Main Facts about the Course

- *Name:* Phys 627, Advanced Thermodynamics and Statistical Mechanics I.
- *Instructor:* Luca Bombelli.
- *Schedule:* Lewis room 1 (astronomy lab), TuTh 11:00–12:15.
- *Website:* `http://www.phy.olemiss.edu/~luca/phys627/`.
- *Textbook:* J Woods Halley *Statistical Mechanics* Cambridge University Press 2007.
- *Other cited books:* D Chandler, *Introduction to Modern Statistical Mechanics*, Oxford University Press 1987; D C Mattis, *Statistical Mechanics Made Simple*, World Scientific 2003; F Reif, *Statistical and Thermal Physics*, McGraw-Hill 1965; F Schwabl, *Statistical Mechanics*, 2nd ed, Springer 2006.

Evaluation

- *Homework:* In principle, a few problems each week; 40% of the total grade.
- *Tests:* Five short, 20-minute quizzes plus a final exam; 60% of the total grade.

List of Lectures

- *Equilibrium Statistical Mechanics:*

01. Introduction to the Course; Review of Probability and Statistics.
02. Introduction to Statistical Mechanics and the Distribution Function.
03. Properties of Distribution Functions; The Microcanonical Distribution.
04. The Canonical Distribution Function.
05. Mixed States in Quantum Mechanics.
06. Quantum Equilibrium Density Matrices.
07. Thermodynamics. 1: Basic Laws.
08. Thermodynamics. 2: Potentials; Equilibrium; Gibbs-Duhem Relation.
09. Thermodynamics. 3: Second-Order Quantities and Relations; Stability.
10. Obtaining Thermodynamics from Statistical Mechanics.

- *Examples of Equilibrium Systems:*

11. Classical Ideal Gas of Pointlike Particles.
12. Quantum Ideal Gas of Pointlike Particles.
13. The Classical Limit of a Quantum Partition Function.
14. The Photon Gas.

[15. The Free Boson Gas and Bose-Einstein Condensation.]
[16. The Free Fermion Gas and Electrons in Metals.]
[17. The Free Quantum Molecular Gas.]

18. The Phonon Gas. 1: General Framework.
19. The Phonon Gas. 2: Einstein and Debye Models.
20. Non-Ideal Gases. 1: The Virial Expansion.
21. Non-Ideal Gases. 2: Classical Approximation and Important Examples.
22. Non-Ideal Gases. 3: Cluster Method for the Virial Expansion.
23. Magnetism. 1: Diamagnetism.
24. Magnetism. 1: Paramagnetism.
25. Magnetism. 2: Ferromagnetism.
26. The Ising Model.

- *Phase Transitions:*

27. The Monte Carlo Method. 1: General Framework.
28. The Monte Carlo Method. 2: Application to 2D Ising Model.
29. Phase Equilibrium.
30. Phase Transitions in Thermodynamics.
31. The Renormalization Group Approach.

- *Non-Equilibrium Statistical Mechanics:*

32. Transport Phenomena.
33. The Fluctuation-Dissipation Theorem.