Quantum Field Theory and the Renormalisation Group
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Lecture 1: Basics of Quantum Field Theory
Why QFT? — finite correlation functions — path integral representation — partition function — Schwinger functional — effective action and convexity — classical and quantum equations of motion — functional relations — Schwinger-Dyson equations

Lecture 2-3: Renormalisation Group
Why RG? — linking micro- with macro-physics — basic ideas: continuous Wilson-Kadanoff blocking, integrating out/in of momentum shells — Wilsonian momentum cutoff — exact functional RG equations — extensions: fermions, finite temperature, finite density, gauge fields — global and local symmetries — properties of RG flow: locality, decoupling of heavy modes, renormalisability — link with Callan-Symanzik equation — systematic approximations: perturbation theory, vertex expansion, derivative expansion

Lecture 4-5: Running Couplings, Fixed Points and Phase Transitions
RG β-functions — fixed points and scale invariance — relevant, marginal, irrelevant couplings — universality — Gaussian and interacting FPs, Landau pole — stability matrix and critical exponents — first- and second-order phase transitions — Ising universality class: phase diagram, spontaneous symmetry breaking, convexity of effective action, critical exponents, optimisation — scalar QED: Coleman-Weinberg phase transition, dimensional transmutation, superconducting phase transition, tricritical behaviour

Lecture 5-6: Gravity and the Renormalisation Group
Why gravity? — basics of classical gravity — path integral methods: perturbation theory, effective theory, asymptotically safe gravity — UV fixed point: anti-screening and dimensional reduction — functional RG equations for gravity — phase diagram of Einstein-Hilbert gravity — stability: higher derivative operators, matter fields, higher dimensions — applications and open challenges

References

Peskin, Schroeder, *An Introduction to Quantum Field Theory* Ch 12: The Renormalisation Group
S Weinberg, *The Quantum Theory of Fields*, Vols. 1-3 (Cambridge UP)
J Zinn-Justin, *Quantum Field Theory and Critical Phenomena*, (Oxford University Press).

K-I Aoki, *Introduction to the Non-perturbative RG* Int.J.Mod.Phys. B14 (2000) 1249-1326
J Berges, N Tetradis, C Wetterich, *Non-Perturbative Renormalization Flow in Quantum Field Theory and Statistical Physics* Phys.Rept.363 (2002) 223-386, hep-ph/0005122.
H Gies *Introduction to the functional RG and applications to gauge theories*, hep-ph/0611146.
DF Litim, *Fixed Points of Quantum Gravity and the Renormalisation Group*, 0810.3675
DF Litim, *Renormalisation group and the Planck scale*, 1102.4624 [hep-th].
M. Niedermaier, *The Asymptotic safety scenario in quantum gravity: An Introduction,* Class. Quant. Grav. **24** (2007) R171-230. [gr-qc/0610018].
JM Pawlowski *Aspects of the functional renormalisation group*, hep-th/0512261.

Lecture notes on *Renormalisation group and gravitation*
Lecture 1: `http://physik.uni-graz.at/schladming2011/LectureNotes/Litim_Part1.pdf`
Lecture 2: `http://physik.uni-graz.at/schladming2011/LectureNotes/Litim_Part2.pdf`
Lecture 3: `http://physik.uni-graz.at/schladming2011/LectureNotes/Litim_Part3.pdf`
Lecture 4: `http://physik.uni-graz.at/schladming2011/LectureNotes/Litim_Part4.pdf`

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`http://physik.uni-graz.at/schladming2011/index.php?sf=14`