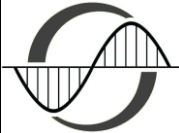




UNIVERSITÀ
degli STUDI
di CATANIA



DIPARTIMENTO DI FISICA E ASTRONOMIA
“ETTORE MAJORANA”

DOTTORATO DI RICERCA IN FISICA
CICLO XLII A.A. 2026/2027

TITLE

Non-equilibrium quantum field theory

CFU 2 (14 hours)

Teaching staff

Name Surname: Giuliano Chiriaco

Email: giuliano.chiriaco@gmail.com

Office: 216

Reception hours: Monday 15-18, Wednesday 15-18

Program of the course:

Review of Green's functions. Differences with equilibrium Green's functions, Keldysh contour. Advanced, retarded, Keldysh components of the Green's function. Kinetic equation formulation. Langreth rules.

Keldysh action formulation and path integral formalism. Equivalence of the two approaches. Examples: polarization bubble for electrons.

Perturbation theory in the Keldysh formalism. Feynman diagrams, self-energy, Dyson equation. Application to case studies (electron-phonon interaction).

Quantum kinetic equation, recovery of the Boltzmann kinetic equation.

Optional topics (depending on timeframe). Application of Keldysh Green's functions: non-equilibrium superconductors, disordered conductors. Gauged quantum kinetic equation, simple cases. Derivation of the Caldeira-Leggett equation. Keldysh formulation of the Lindblad equation.

Bibliography:

A. Kamenev, *Field Theory of Non-Equilibrium Systems*, Cambridge University Press, 2nd edition (2023).

H. Haug, A-P. Jauho, *Quantum kinetics in transport and optics in semiconductors*, Springer (2008).

J. Rammer, *Quantum Field Theory of Non-equilibrium States*, Cambridge University Press (2007).