

Short Description of One Year QFT course at IPM

Quantum Field Theory (QFT) is the natural and the only consistent description of relativistic quantum mechanics. As such the background knowledge for QFT includes special relativity and quantum mechanics. Although I will try to make the course as self-contained as possible, a good grasp of the above two topics plus classical mechanics and electrodynamics at masters level will be assumed.

In this course we will be following

An Introduction to Quantum Field Theory
By Michael Peskin and Daniel Schroder

as the main text, while other QFT books, specially the excellent Weinberg trio, could be used as side readings. In this one year course there will not be enough time to cover the whole book but I hope to be able to cover about 60-70% of the book.

QFT has become the main theoretical framework for all branches of theoretical physics and has not remained limited to high energy physics, from where it originated. Although our text is mainly arranged with a high energy and particle physics taste, the course will hopefully be accessible and useful for all PhD level theoretical physics students.

My plan for this one year course is to cover the following chapters of Peskin's book:

First semester plan

Starting from chapter one, we go through free scalar and fermionic field theories (chapters two and three) and then turn on interactions perturbatively and introduce S-matrix, as done in chapter four. Since I find the representation theory of Lorentz and Poincarè group of Peskin inadequate I will discuss these parts in more detail, as is done in Weinberg's vol.I, chapter 2. We will then make more exercises on computing tree level scattering cross sections in QED, as in chapter five.

Having covered the tree level QFT's and their canonical quantization we start studying loop processes, following chapters six and seven. Here we will learn how to deal with IR and UV divergences, introduce various regularization methods and discuss the physics of loop amplitudes. This will set the stage for a full renormalizability and RG discussion which will come in second semester.

Second semester plan

This part starts with Part II of Peskin's book. The main goal of this semester is to learn the very important notions of renormalizability and RG flow. The latter is indeed the cornerstone of *QUANTUM* field theory. Since these notions are better understood in the path integral formulation, we will first discuss functional methods and path integral quantization. We will then exercise how to renormalize a given

QFT and develop the notion of effective action. The next topic, as of chapter 12 of Peskin, is the very important concept of renormalization group (RG), RG flow and running of the couplings. We will skip section 13, which contains interesting and important concept of critical exponents, to spend more time on non-Abelian gauge theories, their quantization, renormalizability and asymptotic freedom. Skipping chapters 17 and 18 we will start chapter 19 and the discussion of anomalies in quantum field theories.

Depending on the timing we will cover some more advanced topics in QFT's and gauge field theories, Operator Product Expansion (OPE), Spontaneous Symmetry Breaking and Critical exponents and phase transition.

Important Notes for the Students

- Interested students are all kindly asked to contact department secretary Ms Pileroudi, niloufar@theory.ipm.ac.ir, providing their name, institution (or affiliation) and level (Masters or PhD).
- For non-IPM students there is the possibility of formally registering for the course as a “guest student”. For the latter please arrange the formal details with Ms Pileroudi.
- I expect that all the students, those who have formally registered or otherwise alike, to attend the lectures regularly and more importantly take the exercises in the class and the end-of-chapter problem sets seriously; the problem set is an integral part of the book and the course.
- The first session of the QFT-II course will be on Monday Bahman 25th at 8am in Farmanieh classroom.

With our mutual devotion, I am quite positive to have a fruitful experience together in this course.

Sincerely,
Sheikh-Jabbari.