# Quantum Field Theory I+II: Fall 2017/Spring2018

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**Office Hours: W-F 4:15Pm--> 5:00 Pm, or by appt.**

Basics of field quantization: from particles to fields, from fields to particles. Lagrangian and Hamiltonian dynamics: Euler-Lagrange equations, Poisson brackets. Field quantization: Elastic waves: phonons, the continuous string: a scalar field. Quanta as particles. Relativistic QFT: brief review of special relativity. Lorentz transformation laws for fields. Causality. The relativistic string and scalar field theory (the Higgs) Fock representation. Symmetries and conservation laws: Noetherôs theorem, the energy momentum tensor, conserved currents. The Lorentz and Poincare groups: spin. Microscopic causality and commutators. Greenôs functions: advanced, retarded and Feynman. Uses (and abuses). The complex Klein-Gordon field: a global gauge symmetry. Quantized electromagnetic field: photons: (spin 1) gauge invariance, physical degrees of freedom, microscopic causality and propagators. Particle production by external sources. The massive vector field (Proca) (W,Z gauge bosons) the propagator. Effective field theory. Minimal coupling to charged fields and gauge invariance.

Dirac field: Dirac equation, non-relativistic limit, minimal coupling and correct gyromagnetic factor. Spin ½. Helicity. Quantization, Anti-commutators: the Pauli exclusion principle. Spin statistics connection. Antiparticles. Propagators.

Interlude: Second quantization of the Schroedinger field: bosons and fermions, non-relativistic limits of the (complex) Klein Gordon and Dirac fields. Interacting fields discrete symmetries, parity, charge conjugation and time reversal, intrinsic parity. PCT theorem. Weyl and Majorana fermions. P and C violation in weak interactions: the Co60 expt. S-matrix. Feynman diagrams/calculus: Wickôs theorem. Cross sections and decay rates: examples. Unitarity. Disconnected (vacuum) diagrams Quantum electrodynamics: elementary processes: cross sections: Casimir ``trickôô Self-energy corrections, Dyson series and resummation: effective propagators. Examples. Resonances: Breit-Wigner propagators and resonant cross sections. Interpretation of the time evolution. Loops: scalar field theory, regularization: dimensional regularization. Renormalization in QED: Ward identities, dimensional regularization, g-2, Lamb shift effective running coupling: screening. Dressed electrons. Renormalized perturbation theory: counterterms. Dressing by virtual excitations, Gell-Mann-Low theorem.
Asymptotic states: in-out formulation of S-matrix elements. Correlation functions and their relations to cross sections. Structural aspects: spectral representations and dispersion relations.

There will be one homework a week (about 5-6 problems) due back the following week. There will be one mid-term and a final exam. The total grade is 1/3 each (hmwk, mid, final). The class will be complemented with reading assignments and hand-outs.

Books: I will draw material from many different books: QFT and the Standard Model, by M. Schwartz, QFT by Peskin/Schroeder, Relativistic QM and field theory: F. Gross, QFT by Mandl and Shaw, any of the more recent books will do.