

*Ollscoil na hÉireann, Gaillimh*  
*National University of Ireland, Galway*

*GX 923*

**Semester II Examinations, 2002/2003**

Exam Code(s)	AT300
Exam(s)	3 <sup>rd</sup> Science
Module Code(s)	AT302
Module(s)	Computational Astronomy
Paper No.	
Repeat Paper	Special Paper
External Examiner(s)	Professor E. Kennedy
Internal Examiner(s)	Professor S. G. Jennings
	Professor R.M. Redfern

**Instructions:** Answer THREE questions.

Duration	2 hrs
No. of Answer Books	

**Requirements:**

Handout	<i>A formula sheet and table of physical constants is attached to this paper.</i>
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MCQ	
Statistical Tables	
Graph Paper	
Log Graph Paper	
Other Material	

No. of Pages	4
Department(s)	Experimental Physics

## STELLAR INTERIORS AND EVOLUTION

- Q.1 Write a general essay on stellar evolution. You should include brief accounts of main sequence stellar structure, of evolution to the giant branch and of the final stages of stellar evolution. In particular, you should make clear what is the source of the radiated energy at each stage and indicate how the star is supported against gravity. [10 marks]
- Q.2 (a) Give a brief account of the various mechanisms which contribute to the *opacity* of stellar material. [3 marks]
- (b) State, giving reasons, whether conduction or radiation is more important in transporting energy in main sequence stars. [2 marks]
- (c) Derive an expression for the minimum temperature gradient required for convection to occur in a stellar interior. [5 marks]
- Q.3 (a) Explain what you understand by a degenerate gas. [2 marks]
- (b) In what types of star is matter degenerate? [2 marks]
- (c) Show that the pressure of a non-relativistic, highly degenerate gas is proportional to the density raised to the power 5/3. [6 marks]
- Q.4 A spherical star is in hydrostatic equilibrium. Assume that it is composed of an ideal gas of uniform mean particle mass, that there is negligible radiation pressure, and that the gas pressure vanishes at its surface. Prove the following results:
- a)  $P_c > GM_s^2 / 8\pi r_s^4$  [4 marks]
- b)  $T_{av} > GM_s m / 6kr_s$  [4 marks]

$P$  and  $T$  are the pressure and temperature at radius  $r$ ,  $M$  is the mass contained within radius  $r$ , and the suffixes  $c$  and  $s$  refer to central and surface values.  $T_{av}$  is the mean temperature defined by:

$$M_s T_{av} = \int_0^{M_s} T dM$$

$G$ ,  $k$  and  $m$  are the gravitational constant, Boltzmann's constant and the mean particle mass, respectively.

Use the above relations to determine the minimum central pressure and the minimum mean temperature of the Sun.

[2 marks]

Q.5 (a) Explain carefully the physical principles which determine the nuclear fusion reaction rates in a star's interior.

[5 marks]

(b) Discuss pp-chain, CNO cycles and triple- $\alpha$  reactions, and explain why they are of importance at different stages of a star's evolutionary history.

[5 marks]