

LTCC Basic Applied Course

- Title: **Wave Scattering and Resonances**
- Basic Details:
 - Core Audience: 1st year applied (also of interest to theoretical physics students)
 - Course Format: Extended (10h)
- Course Description:
 - Keywords: Resonances, S -matrix, complex poles, causality and analyticity, dispersion relations
 - Syllabus: Resonance phenomena have their historical roots in acoustics and mechanical vibrations, with numerous applications ranging from electromagnetism and optics to quantum mechanics and particle physics. Many of their key properties can be described within the classical wave equation. The aim of this course is to provide an introduction into the theory of resonant scattering of waves, beginning with classical fields and going over to nonrelativistic quantum scattering. Basic concepts of resonances are first introduced using model examples and then extended to a more general setting. An emphasis is placed on the connection between causality and analyticity of S -matrix, and on dispersion relations arising.
Topics to be covered include:
 - I. Damped harmonic oscillator, complex frequency plane, Green's function and causality
 - II. Classical resonance scattering, dispersion relations and Titchmarsh's theorem, applications
 - III. S -matrix: analytic properties, causality condition and Blaschke product expansion
 - IV. Quantum scattering in cutoff potentials, resonances and unstable states
 - V. Elements of R -matrix theory, complex poles and relation to non-self-adjoint operators
 - Prerequisites: Knowledge of the theory of analytic functions, differential equations. A course in quantum mechanics is desirable but not essential.
- Recommended reading:
 - H.M. Nussenzveig, *Causality and Dispersion Relations* (Academic Press, 1972)Optional reading (for more abstract and formal mathematical scattering theory):
 - M. Reed and B. Simon, *Methods of Modern Mathematical Physics*, Vol. 3 (Academic Press, 1979)
 - D.Yafaev, *Scattering Theory: Some Old and New Problems*, Lec. Notes Math. **1735** (Springer, 2000)
- Format:
 - No. of discussion/problem sheets: 4
 - Electronic lecture notes: yes
 - Necessary support facilities: None
 - Necessary software requirements for computing facilities: None
- Lecturer details:
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