20150302 - 1

Lecture I : EOS

Reading ($KW^2 12$)

§ 4.1-4.3, 8.1, 13, 15, 16

Optional §14 (ionization)

Goal: • Being able to build stellar model
• compute stellar evolution

→ need to know relevant physics
→ need to know simple analytic solutions so we can check model

• build simple stellar model (Lane-Emden)
• use stellar evolution code to run own models

Q: What would you do to make a model of a star?
When do you start?

EOS

What is EOS?

→ COMPOSITION + indep. Variables
  (E.g. T, ρ – intensive quantities)
  give: P, E, ...

What do we have to consider?

- GAS (ideal, degenerate)
  Q: what gases (Ions, electrons, ...?)
  composition

- Radiation

But: Change of Composition due to

- ionization
- nuclear reactions
  → strong, weak forces
  [what does each do?]

chemical or nuclear equilibrium

Q: how are these important for EOS
Do they change EOS?
→ can be incorporated in EOS
Q: what does this mean?
How to do?

Many components ... how do they combine?

<u>Example</u> Total Pressure

Simple case: $\sum P_i = P_{TOT}$

Partial pressures

[is this always so?]

Q: What parts do/can we study separately? how do we best divide things?

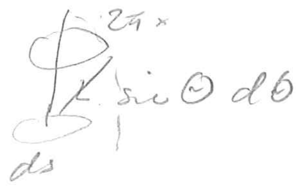
Typical Case:

$$P = P_{RAD} + \underbrace{P_{IONS} + P_{e^-}}_{P_{gas}}$$

Similar for E:

$$E = E_{RAD} + \underbrace{E_{IONS} + E_{e^-}}_{E_{gas}}$$

PRESSURE



1) fraction of particles hitting ds a angle Θ:

$$\frac{2\pi \sin\Theta \, d\Theta}{4\pi} = \frac{1}{2}\sin\Theta \, d\Theta$$

4π ← all possible directions

2) change in momentum

$$dp = 2 \cdot \cos\Theta \cdot p = 2 p_\perp$$

3) rate at which particles hit surface

$$\text{rate} = \cos\Theta \cdot v(p)$$

$$\rightarrow \quad P = \underbrace{\int_0^{\pi/2} 2 \cdot \cos\Theta \cdot \frac{1}{2}\sin\Theta \cdot \cos\Theta \, d\Theta}_{1/3} \cdot \int_0^{\infty} n(p) \cdot v(p) \cdot p \, dp$$

$$n(p): \frac{\#\,\text{Particles}}{\text{Volume} \times dp}$$

↑ $(p, p+dp)$ interval

Energy density:

Similar ...

Energy of particle with momentum p

$$u = \frac{1}{S} \int_0^\infty n(p)\, \mathcal{E}(p)\, dp$$

Q: why do we integrate over p not v?

(think: specific cases!)