20170227-0-

POLICY:
- Respect others
- Always ask if you can't follow
- help answer questions using your own words
- Do not disturb class with non-class related business

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Lecture I: EOS

Reading (KWW 2012)

§§ 4.1-4.3, 8.1, 13, 15, 16

optional § 14 (ionisation)

Goal:
- Being able to build stellar model
- Compute stellar evolution
- Understand nuclear burning phases
  - which occur in what stars where and when

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

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

Q: what would you need to make a model of a star?

→ where do we start?

- UNDERstand physics governing evolution of stars

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Equation of State (EOS)

What is EOS?

→ composition + independent variables

E.g.: T, ρ — intensive quantities

→ give P, E, ...

[Q: how many and which variable do we need?

- What [constituents] do we have to consider?
  - Gas: ideal, degenerate, relativistic

    Q: what gases [Ions, electrons, ...

    → composition ? [virt. particles]
  - Radiation

But: change of composition due to
  - ionisation
  - nuclear reactions

  → strong, weak forces [Q: What does each do?

- chemical or nuclear equilibrium

Q: Do they change EOS? How important for EOS?

...

→ can be incorporated in EOS

Q: what does this mean? How to do, when?

[A: change fast compared to external evolution]

→ EOS has many components...

How to combine?

EXAMPLE: Total Pressure

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

positive pressures!

Q: is this always so [NO]

Q: which pieces should/can we study separately?

How do we best divide things up?

Typical case (relevant under not too extreme conditions)

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

Q: Do you know terms for certain conditions?

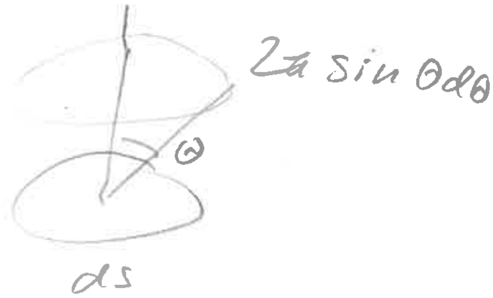
Similar for E

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

But let's dive in detail...

Pressure

$n(p) = \frac{\#\text{ particles}}{\text{Volume} \cdot dp}$



1) fraction of particles at 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 (= momentum transfer)

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

3) rate at which particles hit the surface

$$\text{rate} = \cos\Theta \; v(p) \cdot n(p) \, ds$$

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

$$\boxed{P = \frac{1}{3} \int_0^\infty n(p) v(p) p \, dp}$$

Q: why do we use p as variable for integration? [not v] [consider specific cases]

Energy density

Similar, but energy is scalar not vector
→ no geometric factor from projection

$$u = \frac{1}{\rho} \int_0^\infty n(p)\, \varepsilon(p)\, dp$$

↑ specific internal energy

↑ energy of partical with momentum p

Q: what would be formula for $\varepsilon(p)$ for specific cases?

Q: and for $n(p)$?

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