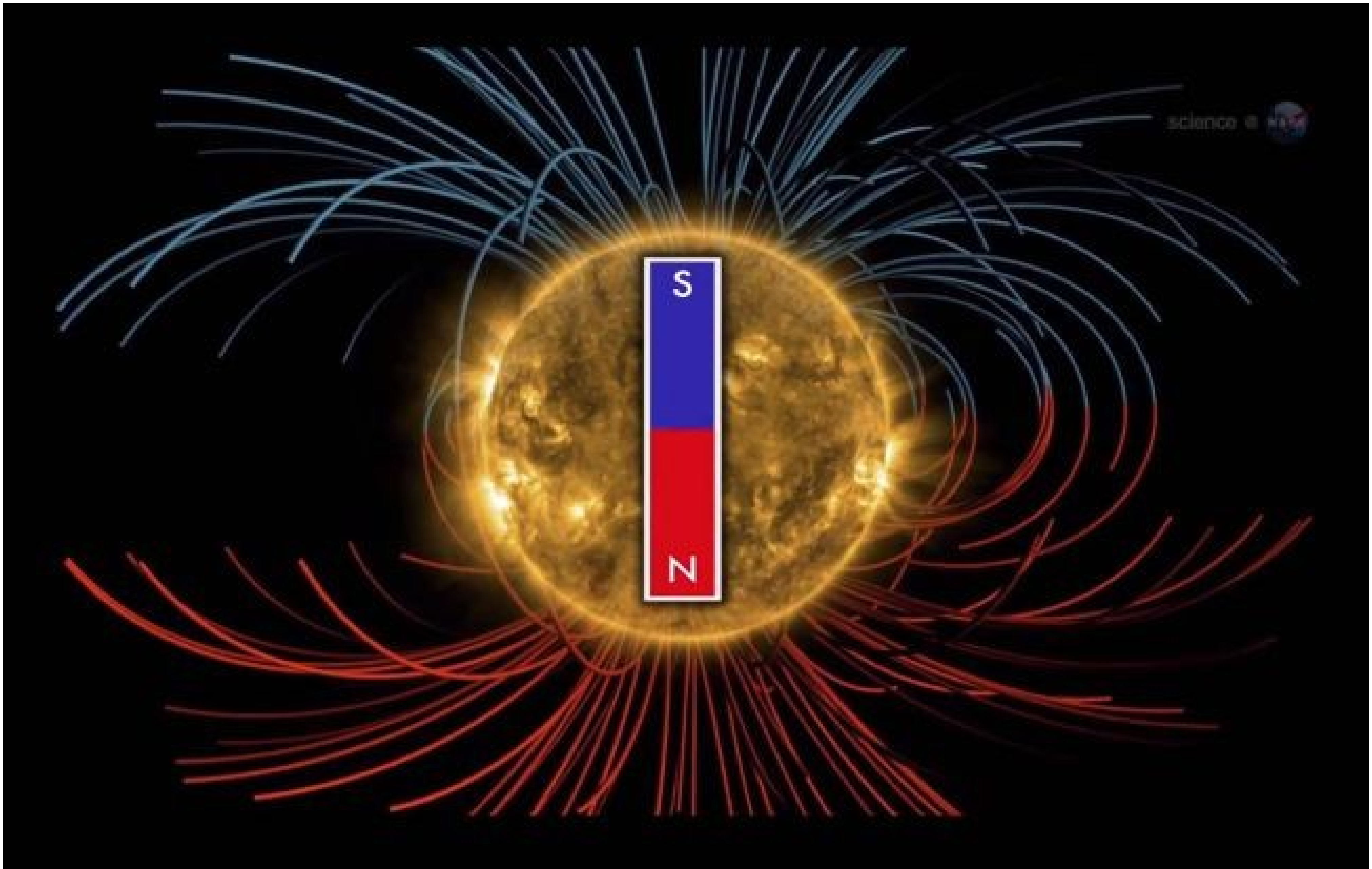


Core, radiative zone, convective zone, and Photosphere. (Summary slide coming)

Sunspots are caused by the wrapping of the Sun's magnetic field.



The sun's magnetic field starts out like a regular north-south magnet.



The sun's magnetic field starts out like a regular north-south magnet.

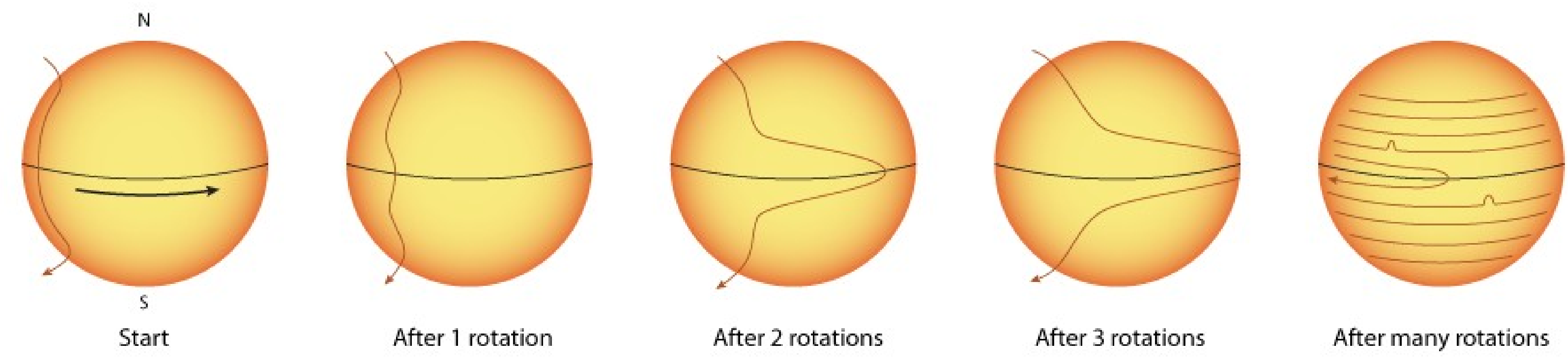
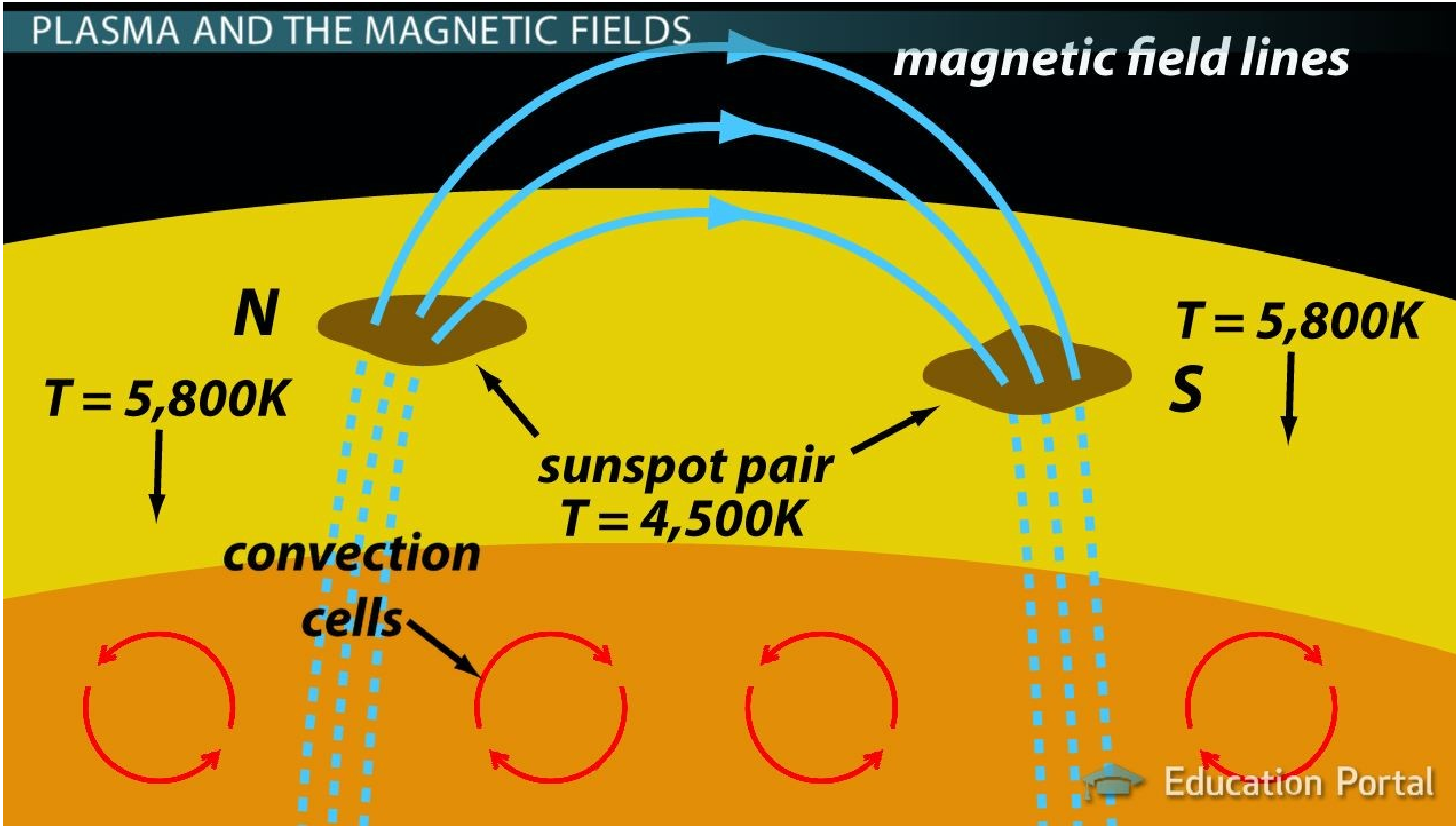


Illustration by José Francisco Salgado, PhD (Adler Planetarium)

Eventually the field lines get wrapped so tight they begin to cross themselves.

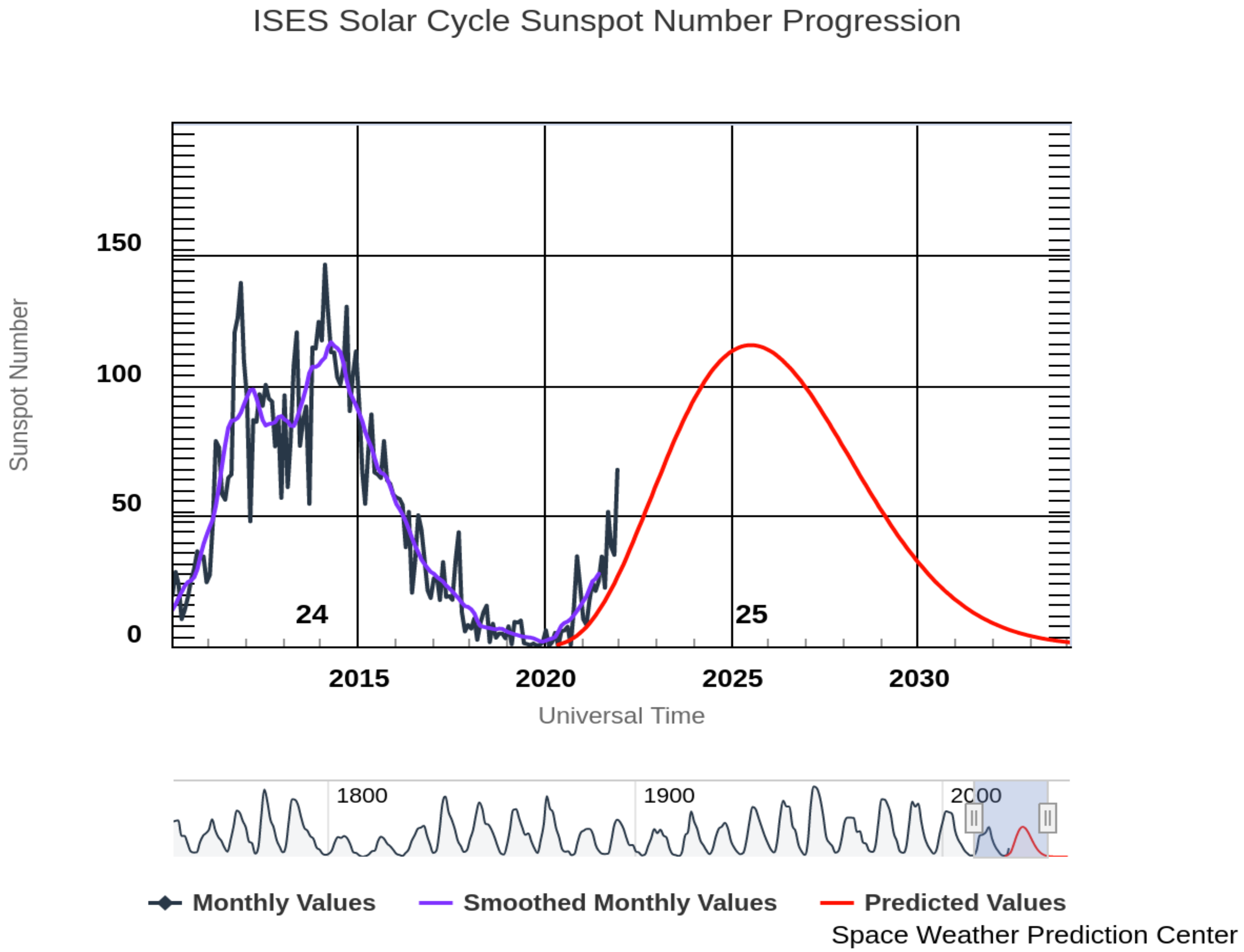
The Sun spins faster at the equator than at the poles (It’s a gas, so it can do this)

Where they cross the surface, they stop convection and that portion just cools, making it appear darker.



Like this!

Counts of sunspots during the current cycle, and predictions for the next few years.



Summary

*Our Sun can be separated into several regions: Core, radiative zone, convective zone, and photosphere

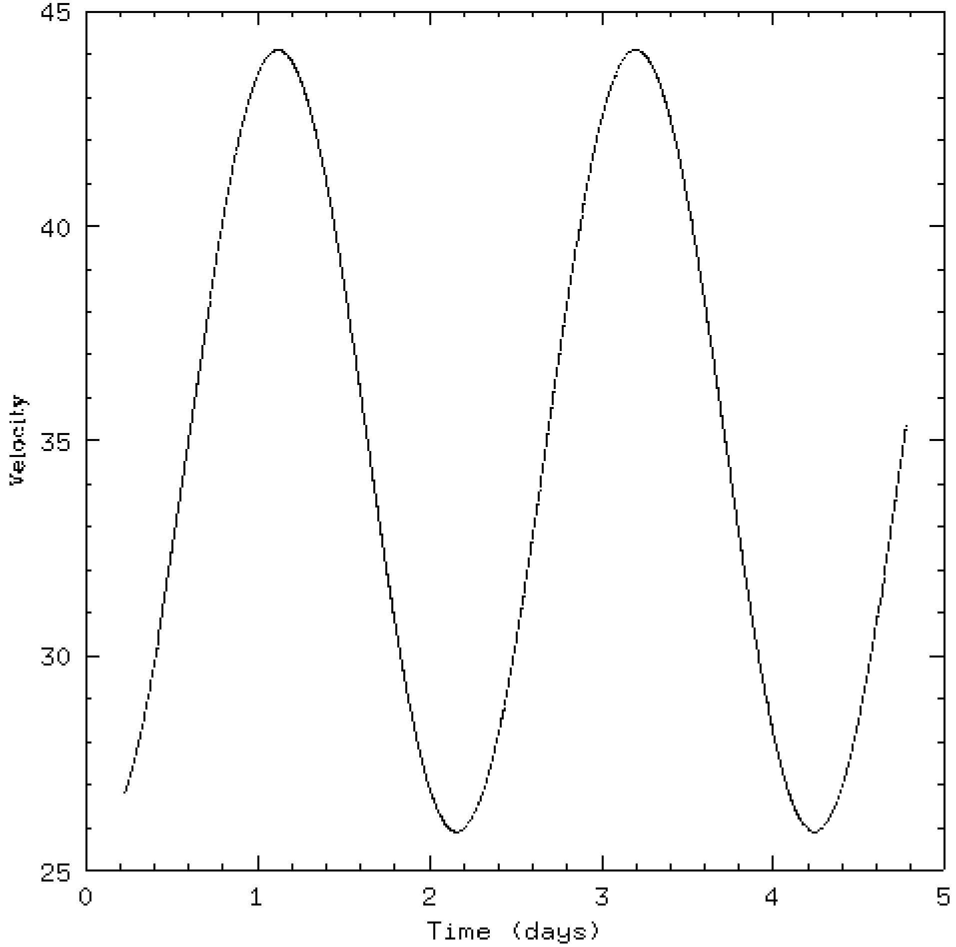
* All the energy is generated in the core

* We see sunspots on the Sun’s surface. They are caused by ‘kinks’ in the Sun’s magnetic field poking through the surface.

* The Sun spins about one every 4 weeks. Faster at the equator, slower at the poles.

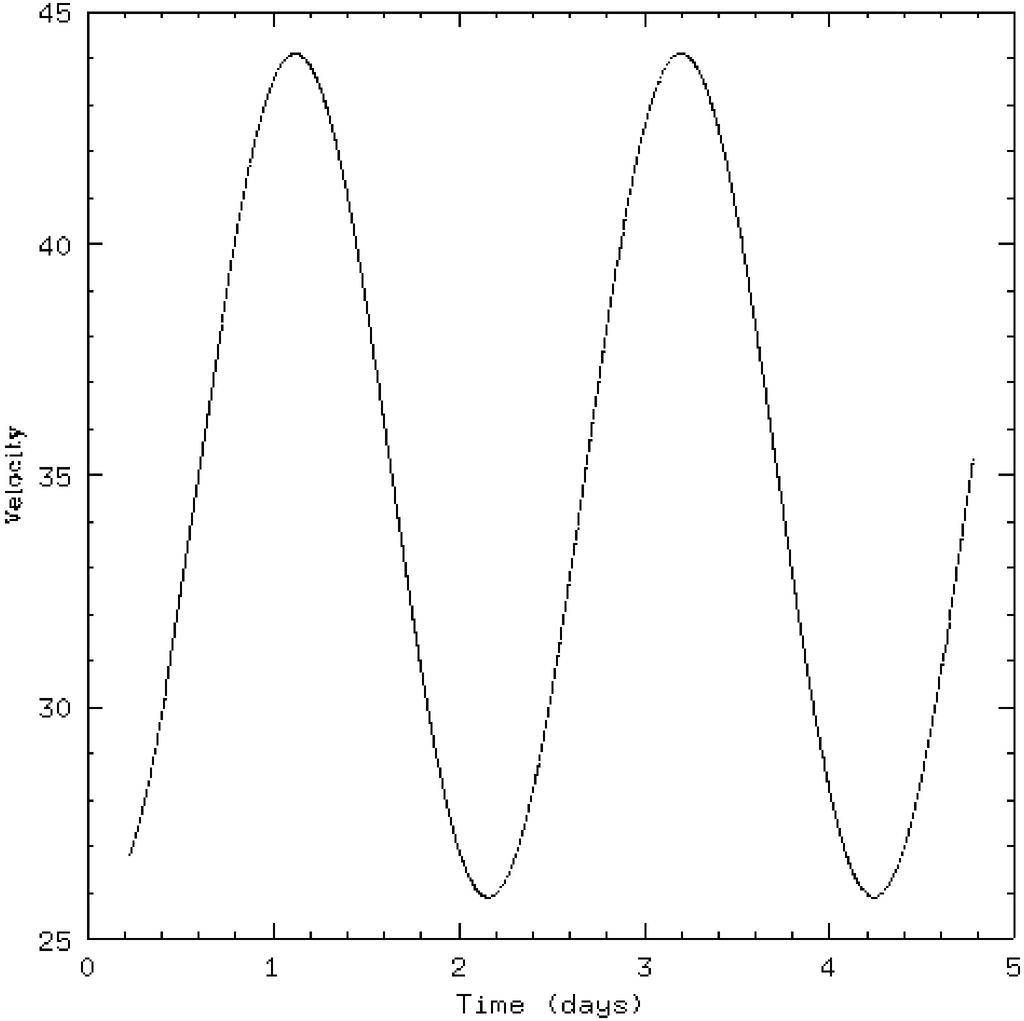
* The Sun’s magnetic field has a cycle that lasts about 11 years. Many (but not all) other stars have magnetic cycles too.

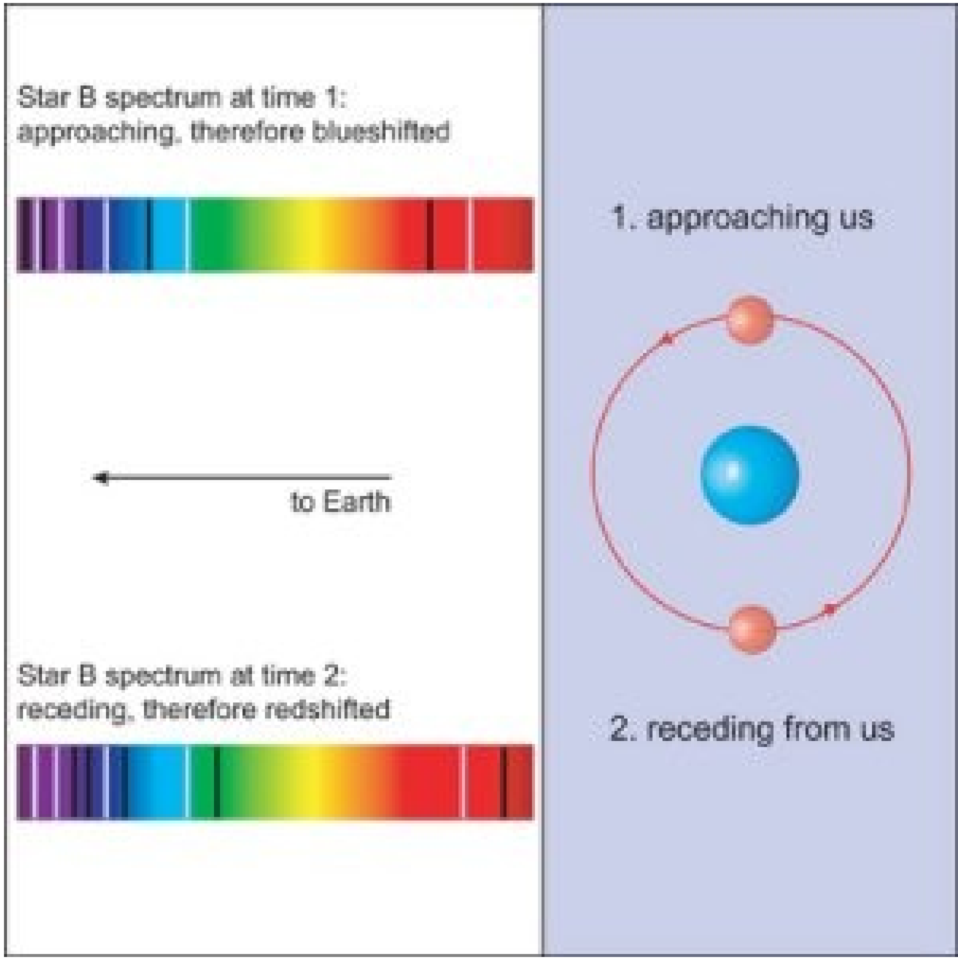
Back to Doppler shifts (radial velocity)



What do you think this graph means?

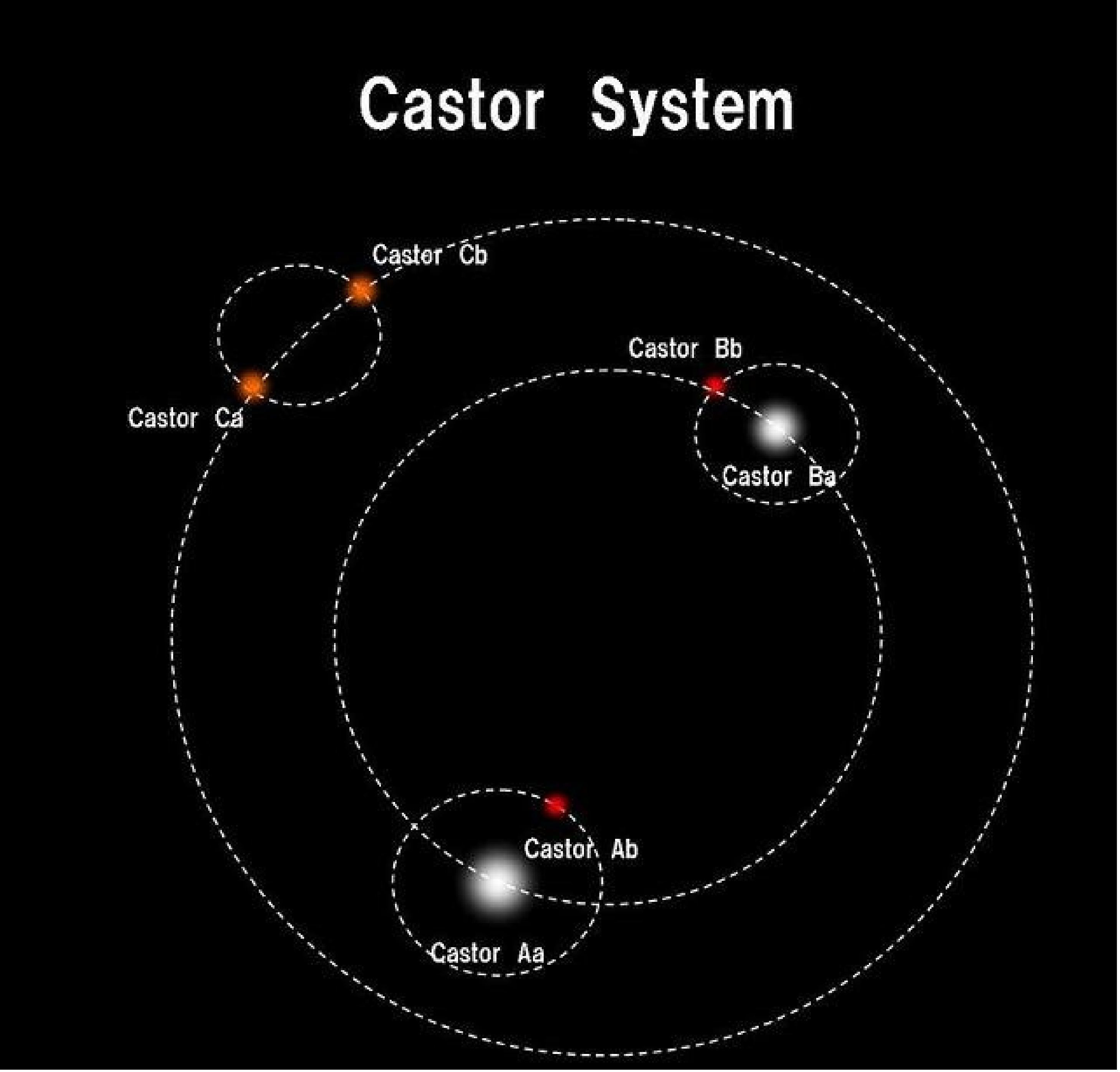
Doppler shift is a wealth of information!





This star is in a binary. About 2/3 of all stars are in binaries.

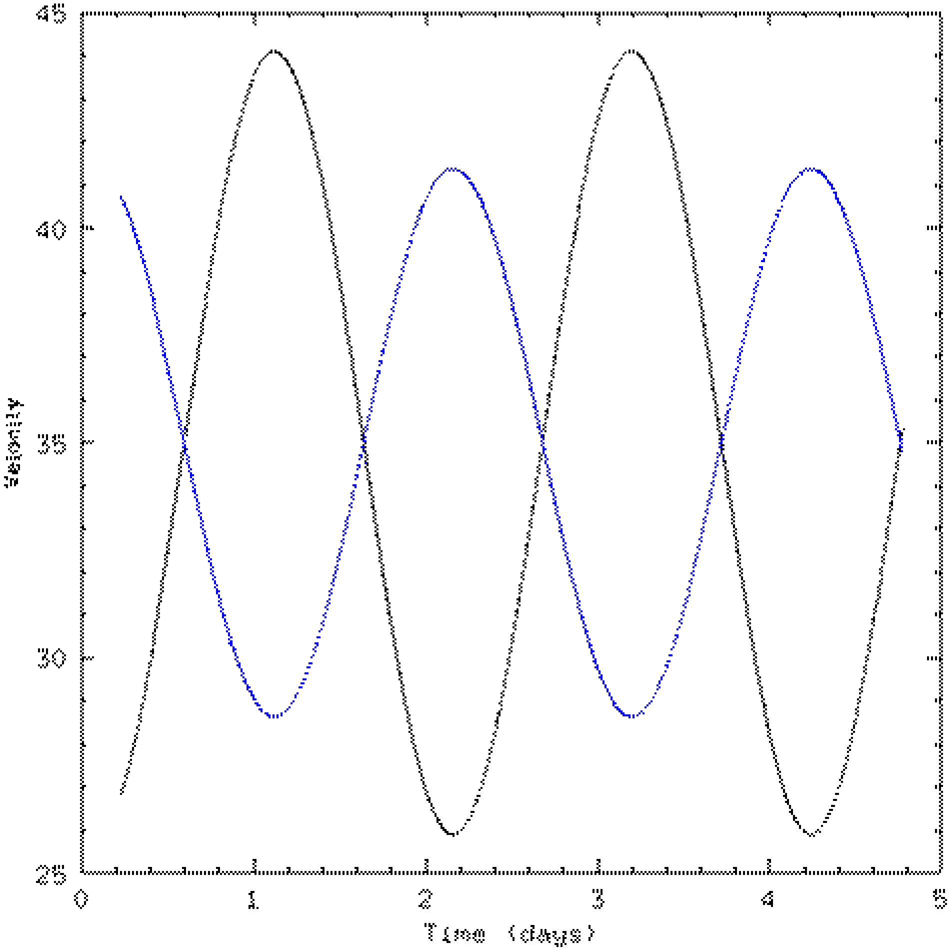

[PROXIMA CENTAURI]
SPECTRAL CLASS M5VE | 4.13 LY
Centauri, is of spectral class M5Ve(12)
or M5VIe, suggesting this is either a
small main sequence star (Type V) or
[AEPHA CENTAURI B]
SPECTRAL CLASS K1 V | 4.39 LY
secondary, slightly smaller and less
luminous than our Sun. This main sequence
star is of spectral type of K1 V,(4)(12)
[ALPHA CENTAURI A]
ACA | SPECT. CLASS G2 V | 4.4 LY
of the binary system, being slightly larger and
more luminous than our Sun. It is a solar-like
main sequence star with a similar yellowish-white
color, whose stellar classification is spectral
type G2 V.(12) From the determined

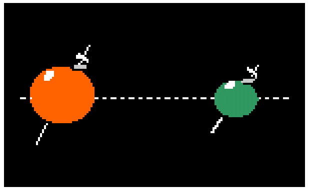


Castor System
Castor Cb
Castor Ca
Castor Bb
Castor Ba
Castor Ab
Castor Aa

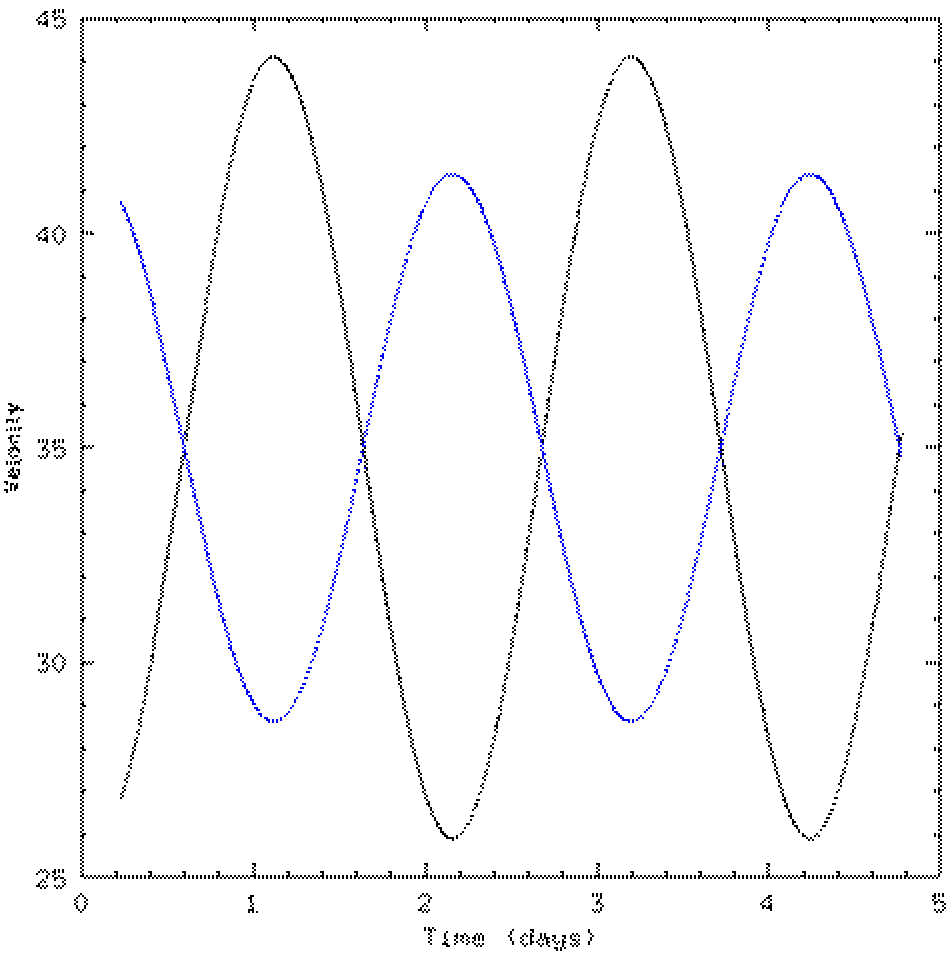
If both stars are measured, it might look more like this.

Why does one star wobble more than the other?





Because the blue track is for a star with slightly more mass than the black track. The star with the most mass moves the least.



So in this case, Doppler shifts give us mass.

This is important! The *only* way we can determine masses of stars (besides our Sun) is from binaries!