Karlsruhe School of Elementary Particle and Astroparticle Physics: Science and Technology (KSETA)

KSETA is the graduate school associated with the KIT Center Elementary Particle and Astroparticle Physics KCETA, which bundles experimental and theoretical research and education at the interface between astronomy, astrophysics, elementary particle physics and cosmology.

We hereby certify that the doctoral researcher

Pascal Nagel

has attended the following courses during his/her time in the graduate school KSETA.

Introduction to statistical methods in particle and astroparticle physics

Apr 05 – 07 2017 *Thomas Schwetz-Mangold*

In this course I will give an introduction to basic methods in probability and statistics from the point of view of an phenomenologist in particle and astroparticle physics. The course will cover frequentist and Bayesian methods and we discuss the problems of parameter estimation, goodness-of-fit and model comparison, as well as sensitivity estimates for future experiments. We will introduce concepts such as the likelihood and chi-squared statistics, discuss global analyses of several data sets, the problem of systematic uncertainties and nuisance parameters.

Introduction to Lattice Gauge Theory

Apr 04 – 05 2017 *Stefan Sint (Trinity College Dublin)*

In this set of lectures I will give an introduction to lattice gauge theories including lattice QCD. On the one hand the lattice regularization is just that, a regularization which can also be used for perturbative calculations. On the other hand, it enables the non-perturbative formulation of gauge theories and numerical simulations as a tool to obtain quantitative results beyond perturbation theory. This numerical approach has its limitations but also offers opportunities, as the theory can be probed in circumstances which are not accessible to experiments.

Introduction to string theory

Sep 21 + 22 2016 *Dr. Timo Weigand (Uni Heidelberg)*

String theory replaces the notion of pointlike fundamental objects in nature by one-dimensional fundamental strings. Combined with the usual axioms of quantization and general covariance, this results in a perturbative interacting quantum theory free of ultra-violet divergences. Its low-energy limit includes massless spin-one and spin-two states, thereby unifying gauge and gravitational interactions in a consistent framework. Compactification of this necessarily higher-dimensional theory makes contact with modern concepts of geometry and provides links to particles physics, quantum field theory, quantum gravity, and mathematics. The first part of these lectures will introduce the basic concepts of perturbative string theory, starting from the quantization of the classical string worldsheet action, including configurations with D-branes, and deriving the Hilbert space of states. In the second part we will discuss aspects of the low-energy effective action and introduce some notions of compactification, time permitting with applications to particle physics.

Collaborative software design

Sep 15 + 22 2016 *Manuel Giffels, Dr. Martin Heck, Thoas Hauth*

Version Control is a standard method for software development in teams but has much broader useful applications. We will introduce collaborative software design and cover topics from the basics (no previous knowledge required) down to deep details like testing, release management, etc.

Slavnov-Taylor-Identities and SUSY breaking in Dimensional Reduction

Apr 7 - 8 2016 *Prof. Dominik Stoeckinger*

Slavnov-Taylor-Identities and SUSY breaking in Dimensional Reduction

Apache Spark in Scientific Applications

Sep 10 2015 *GridKa School 2015, Karlsruhe*

The workshop Spark in Scientific Applications covers fundamentale development and data analysis techniques using Apache Hadoop and Apache Spark. Beside an introduction into the theoretical background about Map-Reduce- and Bulk-Synchronous-Parallel processing, also the machine learning library MLlib and the graph processing framework GraphX are used. We work on sample data sets from Wikipedia, financial market data, and from a generic data generator. During the tutorial sessions we illustrate the Data Science Workflow and present the right tools for the right task. All practical exercises are well prepared in a pre-configured virtual machine. Participants get access to required data sets on a "one node pseudo-distributed" cluster with all tools inside. This VM is also a starting point for further experiments after the workshop.

Application development with relational and non-relational databases

Sep 09 2015 *GridKa School 2015, Karlsruhe*

In this workshop, the students will learn how to use relational and non-relational databases to build multi-threaded applications. The focus of the workshop is to teach efficient, safe, and fault-tolerant principles when dealing with high-volume and high-throughput database scenarios. The course will cover the following three topics: When to use relational databases, and when not (Relational primer, Non-relational primer, How to design the data model), Using SQL for fun and profit (Query plans and performance analysis, Transactional safety in multi-threaded environments, How to deal with large amounts of sparse metadata, Competetive locking and selection strategies), Building a fault-tolerant database application (Distributed transactions across relational and non-relational databases, SQL injection and forceful breakage, Application-level mitigation for unexpected database issues).

Elastic Search, Logstash and Kibana

Sep 08 2015 *GridKa School 2015, Karlsruhe*

Elasticsearch, Logstash and Kibana, known as the ELK stack, are three open source projects designed to ship, parse, search, analyse and visualize your data, from Apache logs to Twitter streams. A short description of the components is the following: Logstash allows you to ship and parse your data using a great variety of plugins. It is highly scalable. Elasticsearch is a search server based on Apache Lucene. It is distributed and highly scalable. Kibana is the visualization platform available through a web browser with a nice interface and easy to customize directly from the browser. In this course we will explain to you these three components and we will guide you through their installation and configuration. Several different data logs will be analyzed in order to finally create your own Kibana dashboards.

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Multivariate data analysis: New techniques and developments in the recent years

Oct 15 – 16 2015 *Dr. Stefan Ohm (DESY Zeuthen)*

We live in a world where the amount of data in all areas of life is exploding. Multivariate analysis techniques are indispensable tools when trying to analyze and interpret this information. Physicists and Astronomers, for instance, are often faced with the situation where they have to crawl large data sets to search for small signals in a large background. In this course I'll give a short introduction to the field of data science, (a glimpse into) the statistics behind it and the topic of machine learning. The most common machine learning algorithms like neural networks, boosted decision trees or k-Nearest Neighbors are discussed in more detail. In the second, hands-on, part of the course we will have a look at real examples: How to get data samples, how to parameterize and prepare them for analysis, and finally how to extract information with multivariate analysis techniques.
- Laptop with python installed and the following packages: pandas, scikit-learn, numpy, astropy, scipy, argparse, pip, ipython
or:
- laptop with VirtualBox installed (an Ubuntu installation and all necessary tools will be provided)
- More details will come on the webpage: http://stefanohm.com

Effective Field Theory

Oct 12 – 13 2015 *Prof. Dr. Thomas Becher*

Effective Field Theories are an important tool in quantum field theory. They allow one to separate physics at disparate energy scales, expand in small scale ratios and resum logarithmically enhanced contributions to all orders. Traditionally, effective field theories are obtained by integrating out the heavy particles in a given theory and their degrees of freedom are the light particles. Modern effective theories (such as HQET, NRQCD, SCET) describe more complicated situations, in which the fields do not directly correspond to particles, but to different low-energy momentum regions which are relevant in a given process. In these lectures, we will first cover the basic concepts of effective field theory. Then, after discussing the momentum regions arising in low-energy expansions of Feynman diagrams, we turn to modern effective field theories and their applications.
The course assumes basic knowledge of quantum field theory and perturbation theory.

Applying Python in Scientific Computing

Mar 26+27 2015 *Dr. Manuel Giffels*

The Course aims towards Python beginners, which have either already done baisc scripting in Python or a good understanding of basic C++. Without going into too much details of the Python syntax itself, the course focuses more on introducing special language features and good coding practices (e.g. the usefulness of coding conventions). An overview over scientific libraries for data analysis will be given as well as a thorough introduction into object oriented programming with special emphasis on structuring analysis code. Finally, if time permits, modern techniques of software engineering such as unit-testing will be briefly touched.

Karlsruhe School of Elementary Particle and Astroparticle Physics: Science and Technology (KSETA)

What do I need, if I will leave science towards industry?

Mar 19 2015 *Dr. Udo Erdmann*

As a graduated scientist or engineer a next career step within industry will definitely include management responsibilities. Therefore skills in management and leadership will be expected. Planning to open an own business or start up requires knowledge in managing a company as well. In both cases the needed skills can be divided in three classes: corporate management, project management, technology and innovation management. This course is focussed on project management and business model evaluation which are part of the first two aforementioned classes. Three examples of possible technological product development projects will be worked on, spanning from the design of the project all the way up to the resource planning. Classical myths and mistakes of product development will be discussed in order to avoid them in real life later on. Before the planning of the project the three project ideas will be checked whether they are fit enough to create revenue. Shortly speaking, the business model of the idea will be tested. Ways to make an idea a business model are worked out throughout the course. For every example one hour is used to check the business model behind an idea, and one more hour to design and plan the product development project based on that business model.

Practical detector physics in the lab for non-experimentalists

Mar 17+18 2015 *Prof. Ulrich Husemann, Prof. Günter Quast, Dr. Alexander Dierlamm, Dr. Ralf Ulrich*

This course is offered specifically for doctoral researcher who have no real-life experience in working in a particle physics laboratory environment. Basic knowledge about experiments, as e.g. obtained from the "Physikalisches Fortgeschrittenen Praktikum" are required. Doctoral researchers will have the opportunity to work in small groups of 2 people in well-equipped laboratories at Campus North on the setup of small particle physics/detector experiments using normal experimental equipment. The following experiments are offered:
1) Muon lifetime measurement with scintillator panels based on coincidence measurements
2) Commission of a Gamma-ray spectrometer with a crystal calorimeter, photon sensor and a signal digitizer
3) a transient current technique measurement of silicon sensors (TCT) with short laser pulses
4) probe-station to measure capacitance, reverse current, and resistances of silicon strip sensors
Two experiments from this list can be selected by any participant. The distribution into groups and assignment to experiments will be performed on the first day, before the start of the practical work. Experienced tutors will be there to help and to discuss. Some basic data analysis with software tools, which are provided, is partly foreseen. The underlying physics will be discussed along the measurement and the data analysis, but is not in the focus of this course.

Instantons and Supersymmetry

Jun 23 – Jul 10 2015 *Prof. Dr. Arkady Vainshtein (University of Minnesota, Minneapolis, USA)*

In these lectures I will introduce the notion of instanton an related calculus in non-abelian gauge theories. Starting with quantum mechanical examples, we move then to QCD, and then to supersymmetric gauge theories. Application to perturbative and nonperturbative quantum effects will be reviewed.

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KSETA-Doktorandenworkshop

Jul 6 – 8 2015 *R. Derco, R. Podskubka, S. Richter, Mrs. C. Assmus, Mr. Ritter*

The KSETA Doctoral Workshop allows interested KSETA fellows to learn more about methods and tools that might support their research. Doctoral students of all KSETA research fields, from theoretical or experimental particle and astroparticle physics to software or cryogenic engineering, are invited to spend three interesting and inspiring days together and to benefit from the other participants' experience. One key aspect of the workshop are the tutorials given by all participating doctoral students. In groups, the participants prepare their tutorial "from doctoral fellows for doctoral fellows" on a topic that could be useful to others concentrating on other fields of research. This tutorial may cover introductions to useful tools, basic technologies for non-engineers, basics in physics for non-physicists, or applicable methods for research. Every tutorial lasts one hour and the presenter is free to use any didactic method like PowerPoint, whiteboard, or interactive methods such as exercises on programs installed on the students' laptops. The workshop program is complemented by invited talks and discussions.

Paradoxes are very illustrative to gain a deeper understanding of critical aspects of physical theories. In this talk, a sample of historic pseudo-paradoxes are presented and resolved. Tricky aspects are addressed and discussed.

Studies of atmospheric neutrinos

Jul 10 + 11 2014 *Prof. Dr. Takaaki Kajita*

Studies of atmospheric neutrinos:
(1) Early days The deficit of atmospheric muon-neutrinos was discovered in 1988. In this lecture, I will review the studies of atmospheric neutrinos until the 1998 discovery of atmospheric neutrino oscillations.
Studies of atmospheric neutrinos:
(2) Present and future After the discovery of neutrino oscillations, atmospheric neutrinos have been contributing to the understanding of neutrino masses and mixing angles. I will present various studies of atmospheric neutrinos that have been carried out so far and discuss prospect of the future atmospheric neutrino studies.

Karlsruhe, November 27, 2017

Dr. Irmgard Langbein
Managing Director