Lecturer: Neri Merhav

- **(Recommended) Prerequisite:** Information Theory (048733).
  
  *Comment:* Prior background in statistical physics is not compulsory. The course will be self-contained in the physics backgrounds.

- **Target Audience and Objectives:** The course is aimed at EE grad students in the area of Communications and Information Theory, as well as grad students in Physics who have basic background in Information Theory (in particular, students that graduated the EE–Physics track) The main objective is to expose the student to various aspects of the relationships between Information Theory and Statistical Physics. Accordingly, strong emphasis will be given to the analogy between these two theories, as well as to the insights, the analysis tools that can be borrowed from Statistical Physics to certain problem areas in Information Theory. This research trend has been very active in the last decades, and the hope is to enhance the background and perspective to carry out research in the field.

- **Detailed Syllabus:**

  0. **Introduction:** Objectives and scope of the course.

  1. **Elementary Statistical Physics and its Relation to Information Measures:** What is statistical physics? Basic postulates and the micro–canonical ensemble; The canonical ensemble: the Boltzmann–Gibbs law, the partition function, thermodynamical potentials and their relations to information measures – extension of the method of types; The equipartition theorem; Generalized ensembles (optional);

  2. **Physical Interpretations of Information Measures:** Statistical physics of optimum message distributions; Large deviations and physics of coding theorems; The second law and Shannon limits; Boltzmann’s H–theorem and the data processing theorem; Generalized temperature and the Fisher information.

  3. **Analysis Tools and Asymptotic Methods in Statistical Physics:** The Laplace method of integration; The saddle–point method + examples; Transform methods for counting and for representing non–analytic functions; examples; The replica method – overview.

  4. **Systems of Interacting Particles and Phase Transitions:** Models of many–particle systems with interactions (general) and examples; A qualitative explanation for the existence of phase transitions in physics and in Information Theory; Phase transitions in the rate–distortion function; Ferromagnets and Ising models: The 1D Ising model, the Curie-Weiss model; Randomized spin–glass models and their relevance to coding: Annealed vs. quenched disorder and randomness; Analogies of quenched disorder in random coding in coded communication systems.

  5. **The Random Energy Model (REM) and Random Channel Coding:** Basic derivation and phase transitions – the glassy phase and the paramagnetic phase; Random channel codes and the REM; The posterior distribution as an instance of the Boltzmann distribution, analysis and phase diagrams, implications on code ensemble performance analysis.
6. **Extensions of the REM (optional):** The REM in a magnetic field and joint source–channel coding; The generalized REM (GREM) and hierarchical ensembles of codes; Directed polymers in a random medium (DPRM) and tree codes.

- **Administration:** The moodle site will be used to post lecture notes, homework assignments, instructions + list of papers for critical summary, and messages.

- **Requirements:** Homework assignments (30%) plus a critical summary (70%) on a paper from a given list (plus an oral discussion). Instructions can be downloaded from the moodle site.

- **Bibliography:**


15. Papers from the current literature.

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1Almost identical to the lecture notes of the course: http://webee.technion.ac.il/people/merhav/papers/gcnotes.pdf