# Preliminary list of physics courses and activities expected in Spring and Fall 2016

*Beware: This list just gives indications and is subject to frequent change.*
*Version updated on 29/10/2015*

***Common courses:***

## Statistics for Physicists

*Period: Spring 2016, 3.5 hours * 13 Thursdays*
*Location: EPFL*

The course will consist of a summary of the basic principles of probability and statistics, from both the Bayesian and Frequentist points of view. Application to problems encountered by physicists, including Monte Carlo calculations.

## Quantum Field Theory and Renormalization Group

*Period: Fall 2016, 1 full week in September of 24 hours + 4 hours * 7 Thursdays*
*Location: EPFL*

- Critical phenomena, mean field theory and the need for a field theory treatment
- $\Phi^4$ theory, functional integrals and perturbation theory
- Renormalisation and Callan-Symanzik renormalization group equations
- The real space Wilson renormalization group formalism
- The Wilson-Fisher \epsilon expansion: the relation between the 2 approaches
- Applications, models with symmetries, universality classes, functional renormalization
- Coherent states and path integrals for bosons and fermions
- Geometrical phases, spin chains, bosonization
- Introduction to conformal invariance

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***Special courses:***

## Energy Landscape Theory: From folding proteins to folding chromosomes

*Period: Early Spring 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

This course will briefly review the status of the physics of the biopolymers with a special emphasis on the complexity of the energy landscape that governs the folding of proteins and the organisation of chromatin. Examples on numerous applications will also be given.

## Optical fibers and metrology applications

*Period: Spring 2016, 4 hours * 8 Thursdays*
*Location: University of Neuchâtel*

This series of lectures will describe the basic principles of various types of optical fibers and some important applications in metrology. Optical fibers constitute a key element in many high precision metrology applications, such as for the generation of coherent supercontinuum spectra that are required for the self-referencing of optical frequency combs, but can also be used as accurate frequency references for laser stabilization or in various optical sensors. Optical fibers are also at the basis of active optical components such as amplifiers and lasers. The basics and the latest developments of various aspects and

applications of optical fibers will be reviewed by international experts in the field.

## New long-lived particles

*Period: Spring 2016, 3.5 hours * 4 Thursdays*
*Location: UNIGE or EPFL*

This course provides a broad overview of direct searches for long-lived particles of various types at collider experiments, high-intensity beam-dump experiments, and astroparticle physics experiments.

## Low dimensional interacting systems

*Period: Spring 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

The effects of interactions in condensed matter is one of the most challenging problems of quantum systems. In low dimensions, the interaction role is reinforced leading to novel physics compared to their higher dimensional counterparts. The course will discuss these phenomena for one and two dimensional quantum systems (for example spin chains and ladders, low dimensional conductors and superconductors) and the theoretical methods needed to tackle such problems.

## Water and solutions with a focus on X-ray techniques

*Period: Spring 2016, 3.5 hours * 4 Thursdays*
*Location: UNIGE or EPFL*

Description of a variety of experimental techniques including x-ray absorption spectroscopy (XAS), x-ray emission spectroscopy (XES), x-ray Raman scattering (XRS), small angle x-ray scattering (SAXS) and wide angle x-ray diffraction (XRD) to study the structure of liquid water in the bulk phase and in aqueous solutions.

## Axions

*Period: May 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

The course will cover the following topics: the strong CP problem (including some non-axionic solutions) the QCD axion solution, possible UV completions, the properties of the axion and its effective field theory, the axion as a DM candidate and its cosmology, existing bounds and detection techniques, and the physics of other axion-like particles.

## The physics of cold atoms

*Period: Spring 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

The course will give an overview of the modern techniques involving cold atoms. A particular focus will be made on building model systems for field theories and experiments that have relevance for cosmology and particle physics. These include pre-thermalization, as predicted for heavy ion collisions and demonstrated in cold atoms, and emergence of correlations after quenches, reminiscent of the CMB fluctuations.

## Evolutionary Dynamics

*Period: Late Spring 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

Evolution is intrinsically dynamical but traditionally, and even with DNA sequencing of genomes of multiple species, most of the available information is historical. But the huge advances in DNA sequencing have enabled evolution of microbial populations to be followed as it happens, both in the laboratory and in human pathogens. Such experiments and observations, the theoretical developments needed to understand the evolutionary dynamics of large populations, and the framing of quantitative questions, will be the focus of these lectures.

## The large-scale structure of the Universe

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

The course will provide an introduction to the theory behind the large-scale structure of the universe. I will first review the theory describing the growth of linear cosmological perturbations, from inflation until today. I will then link this description to observables like the Baryon Acoustic Oscillations (BAO), redshift-space distortions and 21cm intensity mapping and present some recent observations from the BOSS survey. Motivated by the development of future wide fields surveys like Euclid and the SKA, I will then show how these observables, that were constructed in the Newtonian flat-sky regime, have to be modified to account for large-scale effects like relativistic distortions and wide-angle effects. I will discuss the constraints that these observables can place on the theory of gravity and on dark energy.

## Either **Calorimetry in High Energy Physics**

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL or UNIGE*

This course will present the principles of calorimetry in high energy physics experiments, discuss electromagnetic and hadronic calorimeters, different readout techniques, and the large calorimetric systems.

## *or* **Silicon Photon Detectors – Theory and Practice**

*Period: Fall 2016*
*Location: UNIGE or EPFL*

The course will cover photon detection with particular emphasis on recently developed silicon based photomultipliers (Si-PMs). Hands on laboratory session with Si-PMs will complement the lessons.

## Biophysics of Sensory Neuroscience

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

## Theoretical Physics and the Phenomena of Life : How much can we calculate?

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

Living organisms function by the motions and interactions of billions of molecules of tens of thousands different kinds. The sheer complexity of these systems represents a daunting challenge for any quantitative approach, and only in the last few decades has biology moved from a mostly observational to a quantitative science. With better and more reliable quantities at hand, theoretical physics becomes a viable approach to try and understand the fundamental principles of life. In this course I will consider how much we can really calculate given the existing data, and which general concepts emerge from this approach.

## Transport Measurements in functional materials

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

Nano-fabrication technologies; novel physical phenomena in electronic and photonic materials with shrinking dimensions. Size effects in nanoscale ferroelectric materials. Physics and micro- and nano-engineering of thin film devices (dielectric or magnetic multi-layers, multi-functional thin film devices, sensors, micro-actuators, non-volatile memories, DRAMs); multiferroic tunnel junctions.

## Gravity as an Effective Field Theory

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: EPFL*

A pedagogical introduction to the treatment of quantum general relativity as an effective field theory will be given. It will start with an overview of the methods of effective field theory including explicit examples. It will be demonstrated how quantum general relativity matches this framework, together with the limits of the effective field theory description. The insights from effective field theory on the gravitational effects on running couplings in the perturbative regime will be also discussed.

## Neutrino astrophysics

*Period: Fall 2016, 3.5 hours * 4 Thursdays*
*Location: UNIGE or EPFL*

This course will discuss the neutrons from astrophysical sources, the detection techniques, and the implications on particle physics and cosmology of recent observations.

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***Other activities:***

## Zuoz Summer School

*Period: 14-20/08/2016*
*Location: Lyceum Alpinum, Zuoz, Switzerland*

- The Standard Model and extensions
- Evening Lecture: The Rosetta Mission
- Axions and the strong CP problem
- The search for dark matter
- Ingredients for accurate collider physics
- Cosmology and dark matter
- Exotics and searches
- Indirect BSM searches
- Higgs and Standard Model

## 2nd Physics Career Day

*Period: Fall 2016*
*Location: EPFL*

This activity is organized by PhD students themselves. If it follows the same structure as the first event, it would consist of a round table with invited professionals from the private or academy who hold a PhD in physics, followed by an apéritif.