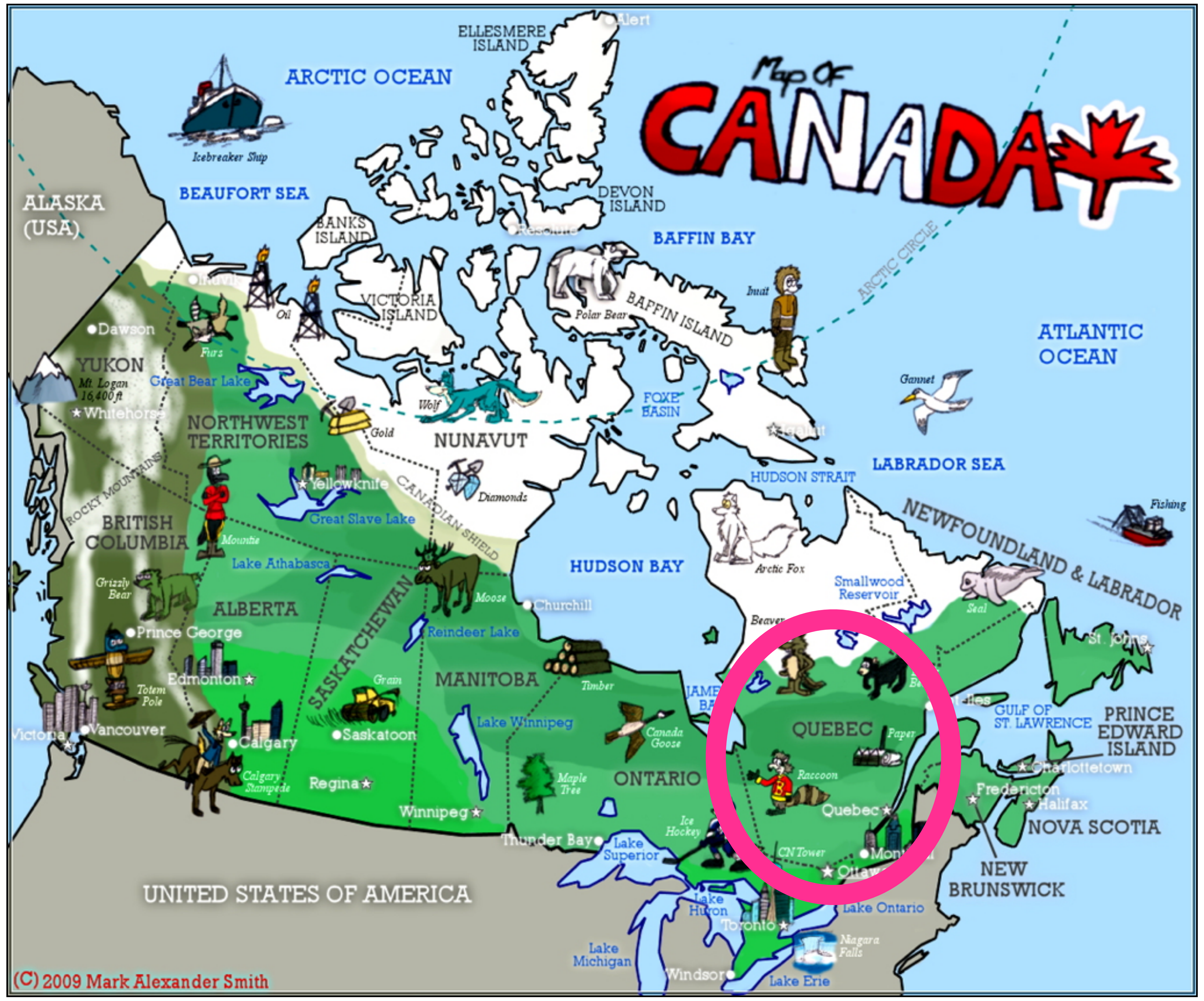
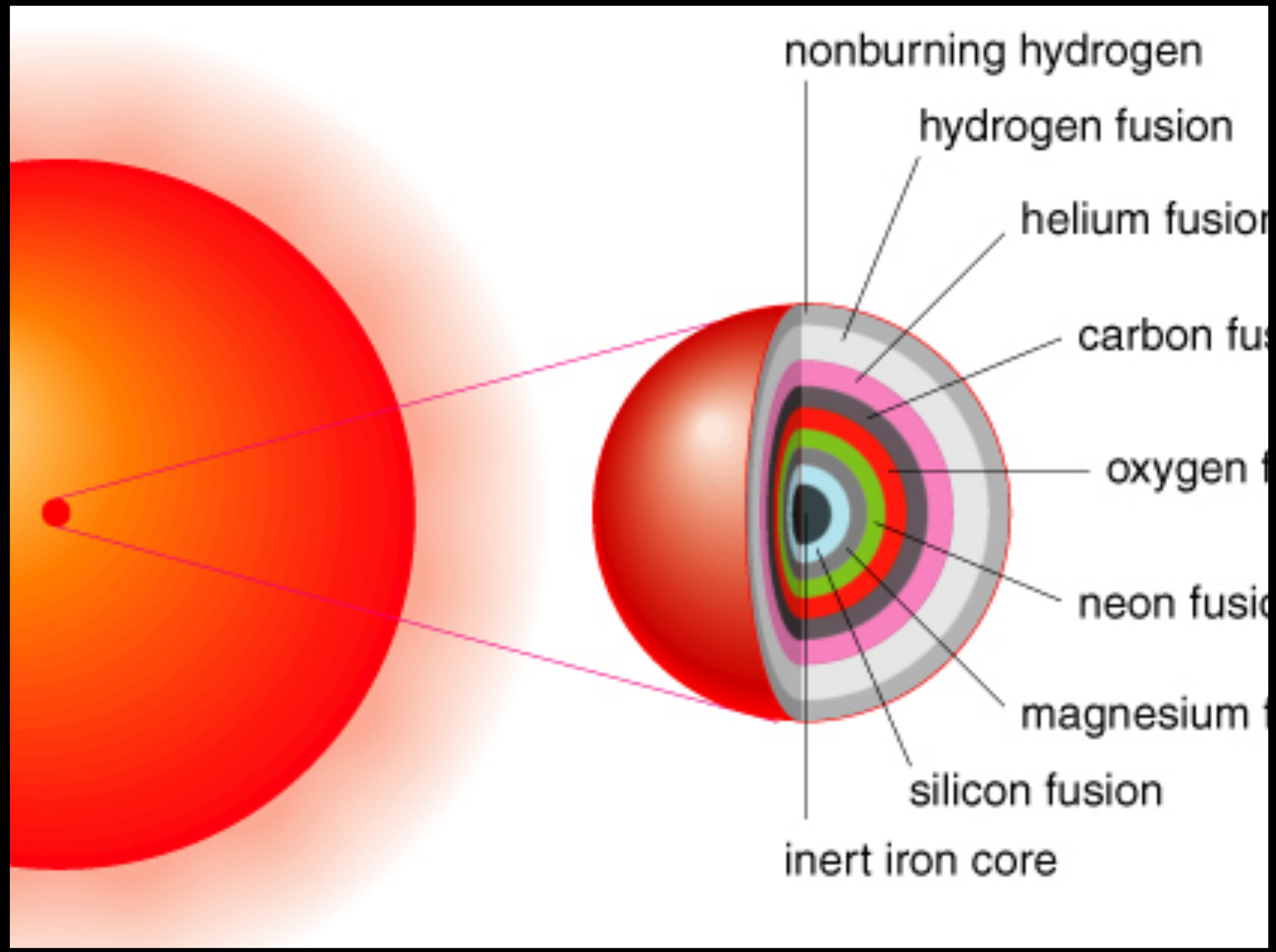
Week 1 Tuesday
L-1
Timescales

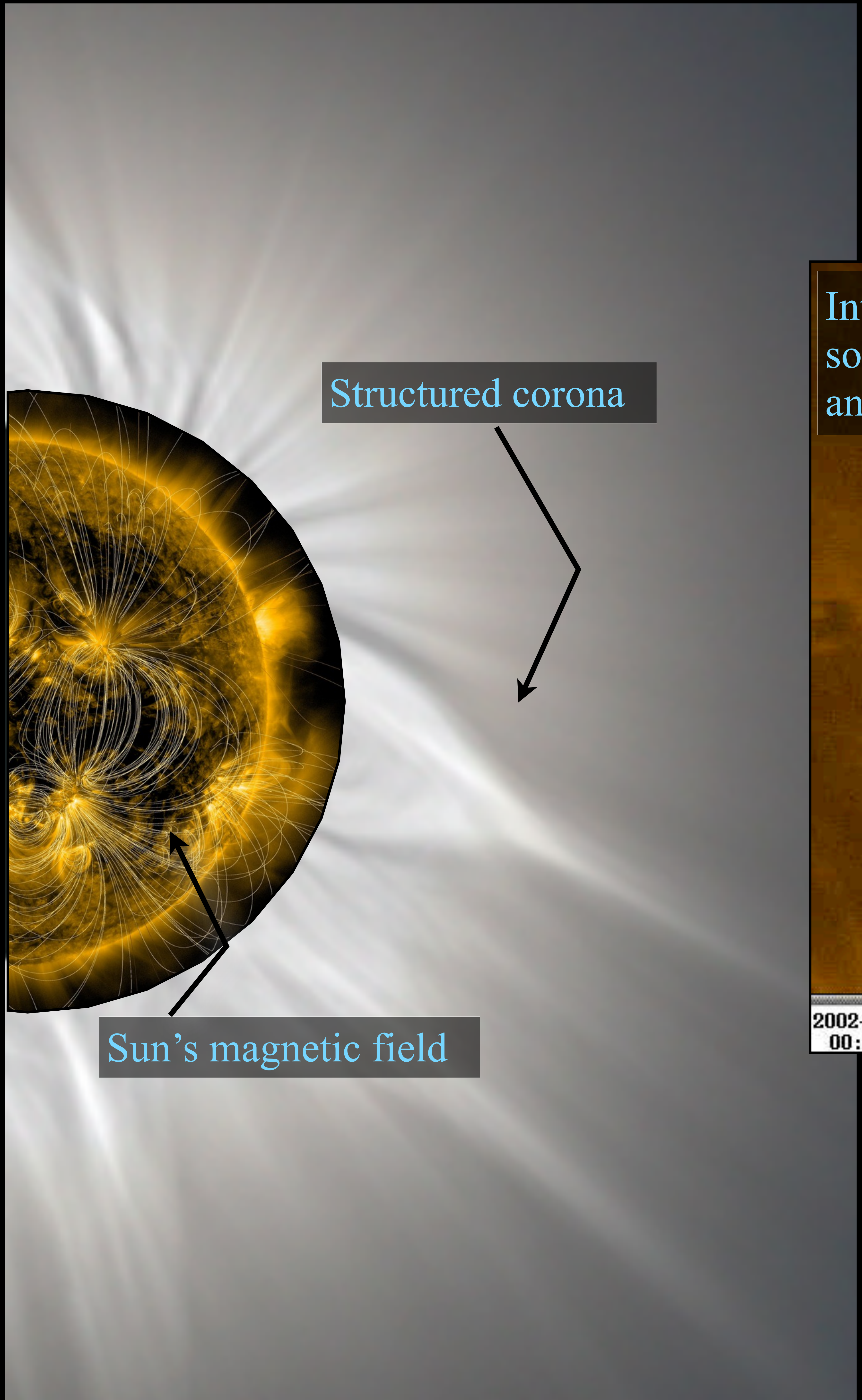
A little bit <canadian> about </canadian> me

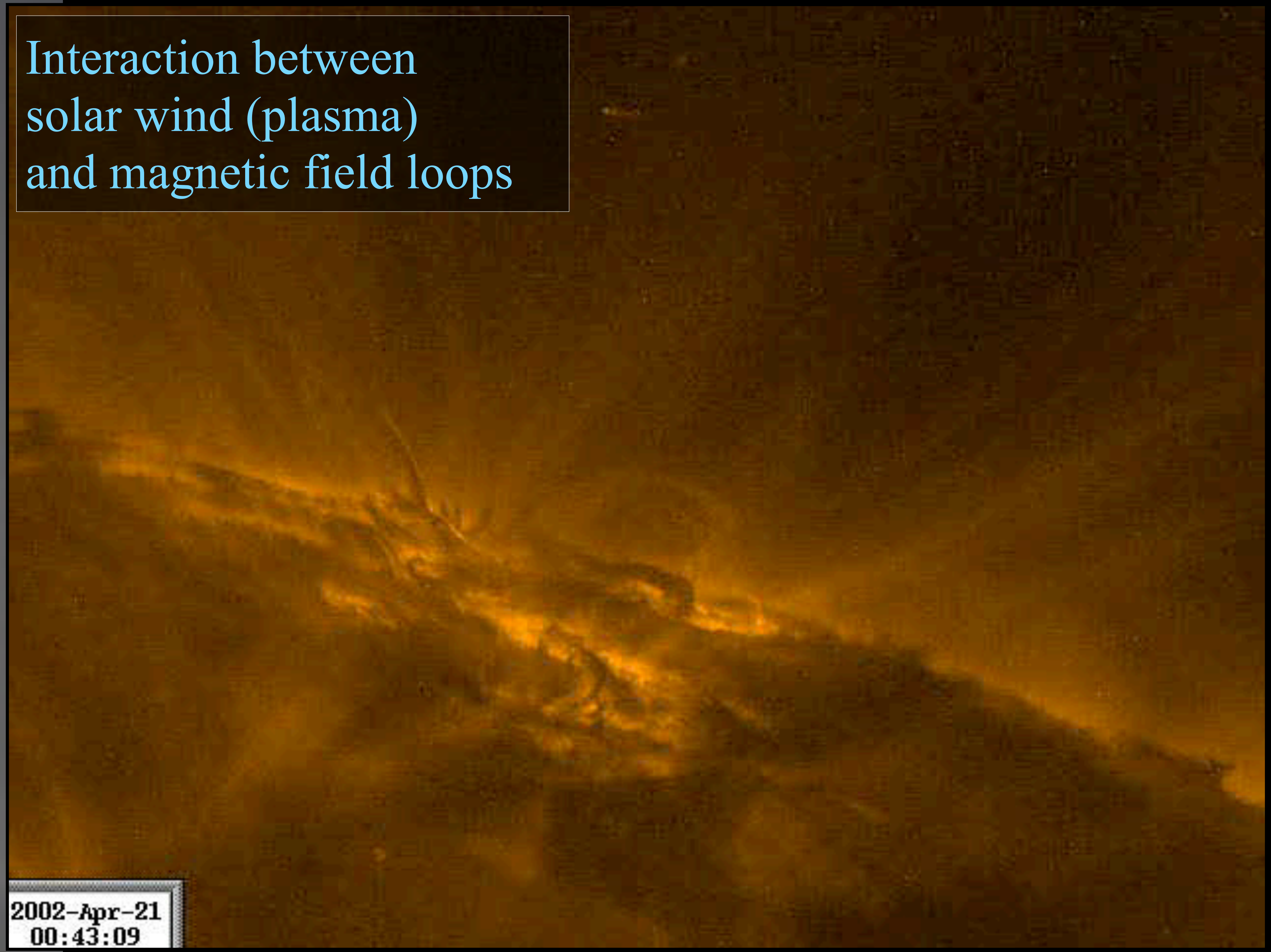



Hot, massive stars in the
star forming region 30 Doradus




The Crab supernova remnant


Structured corona
Sun’s magnetic field


Interaction between
solar wind (plasma)
and magnetic field loops
2002-Apr-21
00:43:09

Scientific goals of this course

Use **physics** to describe the structure and evolution of stars

- How are various properties (such as density, pressure, temperature, etc) distributed inside a star? How can we figure this out?
- If we take a star of a certain — say mass — what will the surface properties will be like? How can we figure this out?
- What happens to a star as time goes by? How can we figure this out?

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Skills goals of this course

Practice applying fundamental physics concepts to a new context

Practice science computing, including numerical calculations and graphs

Practice producing deliverables (papers, reports, etc)

My role: Keep your eyes on the price

Before class

Review of concepts

Readings

In class

Lecture

Notebook

Outside of class

Complete notebook

Additional assignment

Your portfolio

Textbooks

Policies

Code of conduct

Grades

Etc..

-> On the webpage

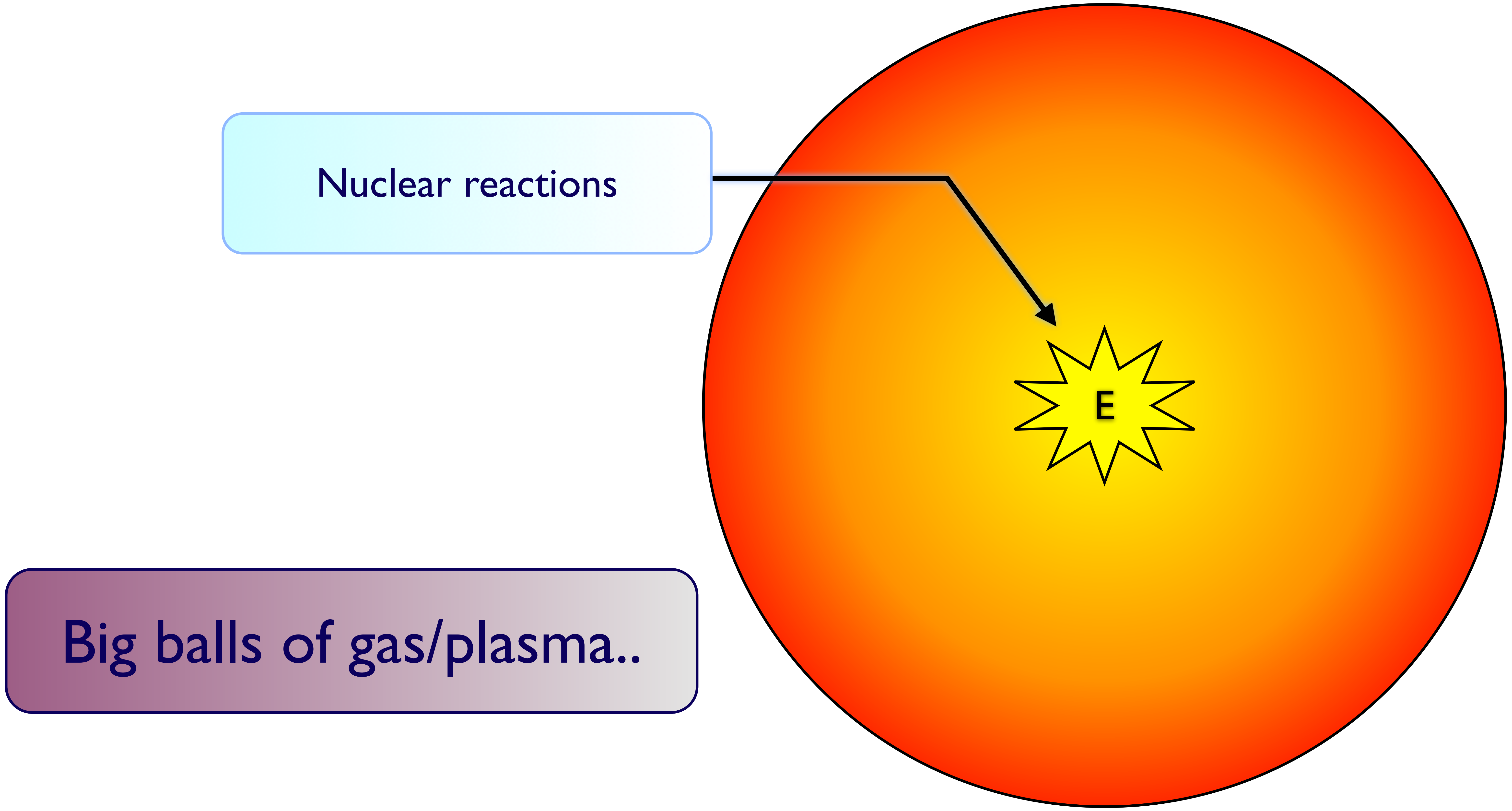
What is a star ?

Reading assignments scattered throughout the course:

We will come up with a list of the physical properties of stars **that are measurable**.

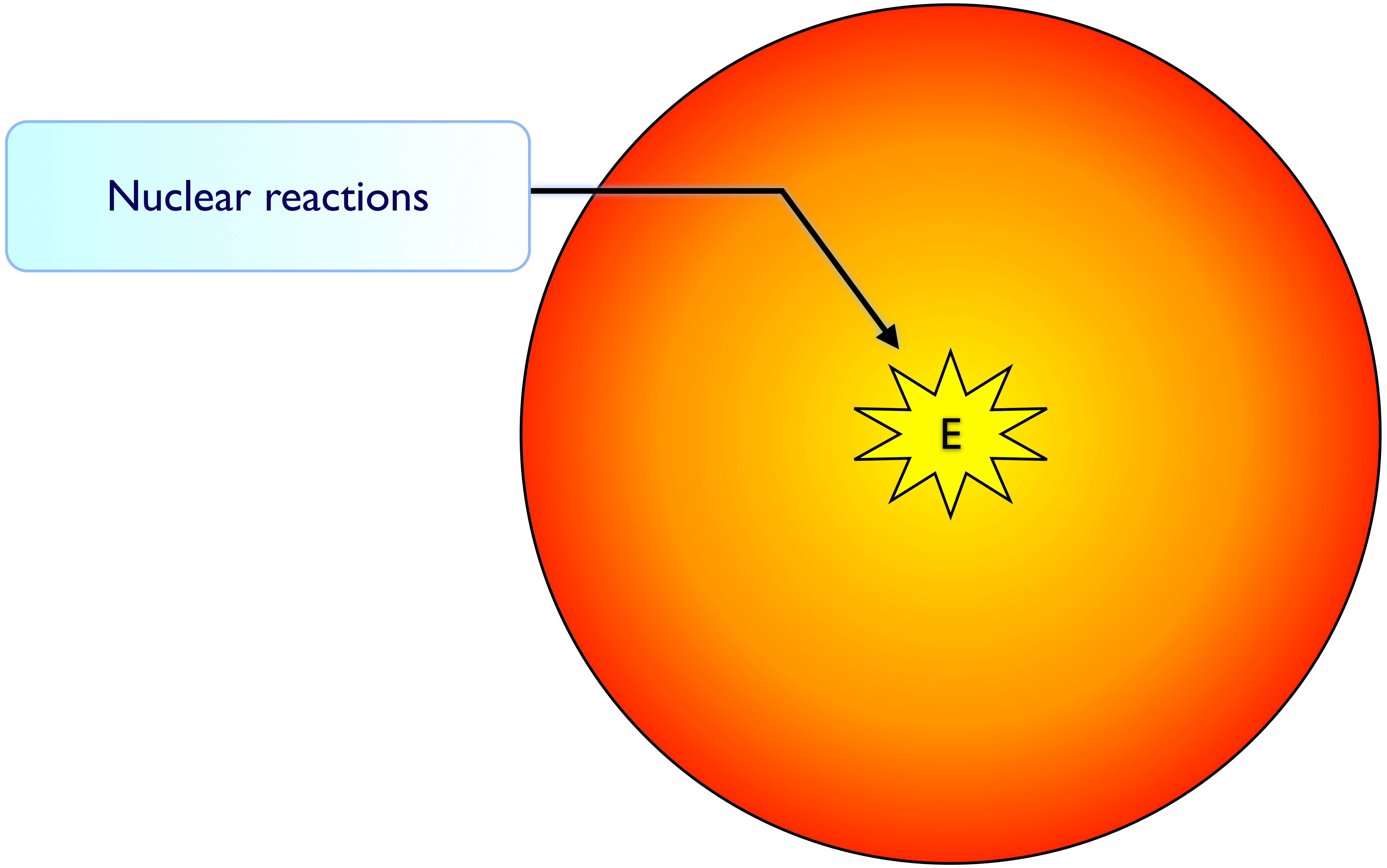
A star is:

Self-gravitating celestial object, in which there is, or once was, sustained **thermonuclear fusion** of hydrogen in their core.

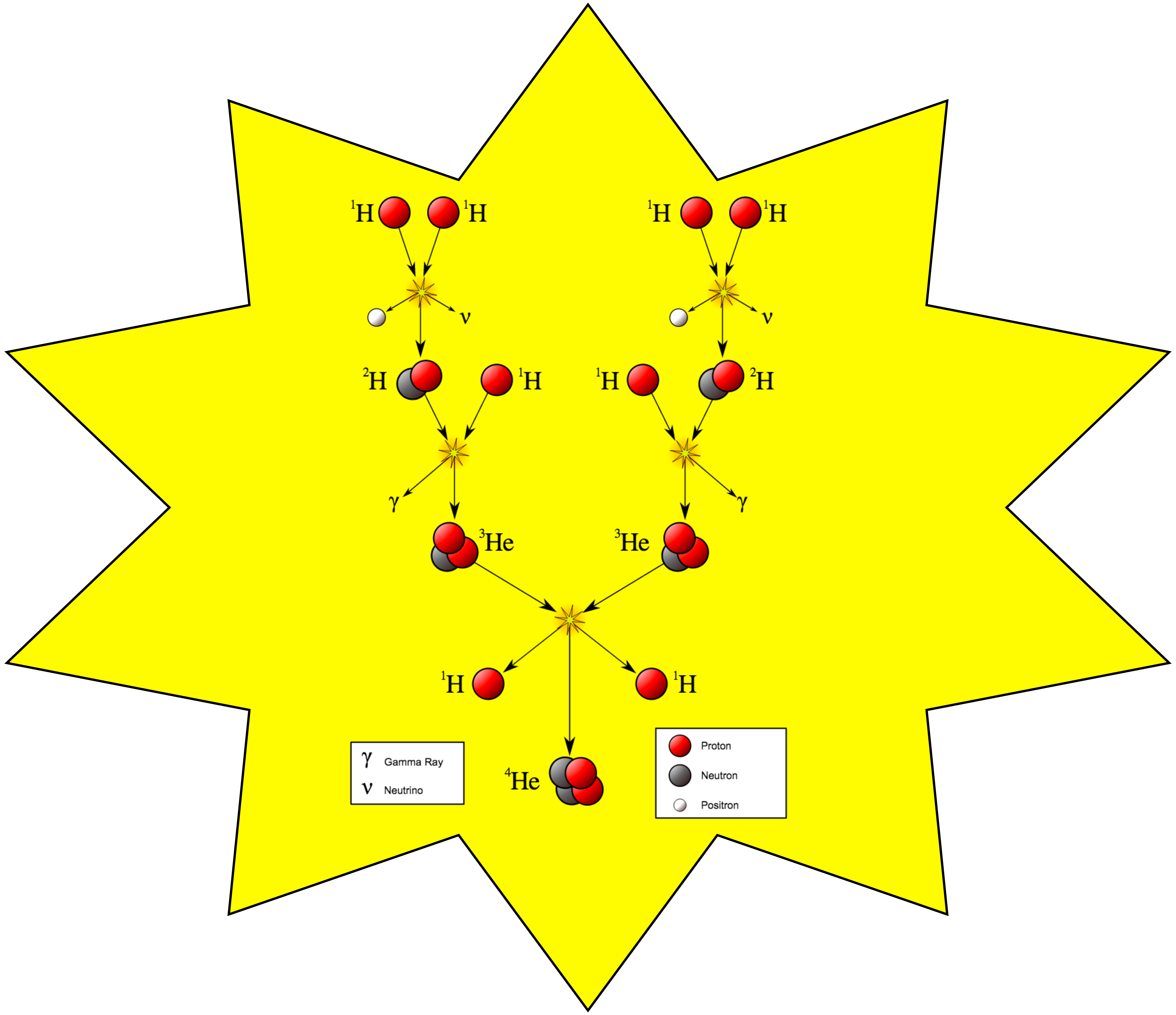


$4\ {}^{1}H \rightarrow {}^{4}He + \text{energy}$

Nuclear physics



$$4\ {}^1H \rightarrow {}^4He + \text{energy}$$

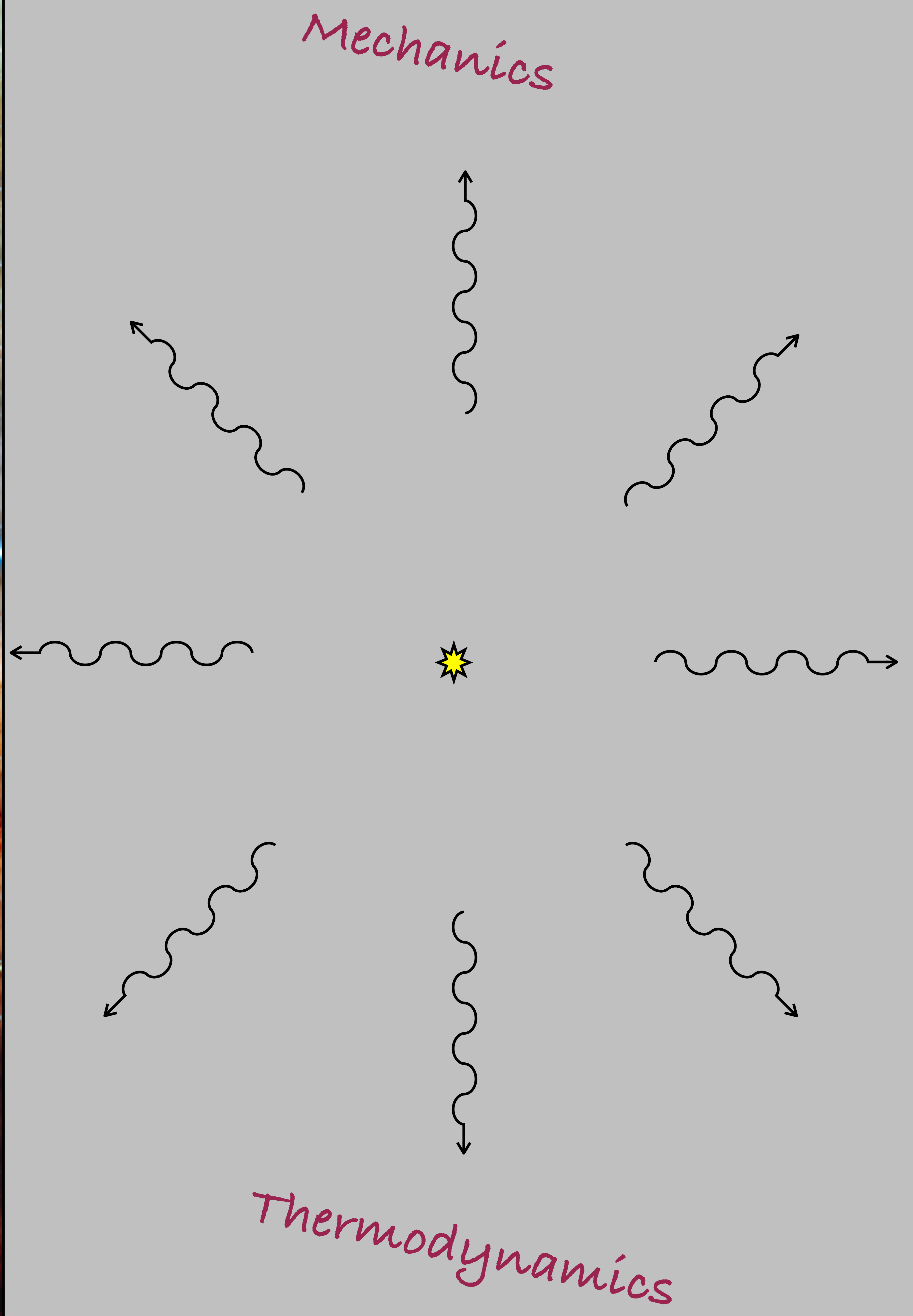


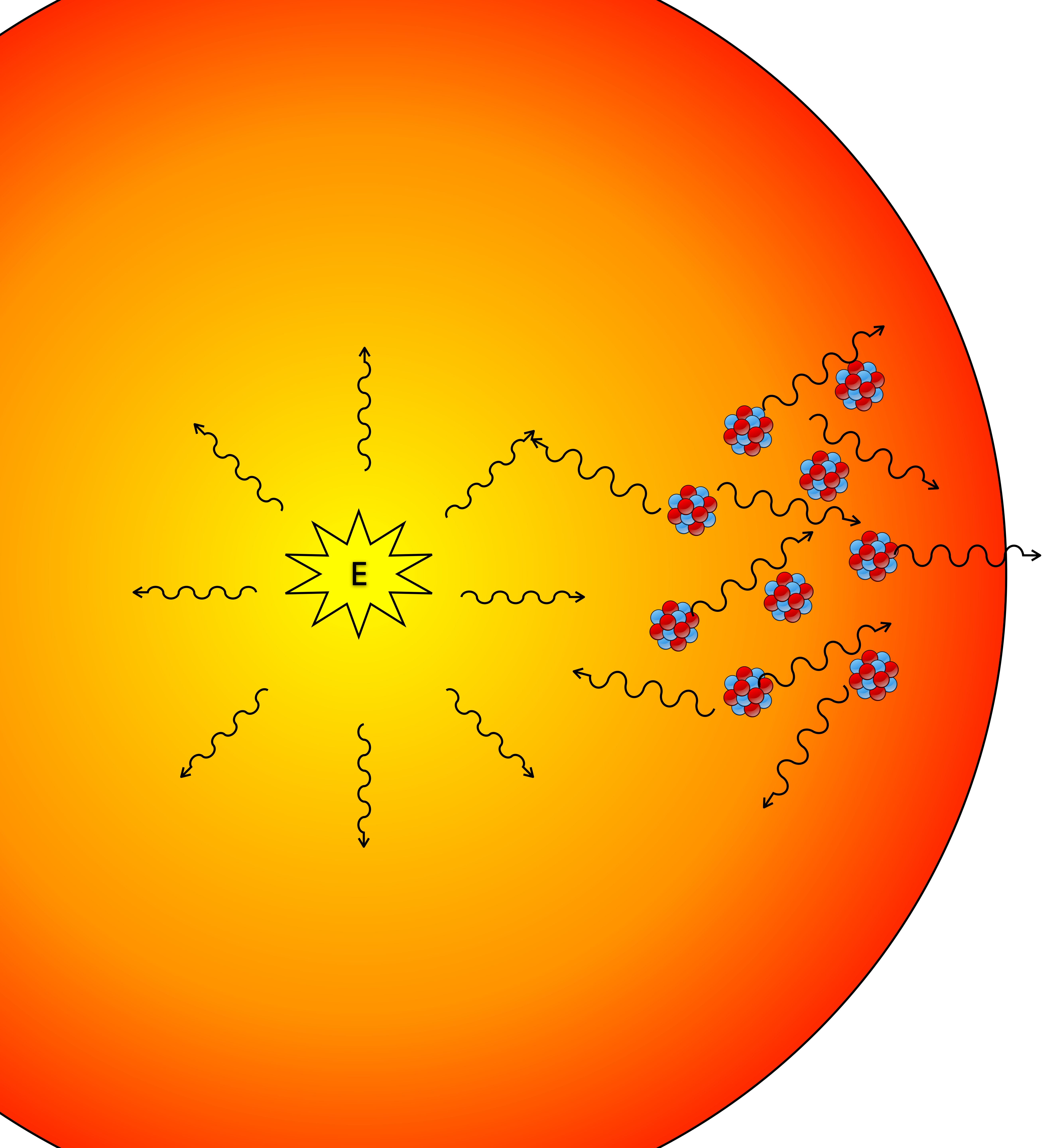
Nuclear physics

Electromagnetism

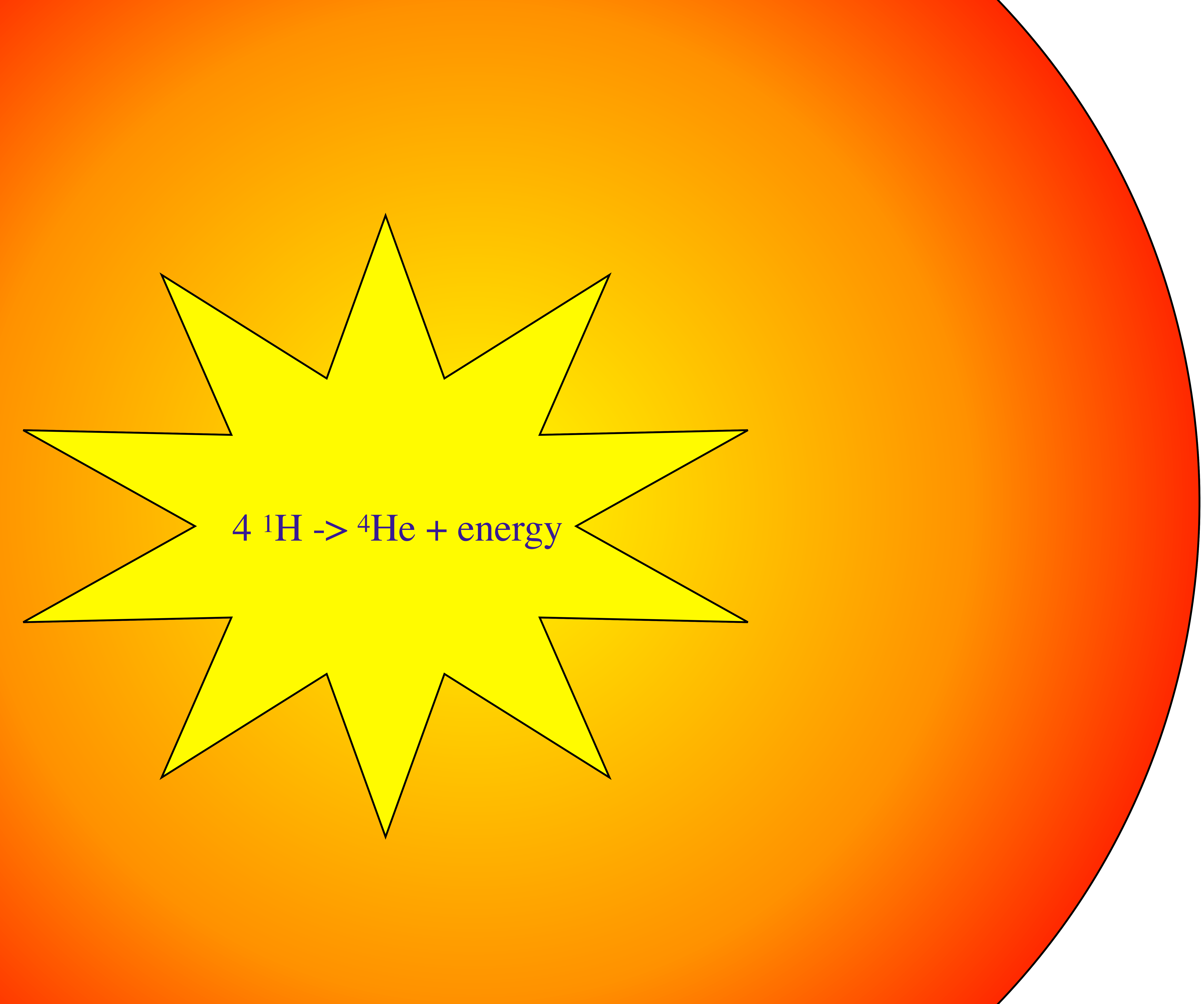
Quantum

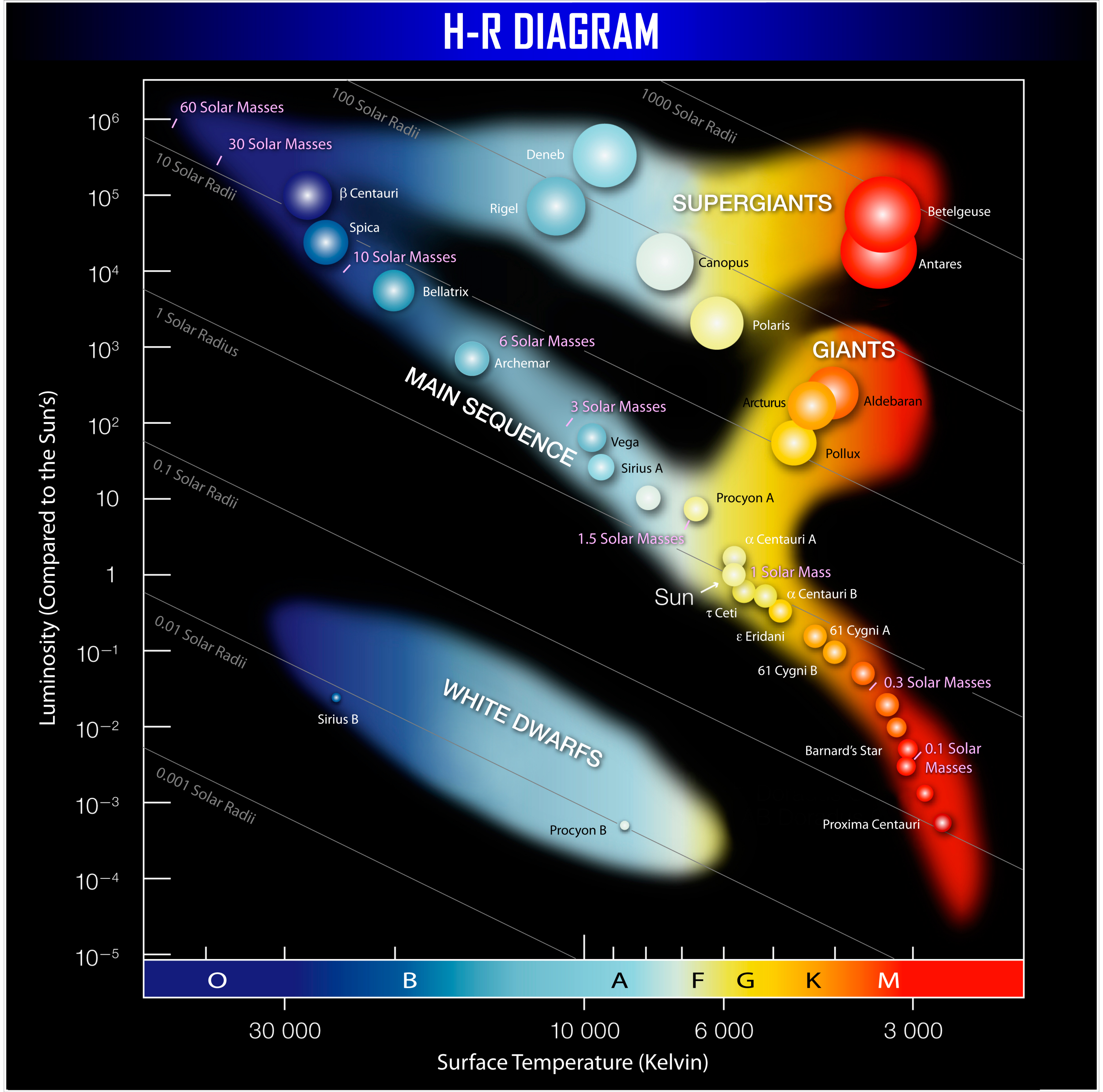

Gravitational collapse

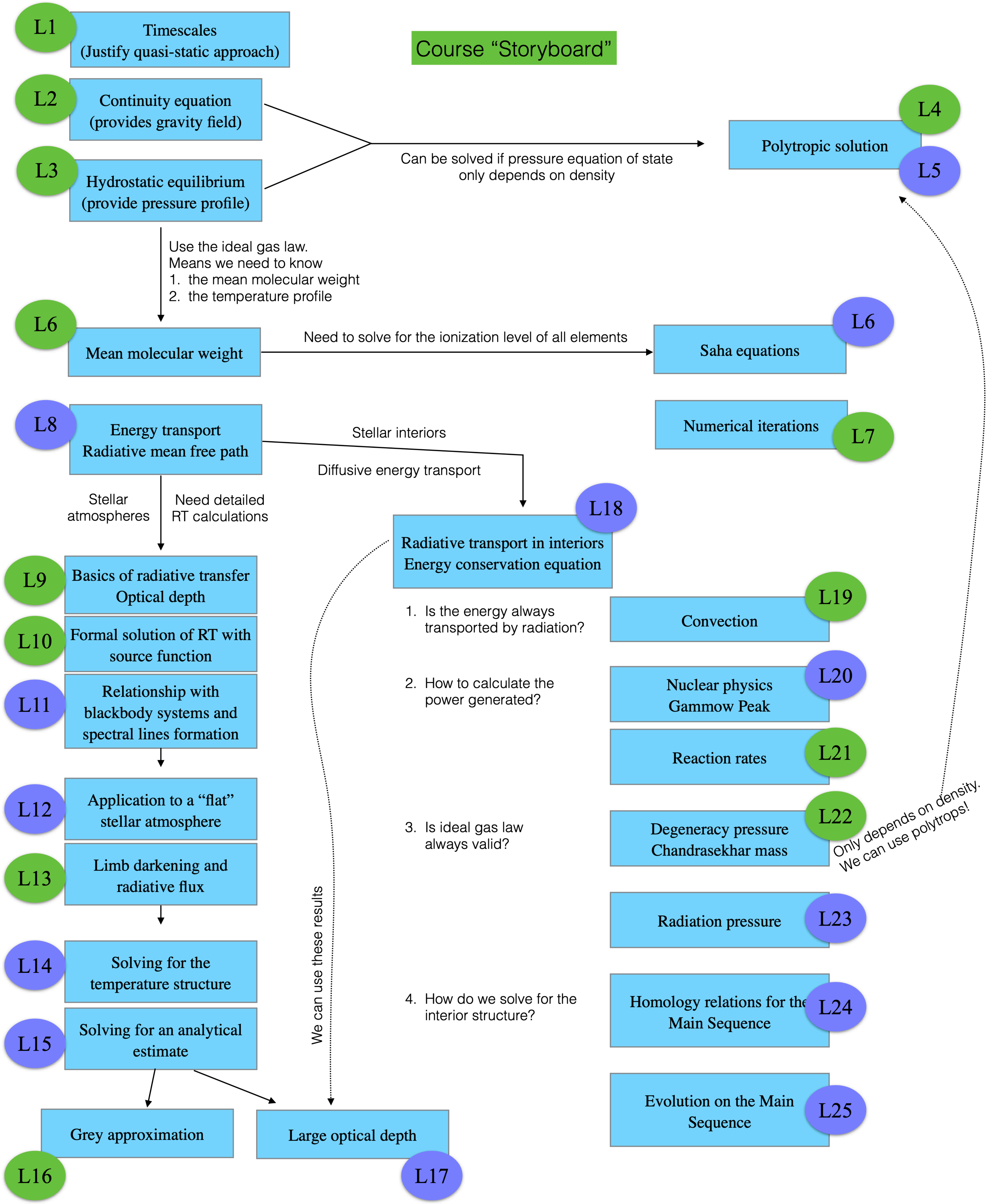

Mechanics
Thermodynamics



Radiative Transport


4 ^{1}H -> ^{4}He + energy


H-R DIAGRAM
Luminosity (Compared to the Sun's)
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Surface Temperature (Kelvin)
30 000
10 000
6 000
3 000
O
B
A
F
G
K
M
10 Solar Radii
100 Solar Radii
1000 Solar Radii
1 Solar Radius
0.1 Solar Radii
0.01 Solar Radii
0.001 Solar Radii
60 Solar Masses
30 Solar Masses
10 Solar Masses
6 Solar Masses
3 Solar Masses
1.5 Solar Masses
1 Solar Mass
0.3 Solar Masses
0.1 Solar Masses
SUPERGIANTS
GIANTS
MAIN SEQUENCE
WHITE DWARFS
Deneb
Rigel
β Centauri
Spica
Bellatrix
Archemar
Canopus
Polaris
Betelgeuse
Antares
Arcturus
Aldebaran
Pollux
Vega
Sirius A
Procyon A
α Centauri A
Sun
τ Ceti
α Centauri B
ε Eridani
61 Cygni A
61 Cygni B
Barnard's Star
Proxima Centauri
Sirius B
Procyon B



The whole course in a nutshell!
(Posted on website)

Set of equations for interior

Continuity equation

$$\frac{dM_r(r)}{dr} = 4\pi r^2 \rho(r)$$

Hydrostatic equilibrium

$$\frac{dP(r)}{dr} = -\rho(r)\frac{GM_r(r)}{r^2}$$

Radiative energy transport

$$\frac{dT(r)}{dr} = -\frac{3\kappa_R(r)\rho(r)}{64\pi\sigma}\frac{L_r(r)}{r^2 T^3(r)}$$

(Or = to convection transport)

Energy source

$$\frac{dL_r(r)}{dr} = 4\pi r^2 \rho(r)\epsilon(r)$$

$M_r(r)$ $P(r)$ $L_r(r)$ $T(r)$

$\rho(r)$ $\mu(r)$ $\epsilon_{\rm nuc}(r)$ $\kappa_R(r)$

comp

Is a very slow function of time…

Ideal gas law

$$P(r) = \frac{\rho(r)}{\mu(r) m_H} kT(r)$$

(Or = to degeneracy pressure)

Mean molecular weight

$$\mu(r) = f(\text{comp}, T(r), P(r))$$

Mean Rossland opacity

$$\kappa_R(r) = f(\text{comp}, T(r), P(r))$$

Nuclear rates

$$\epsilon_{\rm nuc}(r) = f(\text{comp}, T(r), P(r))$$

Timescales

Where does the energy come from?

Luminosity (energy lost by the Sun per second)

$L_\odot \sim 10^{26}$ joule/s (or watts)

On the board: calculating the life-time of the Sun (considering that it loooses 10^{26} joules per second through radiation) if:

* the Sun was powered by chemical reactions?
* the Sun was powered by gravitational contraction? (Kelvin-Helmholtz timescale)
* the Sun was powered by nuclear reaction? (Nuclear timescale)

On the board: How quickly would a star readjust its structure if something was to change? (Hydro timescale)

==> Conclusion: Quasi-equilibrium system.