From the thermodynamics to the statistical mechanics of black holes

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The course will lay out a general review of the thermodynamic properties of black holes implied by their classical description given by General Relativity, of the problems and paradoxes encountered when trying to provide a microscopic explanation of these properties, and of their resolution within String Theory, epitomised by the statistical derivation of the entropy of supersymmetric black holes. Only a basic knowledge of General Relativity and of elementary Statistical Mechanics will be assumed. The use of concepts and techniques from String Theory will be kept to the bare minimum and anyhow introduced from scratch.

Synopsis:

1. Sketchy review of black holes in General Relativity: black hole metrics, horizons, singularities.

2. Energy extraction from rotating black holes, the Penrose process.

3. Surface gravity and the zeroth law.

4. The first law.

5. Area theorems and the second law.

6. Euclidean computation of the black hole entropy (Gibbons-Hawking).

7. A sketch of Hawking radiation.

8. The information paradox.

9. An elementary introduction to black holes in String Theory.

10. The microscopic counting of black hole states (Strominger-Vafa).