UNIVERSITÀ DI TRENTO
Department of Physics
Doctoral Programme in Physics

SYLLABUS Academic year 2021/2022
(ANNEX TO THE TRAINING PROGRAMME)

Each PhD student must attend courses corresponding to **12 credits** by choosing advanced courses organized:

- by the Doctoral Programme in Physics
- by the Master degree in Physics, or by other similar Master degree courses
- by other similar Doctoral programmes

Other mandatory activities include:

- Research activity followed by a tutor assigned by the Doctoral Programme Committee.
- Attendance of seminars organised by his/her own Research group
- Attendance of Dialogues, Colloquia and Joint Colloquia organized by the Department of Physics also on topics different from the research activity carried out by the PhD students.

Each student must submit his/her study plan to the Doctoral Programme Committee for the approval**.** The study plan must be previously agreed with the tutor.
The credits should be achieved_**within the end of the first year**_with the extension to the first semester of the second year **only** for Master degree courses activated in that time (for up to 6 credits).
PhD students can obtain **up to 6 credits** for the attendance of International Schools (Summer/ Winter school, etc.) upon the authorization by the tutor and the Doctoral Programme Committee and after passing an exam.

Courses organized by the Doctoral School in Physics – a.y. 2021/2022

Professor	Course	Credits	Hours
G. BALDI, R.S. BRUSA* (COORDINATORI)	**ADVANCED TECHNIQUES IN EXPERIMENTAL PHYSICS**	3	21
A. CHIASERA	**OPTICAL AND SPECTROSCOPIC DIAGNOSTIC OF MATERIALS FOR PHOTONICS**	3	21
A. PERRECA	**ADVANCED INTERFEROMETRY**	3	21
A. QUARANTA	**QUANTUM SENSING**	3	21
R. BATTISTON, L. BRUZZONE, S. VITALE	**SPACE-BASED OBSERVATION TECHNIQUES AND METHODS**	6	42
M. CALANDRA, F. PEDERIVA, R. POTESTIO	**MULTISCALE MODELING: FROM THE ATOM O THE CELL**	3	21
C. CONTI	**GAUSSIAN STATES AND QUANTUM MACHINE LEARNING**	3	24
M. RIZZI	**ENTANGLEMENT IN MANY-BODY SYSTEMS: FROM CONCEPTS TO ALGORITHMS**	3	21
V. SCARANI	**BELL NONLOCALITY, FROM FOUNDATIONS TO APPLICATIONS**	3	21
M. LOSTAGLIO	**AN INTRODUCTION TO QUANTUM-INFORMATION THERMODYNAMICS**	3	21

D. ASCENZI, E. SCIFONI	**RADIATION CHEMISTRY**	3	21
P. GHIGGINI	**SELECTED TOPICS IN GEOMETRY AND TOPOLOGY**		
TALENT (Training in Advanced Low-Energy Nuclear Physics)	**TO BE DEFINED**	6	45
ECT* (European Centre for theoretical Studies in Nuclear Physics and related Areas)	**ECT* DOCTORAL TRAINING PROGRAMME 2022: HIGH-ENERGY AND NUCLEAR PHYSICS WITHIN QUANTUM TECHNOLOGIES**	6	
ISAPP	**HTTPS://WWW.ISAPP-SCHOOLS.ORG/**	3	

*Proff. Baldi and Brusa will coordinate the course with the support of the professors of the experimental research Laboratories.

ADVANCED TECHNIQUES IN EXPERIMENTAL PHYSICS, PROF. G. BALDI

Prerequisites

The knowledge of a physics graduate is requested.

Contents

This course is organized as a collection of 4 lecture cycles on different topics in advanced experimental physics. Each cycle is given by an invited scientist or a member of the department, and consists in about 4-5 hours of lectures. The topics are selected every year in experimental research areas of interest of the physics department, giving priority to topics not already discussed in other dedicated PhD courses, as for instance:

1) Antimatter experiments, anti-hydrogen, positron beams, atomic physics experiments with positronium, positron and positronium for matter studies;
2) Applications of particle beams in medicine;
3) Biophysics, in particular methods for the conditioning/investigation of single biological molecules and for the imaging;
4) Cold gases condensates, atomic interferometry;
5) Instrumentation and methods for observational astrophysics and cosmology;
6) Instrumentation and methods in condensed matter and glasses and in surface science;
7) Instrumentation for synchrotron radiation and free electron laser based experiments;
8) Particle and radiation detectors;
9) Photonic devices;

The selection of topics of the course depends also on the availability of lecturers coming from other research institutes. The schedule of the course has to match the agenda of the lecturers and it is provisionally planned.

Schedule

To be defined

Exam

PhD students will give a seminar of 20 minutes on an experimental topic related to the four lectures or to an experimental research presented in the Dialogues, Colloquia and Joint Colloquia. The topic is freely chosen by the PhD student but must be previously agreed with the coordinators of the course and must be different from the field of research of the PhD student.

OPTICAL AND SPECTROSCOPIC DIAGNOSTIC OF MATERIALS FOR PHOTONICS, DR. A. CHIASERA (CNR–IFN)

Prerequisites

The typical skills of a Physics, Engineering graduate are requested.

Contents

Phenomenological course

Programme

- Introduction to Glass Photonics
- From bulk to nano- and microscale photonics systems
- Rare earth –activated glasses
- Photonics devices fabrication and assessment
- Radiative and non-radiative transitions
- Transition probability
- Energy transfer
- Optical parameters, dispersion curve
- Absorption and emission cross sections; Quantum efficiency
- Light scattering for characterization of material properties
- Confined structures: Planar waveguides
- Confined structures: Nanospheres
- Confined structures: Direct and inverse opals
- Confined structures: Spherical Microresonators
- Confined structures: 1D - Microcavities
- Nanocomposites systems and transparent glass ceramics
- Integrated optics
- Resonant florescence line narrowing and spectral hole burning
- Single ion emission
- Homogeneous and inhomogeneous emission and absorption band
- Energy conversion
- Energy trapping
- Plasmonic structures
- Fluorescence enhancement using different sensitizers – metallic and semiconductor nanoparticles, lanthanides ions, nanocrystals.
- Fibers and fiber lasers
- Nano -micro thermometers
- Solar energy conversion by quantum cutting.
- Lightning
- Persistent luminescence
- Scintillators

Schedule

From February to April 2022

Exam

Seminar and discussion

Bibliography

Specific papers and books will be suggested during the lectures

Contents

Description

This course aims at describing frontier experiments on fundamental interactions, pointing out common and distinctive features of different fields of Physics. We will discuss the most important observational results of the last two decades in High Energy Physics, Flavor Physics, Astroparticle Physics and Search for Dark Matter, Neutrino Physics and Astrophysics, Gravitational Wave Astronomy and Cosmology. Lectures will be focused on experimental techniques, showing strength points and explaining intrinsic limits of sensitivity.

Organization

This is a lecture course in which topics are presented by the teacher.

Course objectives

- To provide PhD students with basic knowledge of modern experimental techniques applied in research fields different from theirs.
- To introduce PhD students to scientific methods and techniques widespread in particle and astroparticle Physics.
- To give PhD students a taste of what the hunt for Dark Matter currently.

Course topics

- Gravitational Wave Astronomy, compact binary stars populations, tests of General Relativity and consequences in cosmology.
- Standard Model and Beyond. The ΛCDM model.
- Detecting particles, how to.
- The problem of MASS. The electroweak sector. LEP, Tevatron and the LHC. The Higgs sector. Searches for New Physics.
- The problem of BARYOGENESIS. CP violation. CPT violation measurements. Cosmic antimatter asymmetry.
- The problem of DARK MATTER. Hypotheses. Spin-dependent/spin-independent. The WIMP miracle. Direct and indirect searches.
- The problem of NEUTRINOS. Neutrino mass. Neutrino oscillation. Neutrinoless double-beta decay. Astrophysical neutrinos.

Schedule

Part of the LM Course, see LM program

Exam

Grading plan
Written exam (quizzes): 25%
Short report on a topic agreed with the teacher: 25%
Oral exam: 40%
Attendance: 10%

Bibliography

Teacher notes will be made available on time.

ADVANCED INTERFEROMETRY, PROF. A. PERRECA

Prerequisites

The knowledge of physics at graduate level is requested.

Contents

The course will present advanced interferometric techniques for current and future experiments. Interferometry is an important investigative technique in the fields of astronomy, photonics, engineering metrology, optical metrology, plasma physics, biomolecular interactions, optometry and quantum mechanics. Several interferometers topology are widely used in science for the measurement of small displacements, refractive index changes and surface irregularities down to quantum limited sensitivity. This course will describe principles and effects of various interferometry topologies and example of applications.

The course is organized as follows:

Topology

- Plane waves and Gaussian beams. Michelson Interferometer: contrast, displacement sensitivity, shot noise. Fabry-Perot cavities: stability, resonance condition, finesse. The Pound-Drever-Hall technique for the locking of cavities. Other interferometer topologies: Sagnac interferometer, Mac-Zehnder interferometer: scheme and characteristics. More interferometric techniques: time delay interferometry, laser-ranging interferometry.

Advanced Interferometry for Gravitational Waves detectors

- Brief introduction to gravitational waves. Detection of gravitational waves. LIGO-Virgo interferometers at the time of their detections: Detection principle, Main noise contributions, Sensitivity curve. Future earth based GW detectors. Project for space based interferometers

More application of advanced interferometry

- Interferometry for the Gravity Recovery and Climate Experiment GRACE: introduction and working principle, current results. The next future: Grace follow-on.
- Interferometry for rotation measurements: the Sagnac effect. Application: ring-laser and gyro-lasers. Ring lasers for geodesy measurements. Ring lasers for general relativity measurements. The Lens-Thirring effect.

Improving the interferometer sensitivity

- Quantum nature of light. Coherent and squeezed states. Application of squeezed light in advanced interferometry: the case of GW interferometers.

Schedule

February-March 2022

Exam

Seminar and discussion

Bibliography

Specific papers and books will be suggested during the lectures

QUANTUM SENSING, PROF. A. QUARANTA

Prerequisites

. Properties of electrical and magnetic fields.
. Optics.
. Electromagnetic waves.
. Principles of quantum mechanics.

Contents

. Measurements and noise.
. Principles of photon detection.
. Single photon sources.
. Detection of entangled photons.
. Principles of quantum sensing.
. Advantages of quantum sensing.
. Examples and proof of principles of quantum sensing.

Schedule

To be defined

Exam

The exam will be a seminar about a topic selected by the student

Bibliography

The bibliography is a collection of papers on the arguments discussed during the course. All the papers will be available during the course.

UNIVERSITÀ
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SPACE-BASED OBSERVATION TECHNIQUES AND METHODS, PROFF. R. BATTISTON, L. BRUZZONE, S. VITALE

Contents

1. Gravitational wave detectors in space (S. Vitale)
    - Gravitational waves basics
    - Sources
    - Gravitational wave detectors
        - Geodesic motion and LISA Pathfinder
        - Time delay interferometry and the LISA detector
        - Other space borne detectors
    - Other applications of curvature detectors
2. Particle detectors in space (R. Battiston)
    - Sources of Cosmic Radiation
    - Cosmic ray detectors
    - X- and gamma-ray detectors
    - Optical detectors
    - Millimeter and infrared detectors
3. Radar and multispectral sensors in Earth observation and planetary exploration (L. Bruzzone)
    - Basics on remote sensing instruments
    - Multispectral and hyperspectral scanners
    - Radar for imaging (side-looking radar and synthetic aperture radar)
    - Radar for subsurface investigations (ground penetrating radar, radar sounder)
    - Examples of use of the instruments in missions for Earth observation (e.g. Worldview, Sentinel, Cosmo-Skymed, Prisma) and planetary exploration (e.g., JUICE, Cassini, Mars Express, MRO)

Schedule

February 2022

Exam

To be defined.

Bibliography

To be defined.

MULTISCALE MODELING FROM THE ATOM TO THE CELL, PROF. R. POTESTIO, PROF. F. PEDERIVA AND PROF. M. CALANDRA

Prerequisites

Good knowledge of quantum and statistical mechanics as well as of manybody physics

Contents

F. Pederiva (5 hours) on Basics of Quantum Monte Carlo: Variational Method and stochastic Imaginary Time Projection Method.
M. Calandra (10 hours): Density Functional theory from the blackboard to the computer with applications.
R. Potestio (5 hours): From the renormalization group to coarse-graining in soft matter

Schedule

February 2022

Exam

Individually selected research problem, possibly leading to an interesting research result/publication

Bibliography

Giuliani and Vignale, *Quantum Theory of the Electron Liquid*, Cambridge University Press
Richard Martin, *Electronic Structure Basic Theory and Practical Methods*, Cambridge University Press
Ihm and Cohen, *Momentum-space formalism for the total energy of solids*, J. Phys. C. Solid State Phys. 12, 4409 (1979)
Grosso, Pastori, Pallavicini, *Solid State Physics*, Elsevier
Marvin L. Cohen and S. Louie, *Fundamental of Condensed Matter Physics*, Cambridge University Press
E. Lipparini, *Modern May-Particle Physics (2nd edition)*, World Scientific
M. E. Tuckerman, *Statistical mechanics: theory and molecular simulation*, Oxford
G. A. Papoian, *Coarse-Grained Modeling of Biomolecules*, CAC press
W. G. Noid, Perspective: *Coarse-grained models for biomolecular systems*, J. Chem. Phys. 139, 090901 (2013)

GAUSSIAN STATES AND QUANTUM MACHINE LEARNING, PROF. CLAUDIO CONTI (UNIV. ROMA LA SAPIENZA)

Prerequisites

Basic quantum mechanics and/or quantum optics
Basic programming in C, python, or matlab

Contents

Introduction to Python and TensorFlow for machine learning
Introduction to quantum computing and quantum machine learning
Introduction to phase space methods in quantum mechanics
Gaussian States
Examples of quantum machine learning by Python and TensorFlow
Gaussian Boson sampling
Neural Network Variational ansatz for many-body applications

Schedule

Period Feb/March 2022 (to be decided)

Exam

Developing a coding application or oral exams on theoretical aspects

Bibliography

Barnett, S.M., Radmore, P.M.: Methods in Theoretical Quantum Optics. Oxford University Press, New York (1997)
Ferraro, A., Olivares, S., Paris, M.G.A.: Gaussian states in continuous variable quantum information. arXiv:0503237 (2005)
Wang, X., Hiroshima, T., Tomita, A., Hayashi, M.: Quantum information with gaussian states. Phys. Rep. 448, 1–111 (2007).
Python Machine Learning, S. Raschka, V. Mirjalili

ENTANGLEMENT IN MANY-BODY SYSTEMS: FROM CONCEPTS TO ALGORITHMS, DR. M. RIZZI (UNIVERSITÄT KÖLN)

Prerequisites

Prerequisite for this course is a fair knowledge of the following topics:
- quantum mechanics (Hilbert spaces, probabilities, unitary evolutions, spin and Pauli matrices, composite systems, possibly density matrices)
- basic quantum many-body theory and statistical mechanics concepts (Fermionic/Bosonic statistics, 2nd quantization formalism, possibly some concept of renormalization and/or critical exponents)
- basic computer programming (language is not too important: e.g. Fortran, C++, Matlab, Mathematica)

The class will include a practical part consisting in writing up a simple Density Matrix Renormalization Group (DMRG) code based on Matrix Product States (MPS) formalism in order to solve some simple problems and to provide you a potential instrument for further studies in many fields.

Contents

After a brief introduction of entanglement and other quantum information concepts (overlapping to other classes), leading to the Tensor Network Ansatz family, we will focus on their use as tools to investigate many-body systems and their quantum phases, both from the conceptual and from the computational point of view. The concepts and tools are so general that they can find application in different current research fields like, e.g., cold atoms in optical lattices, spins in magnetic materials, electrons in solids, quantum chemistry, topological materials, and so on.
The theoretical aspect will be complemented by a practical part, via the development of your own simple Density Matrix Renormalization Group (DMRG) code based on Matrix Product States (MPS) formalism in order to solve some simple problems (e.g. compute low energy spectra and/or structure factors of toy systems).
A tentative outline of the lectures is:

1. Intro: General motivation on Entanglement in Many-Body Systems
2. Intro: General idea behind Tensor Networks (TN), a menu thereof & three viewpoints on them
3. Rudiments of TN: graphical notation, area-law of entanglement, information-based renormalization, gauge freedom & canonical forms
4. Rudiments of TN: contractions & costs, extraction of observables & correlations, some exact examples
5. TN as numerical tool: description of usual goals (ground states / dynamics / thermal ensembles) & typical systems treated, Algorithm 1 – Time-Evolving Block Decimation (TEBD) for Matrix Product States (MPS)
6. TN as numerical tool: Algorithm 2 – Ground-State Variational Search, concept of Matrix Product Operator
7. TN as numerical tool: Algorithm 3 – Time-Dependent Variational Principle (TDVP) for longer-range models, Algorithm 4 – some rudiments of Thermal Ensembles
8. Advanced topic: Symmetry groups (quantum numbers) in TN algorithms, why and how (details on Abelian, hints to non-Abelian cases)
9. Advanced topic: Projected Entangled Pair States (PEPS) for 2D systems, generalities, algorithms & exact cases
10. Advanced topic / Outlook: a bird-eye view on all what we did not touch in detail (parent Hamiltonians, topological order, classification of phases, continuous MPS, holography, quantum chemistry, etc.)

This is not a too rigid scheme, and may be adapted on-the-fly to the skills and interests of the participants.

Schedule

19-29 October 2021

Exam

Free choice between the following options:

i) Little seminar on a selected topic of interest
ii) Short essay on a self-made numerical simulation
iii) Traditional oral exam

Bibliography

1) do not feel scared by the articles, they are just as good as (or even more than) book chapters (and anyway we can help you through)
2) in case you are not able to download them (it should be possible from the Uni-Account), let us know and we will provide PDF's to you.

General literature on Quantum Information
- Quantum Computation and Quantum Information - Nielsen and Chuang - Cambridge Univ. Press
- Lecture Notes on Quantum Information - Preskill - www.theory.caltech.edu/people/preskill/ph229
- Computational Many-Particle Physics - edited by H Fehske, R Schneider, and A Weiße - Springer 2008 - http://link.springer.com/book/10.1007/978-3-540-74686-7/page/1
- special issue of Journal of Physics A, Vol 42, Num 50 - edited by Calabrese, Cardy, Doyon
- Amico, Fazio, Osterloh, Vedral - Rev. Mod. Phys. 80, 517 (2008) - arXiv:quant-ph/0703044
- Horodecki^4 - Rev. Mod. Phys. 81, 865 (2009) - arXiv:quant-ph/0702225
- Eisert, Cramer, Plenio - Rev. Mod. Phys. 82, 277 (2010) - arXiv:0808.3773

Specific literature on Tensor Networks
- Orus, Annals of Physics 349, 117-158 (2014) — arXiv:1306.2164v3
- Schollwöck - Ann. Phys. 326, 96 (2011) - arXiv:1008.3477

Deeper literature on Tensor Networks
- Schollwöck - Rev. Mod. Phys. 77, 259 (2005) - arXiv:cond-mat/0409292
- Cirac - lecture notes from Les Houches - arXiv:1205.3742
- Verstraete, Cirac, Murg - Adv. Phys. 57, 143 (2008) - arXiv:0907.2796
- Cirac, Verstraete - Jour. Phys. A 42, 504004 (2009) - arXiv:0910.1130
- Orus, Eur. Phys. J. B 87: 280 (2014) — arXiv:1407.6552v2

Own literature on Tensor Networks
- De Chiara, **MR**, Rossini, Montangero, J. Comput. Theor. Nanosci. 5, 1277_1288 (2008) (codesource www.dmrg.it),
- Silvi, Tschirsich, Gerster, Jünemann, Jaschke, **MR**, and Montangero, SciPost Phys. Lecture Notes 8 (2019)
- P. Schmoll, S. Singh, **MR**, R. Orús, arXiv:1809.08180

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BELL NONLOCALITY: FROM FOUNDATIONS TO APPLICATIONS
PROF. VALERIO SCARANI (NATIONAL UNIVERSITY OF SINGAPORE)

Prerequisites

Good knowledge of the kinematics of quantum mechanics (finite-dimensional vector spaces, tensor product, pure and mixed states). Familiarity with some notions of quantum information is desirable.

Contents

The course will run over 5 weeks:

1. Bell nonlocality: an overview of the notion and discussions
2. Mathematical setting: Fine's theorem and the local polytope.
3. Bell nonlocality in quantum theory.
4. The applied side: device-independent certification and its tools
5. Seminar: each student to present a pre-assigned research article.

Schedule

1 November – 17 December 2021 (5 weeks, 4 hours per week).

Exam

The students will be evaluated through the seminar in Week 5, which consists of a presentation of a pre-assigned research article.

Bibliography

- The course will follow the book: V. Scarani, Bell Nonlocality (Oxford University Press, Oxford, 2019).
- A lot of material can be gathered from the review article: N. Brunner et al., Bell nonlocality, Rev. Mod. Phys. 86, 419 (2014), downloadable from https://arxiv.org/abs/1303.2849.

``ENTANGLEMENT, THERMODYNAMICS, ALGORITHMS: THE QI PERSPECTIVE''

DR. M. LOSTAGLIO (UNIVERSITY OF AMSTERDAM, QUSOFT)

Prerequisites

Basic linear algebra. Dirac's notation. Familiarity with basic quantum mechanics is useful, but not indispensable. Please don't hesitate to drop me an email at lostaglio@protonmail.com, I am very happy to send background material covering the prerequisites.

Contents

The course introduces the perspective and some core tools of the quantum information approach to physics, which recently has been applied throughout the quantum sciences. The approach is showcased in the context of the theory of entanglement, quantum thermodynamics and basic quantum algorithms.

PART 1: THE QI TOOLBOX (approx. 5h)
Operationalism and the information theory perspective; from classical probability theory to quantum theory; quantum states (density matrices, ensemble ambiguity, purifications); measurements (POVM); quantum operations and their representation (Stinespring, Choi, Kraus).

PART 2: ENTANGLEMENT (approx. 5h)
Entanglement from a resource theory perspective; LOCC operations; interconvertibility of entangled resources: the pure, bipartite case (majorization); mixed state entanglement: witnesses, PPT criterion, distillation.

PART 3: THERMODYNAMICS (approx. 5h)
Quantum thermodynamics from a resource theory perspective; thermal operations; the diagonal case: thermo-majorisation; monotones and the many second laws; work extraction, work of formation; the role of quantum superposition.

PART 4: ALGORITHMS (approx. 6h)
General background on quantum algorithms; basic primitives: phase kick-back, encode pre-image in a quantum state; amplitude amplification algorithms; Hadamard-based algorithms; quantum Fourier transform.

Schedule

October 18 – November 12 (4 weeks)

Exam

A seminar to the rest of the class presenting a further topic on entanglement, thermodynamics, or algorithms. Details will be discussed in class.

Bibliography

I will mostly follow D. Jennings' great lecture notes for Part 1,2 and 4 (these will be provided). In Part 3, I will present selected topics from the review https://arxiv.org/abs/1807.11549. Nielsen and Chuang's book and Watrous lecture notes (https://cs.uwaterloo.ca/~watrous/) are also useful references to keep in mind.

RADIATION CHEMISTRY,
DR. EMANUELE SCIFONI, PROF.SSA DANIELA ASCENZI

Prerequisites

Elements of radiation physics and radiation-matter interaction. Basic knowledge of programming. Having followed the LM courses "Radiation: Detection and Applications" and "Medical Biophysics" is a useful complement.

Contents

The course is intended to focus on the particular stage of radiation - matter interaction involving generation, transport and reaction of chemical species, mostly radicals and reactive oxygen species but including also electrons and ions, and is complementing the other courses on radiation biophysics held in the department.
Mostly dedicated to biomedical applications of radiation, it will cover also radiation effects on different materials, including an overview on chemical based dosimetry. The main scope is to provide the basis for spatiotemporal resolved, mechanistic investigations of different radiation-initiated processes.
It will last 21 h, covering the following topics:

Introduction: Stages of Radiation action in medium
Ionization and Excitation products
Electron Thermalization in media and Related Phenomena
Diffusion/Reaction dynamics
Free Radicals and Scavengers
Pulse radiolysis and related experimental techniques overview
Electron and Radical interactions with DNA
Chemical based Dosimetry
Simulation Codes for Homogeneous and Heterogeneous Radiation Chemistry
Some applications: FLASH radiotherapy
Hands-on exercises with TRAX-CHEM and TOPASnBIO

Schedule

Period: March-June 2022 (detailed schedule to be agreed with the participants)

Exam

20 min seminar on a selected article OR Simulation exercise AND 10 min general questions

Bibliography

Spotheim-Maurizot: Radiation Chemistry: From Basics to Applications in Material and Life Sciences
Von Sonntag: The Chemical Basis of Radiation Biology
Others to be provided

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SELECTED TOPICS IN GEOMETRY AND TOPOLOGY

PAOLO GHIGGINI (CNRS, UNIVERSITÉ DE NANTES)

Prerequisites

The course will require fluency with calculus in several variables (partial derivatives, differentials, implicit function theorem). Basic properties of ODE (existence, uniqueness and smooth dependence on the initial value) will also be used. Basic notions of general topology will help, but will not be necessary.

Contents

The course will be a fast and rather informal introduction to differential topology and Riemannian geometry. Covered topics will include differentiable manifolds, Riemannian metrics, geodesics, vector bundles, connections and curvature, and characteristic classes.

Schedule

From the 26th of April to the 31h of May

Exam

The type of exam will be agreed with the students; the options are an oral examination on the contents of the course or a seminar on a related topic.

Bibliography

The course will not follow any text, but references for the various topics will be given in the lectures.

TALENT 2022

http://www.ectstar.eu/talent

ECT* DOCTORAL TRAINING PROGRAMME 2022

https://www.ectstar.eu/activities/trainings/

ISAPP

https://www.isapp-schools.org/isapp-schools