Physics of Stars 2021/2022

Practise Exam (real exam will be 40% of grade)

date - before exam

Important Notes.

- You are allowed to bring a self-made "cheat sheet" that can cover both sides of one A4.
- No other notes or books, nor are any internet connected devices are allowed.
- Write your name and student number clearly on *all* the pages that you hand in
- Please make sure your handwriting is legible.

The exam consists of 3 questions, and each question is worth 10 points, and the final grade for this exam will be the sum of these points normalised to a mark out of 10.

Tips

- Read all the questions and sub-questions carefully before answering.
- Give concise answers to questions. Answers which look like everything that is known about a subject has been written down without regard to the actual question risk to be penalised.
- If, as the result of a calculation, you obtain values that do not make sense to you, but you can't find the errors, write a comment indicating the order of magnitude of the value you would have expected and why.

1. **Question 1: Stellar Evolution & Nucleosynthesis**

   (a) Why do different mass stars evolve differently?

   (b) Using Figure 1 give the names of the different stellar evolution phases given as red letters for a $1M_\odot$ star, and say in each case what is happening in the core of the star.

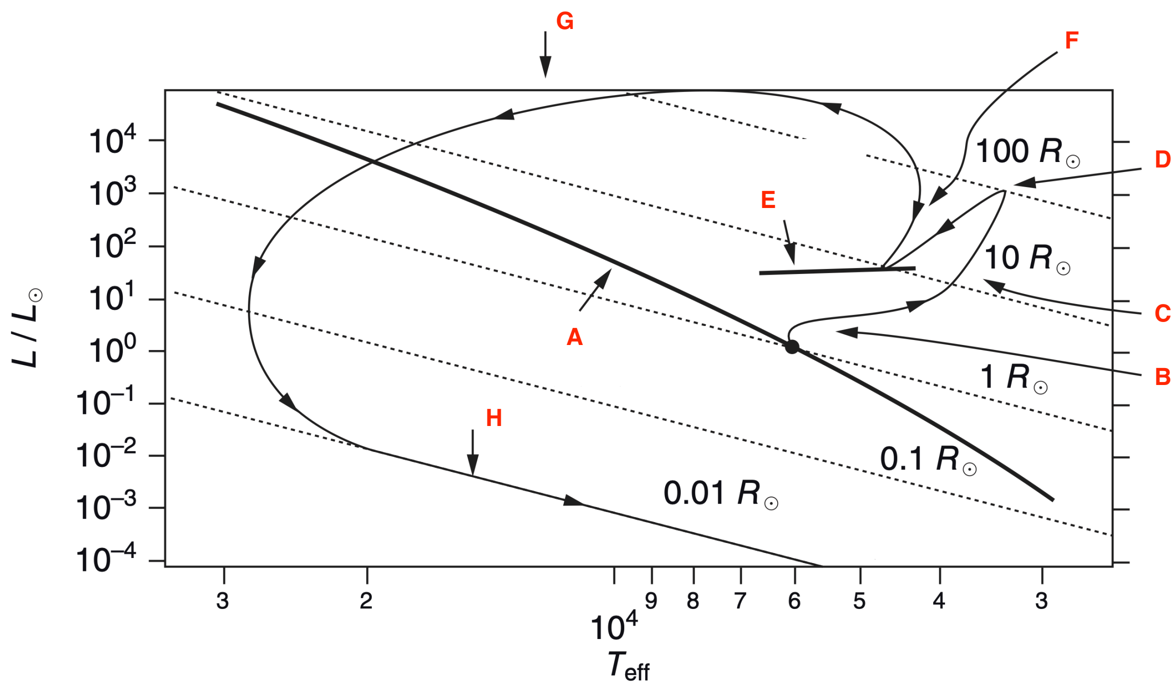

Figure 1: Give the names of the stellar evolution phases given here as letters

   (c) How can chemical elements produced by nuclear burning in a $1M_\odot$ star be expelled into the interstellar medium around the star? which elements could this be?

2. **Question 2: Energy Transport in Stars**

   (a) With the help of the equation given, explain how radiation is typically transmitted from the centre of a star to the surface, what is a fundamental requirement that this can occur?

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

   (b) Use the virial theorem $U = -\frac{\Omega}{2}$, to explain why stars are hot, and so calculate the average temperature inside a star with mass $M_\star$ and radius $R_\star$

   (c) Explain how convection may occur in a star

3. **Question 3: Spectral line formation in a star**
   (a) What is the physical process that leads to the formation spectral lines in stellar spectral?
   (b) What are the major effects that determine the breadth and shape of the resulting spectral lines?
   (c) With the help of sketch, explain what is meant by the equivalent width of a spectral line?
   (d) If the temperature of a stars atmosphere were increasing outwards, what type of spectral lines would be expected in a star's spectrum?

4. **Question 4: Nucleosynthesis**
   (a) Explain the difference between and endothermic and an exothermic nuclear reactions?
   (b) Describe what is happening in the following reaction, the first step in nuclear burning in all stars:

$$^1H + ^1H \quad \rightarrow \quad ^2H + e^+ + \nu_e$$

   (c) How much energy does this generate?
   (d) Which interaction is required for elements heavier than iron be able to be formed, and where can this occur?

Physical constants

Not all are needed for the exam. Be careful that in the study of stellar physics sometimes the same symbol is used with different meanings and thus different definitions or values, so be very careful of the context when looking up symbols here. For example the u used in the equation in question 2 is **not** the same as the u given here.

Constants	Symbol	Value	Units (cgs)
Speed of light	c	$2.99792458 \times 10^{10}$	$\mathrm{cm\,s^{-1}}$
Gravitational constant	G	6.67408×10^{-8}	$\mathrm{cm^3\,g^{-1}\,s^{-2}}$
Boltzmann constant	k	$1.38064852 \times 10^{-16}$	$\mathrm{erg\,K^{-1}}$
Planck constant	h	$6.626070040 \times 10^{-27}$	$\mathrm{erg\,s}$
Mass of electron	m_e	$9.10938356 \times 10^{-28}$	g
Mass of proton	m_p	$1.672621898 \times 10^{-24}$	g
Mass of ^{1}H atom	m_H	1.0078250	u
Mass of ^{4}He atom	m_{He}	4.0026032	u
Atomic mass unit	u	1.660540×10^{-24}	g
		931.5	$\mathrm{MeV/c^2}$

Astrophysical standard values

Constants	Symbol	Value	Units
Parsec	pc	3.0856776×10^{18}	cm
Solar mass	$M_\odot$	1.9891×10^{33}	g
Solar radius	$R_\odot$	6.95508×10^{10}	cm
Solar luminosity	$L_\odot$	3.8458×10^{33}	$\mathrm{erg\,s^{-1}}$
Sidereal year	yr	3.155815×10^7	s