

FALL 2011 MO WE FR 10:40 - 11:35 IN P119
ADVANCED QUANTUM FIELD THEORY (PHYS 621.01)

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This course deals on the one hand with subjects one seldomly reaches in ordinary courses but which are important (instantons, solitons, background field method, finite-temperature field theory, Dirac formalism and anti-fields), while on the other hand it expands on topics already briefly covered in standard courses (anomalies, renormalization and unitarity of nonabelian gauge theories, BRST symmetry, infrared divergences in QCD, various regularization schemes and evanescent counterterms). Solid knowledge of the material of a first-year course on quantum field theory is assumed (the action with ghosts for QCD, Higgs models, calculation of one-loop Feynman graphs). Typed notes (chapters of a forthcoming book) are distributed so that one can listen and ask questions instead of taking notes. This course has been taught in the past every other year. The list of topics for this semester is as follows (next semester we do the rest)

1. Instantons: classical solutions; zero modes, collective coordinates; zero modes for fermions; path-integral measure for zero modes; instantons in quantum mechanics; tunnelling; θ -vacua; the strong CP problem; the U(1) problem.
2. Solitons: the classical solutions (kink, vortex, monopole); the BPS bound; zero modes; quantization of collective coordinates; one-loop corrections to the mass and central charge of solitons.
3. BRST symmetry and Ward identities for nonabelian gauge theories (the $\Gamma\Gamma$ equation).
4. Renormalization of nonabelian gauge theories (such as QCD, contains QED as a special case).
5. Renormalization of Higgs models (such as the Standard Model) and renormalization of models with spontaneously broken rigid symmetries.
6. Unitarity of nonabelian (and abelian) gauge theories using the cutting equations.
7. Anomalies: triangle, box and pentagon anomalies; consistent and covariant anomalies; Wess-Zumino terms; descent equations; higher loops; Adler-Bardeen theorem.
8. Background field method: for scalar fields; for gauge fields; renormalization (extended BRST symmetry); 2-loop β function; gauge-choice independence of β function.