Elective : Simulations in Collider Physics and Cosmology (2-0-3-4)

Instructors

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Syllabus

Part 1: Review of Monte Carlo Technique; Inverse Transform method; Acceptance-rejection method; Algorithms for random number generation; Markov chain Monte Carlo; Physics Behind Monte Carlo event generators; Introduction to collider process; Short distance physics; Hadronization Model; Models of soft Hadron-Hadron Physics; Parameters and Tuning; Hands-on with existing codes for LHC; Generic Landscape; LanHEP (Lagrangian-Model files); CalcHEP (Hard Process); Pythia (Showering and Hadronization); PGS (Detector simulation);
Part 2: Introduction to particle-based methods; scope and application of particle- based methods in cosmology; The collision-less Boltzmann equation; the Vlasov equation; Cosmological structure formation; The Particle-Mesh approach; The Particle-Particle-Mesh approach; The Tree-Particle-Mesh approach

Lecture-wise split-up

Lecture 1-2: Review of Monte Carlo Technique; Inverse Transform method; Acceptance-rejection method; Algorithms for random number generation; Markov chain Monte Carlo

Lecture 3-4: Physics Behind Monte Carlo event generators; Introduction to collider process;

Lecture 5: Short distance physics

Lecture 6-7: Hadronization Model; Models of soft Hadron-Hadron Physics; Parameters and Tuning

Lecture 8: Hands-on with existing codes for LHC; Generic Landscape; LanHEP (Lagrangian-Model files)

Lecture 9: CalcHEP (Hard Process)

Lecture 10: Demonstration with CalcHEP

Lecture 11: Pythia (Showering and Hadronization)

Lecture 12: PGS (Detector simulation); Demonstration

Lecture 13-14: Introduction to particle-based methods; scope and application of particle-based methods in cosmology; other examples

Lecture 15-16: The collision-less Boltzmann equation; the Vlasov equation

Lecture 17-18: Cosmological structure formation

Lecture 19-20: The Particle-Mesh approach

Lecture 21-22: The Particle-Particle-Mesh approach

Lecture 23-24: The Tree-Particle-Mesh approach

Lab component

Lab 1: Introduction to linux and installation of codes

Lab 2: Introduction to Calchep: simple process, model files

Lab 3 : Calchep: implementing new models

Lab 4: Calchep: New Model 1

Lab 5: Calchep: New Model 2

Lab 6: Lanhep-Madgraph-Pythia : demonstration and hands-on

Lab 7: Installation and running the P-M cosmological N-body code

Lab 8: Validation of the code

Labs 9,10: Quantitative analysis of N-body output

Lab 11: Data visualization of N-body output

Lab 12: Generation of mock surveys from N-body output

Text and References

1. Ref: PDG review by G. Cowan [http://pdg.lbl.gov/2014/reviews/rpp2014-rev-monte-carlo-techniques.pdf]
2. Chapter 1 of Buckley et al., General-purpose event generators for LHC physics, Phys. Rept. 504 (2011) 145 and PDG review by P. Nason and P.Z. Skand [http://pdg.lbl.gov/2014/reviews/rpp2014-rev-mc-event-gen.pdf]
3. Ask et al., From Lagrangian to Events: Computer Tutorial at the MC4BSM-2012 Workshop, arXiv:1209.0297 [hep-ph], K. Kong, TASI 2011: CalcHEP and PYTHIA Tutorials, arXiv:1208.0035 [hep-ph].

4. Computer Simulation Using Particles by R.W Hockney and J.W Eastwood, *Taylor and Francis*, 1988

Exam and evaluation:
Mid-semester: 30%
End-semester: 50%
TA: 20% (Practicals/simulation report)

Pre-requisites: Consent of the instructors

Maximum number of students allowed to register: 20

Semester in which the course will be offered: Autumn