



UNIVERSITÀ degli STUDI di NAPOLI «Federico II»
SCUOLA DI DOTTORATO IN SCIENZE FISICHE
DOTTORATO DI RICERCA IN FISICA FONDAMENTALE ED APPLICATA

Physics PhD course catalog – 2011

(last updated on May 24th, 2011)

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- [Quantum Information](#) (Salvatore Solimeno)
- [Statistical Methods for Data Analysis](#) (Luca Lista)
- [String and brane theories](#) (Franco Pezzella)
- [Theoretical Astroparticle Physics](#) (Gianpiero Mangano)
- [Waves and Interactions in Nonlinear Media](#) (Renato Fedele)

Important note: normally, each listed course will be actually “activated” in a given year only if at least two graduate students, even of different classes or different PhD programs, choose to attend it. If only one student is interested, then the course can be often transformed into a “supervised reading” option (see the PhD educational program for details about this option).

Other courses offered by the Doctorate School in Physical Sciences

(primarily offered for the PhD program in Seismic Risk but open also to Physics PhD students):

- **Elementi di ingegneria sismica**, G. Fabbrocino, 16 ore
- **Site response analysis**, F. Silvestri, 16 ore
- **Principi di sismologia**, A. Zollo, 16 ore
- **Seismic reliability of structures**, I. Iervolino, 16 ore
- **Advances in seismic hazard analysis**, V. Convertito, 8 ore
- **Soil dynamics**, F. Silvestri, 16 ore
- **Design of geotechnical structure**, F. Silvestri, 16 ore
- **Metodi numerici per la sismologia e l'ingegneria**, G. Festa, 16 ore
- **Meccanica della sorgente sismica**, G. Festa, 16 ore
- **Early-warning sismico**, A. Zollo, 16 ore
- **Structural identification and monitoring of structures**, G. Fabbrocino, 16 ore
- **Metodi per la valutazione del rischio sismico**, G. Zuccaro, 16 ore
- **Fundamentals of theory of probabilities**, F. Jelayer, 16 ore
- **Metodi inversi**, A. Emolo, 16 ore
- **Segnali e sistemi**, L. Milano, 16 ore
- **Metodi della meccanica statistica per la frattura di materiali e la sismologia**, L. De Arcangelis, 16 ore
- **Tecnologia e reti per il monitoraggio sismico**, G. Iannaccone, 16 ore
- **Damage assessment, cost estimation and repair scheduling for performance-based earthquake engineering**, D. Vamvatsikos, 16 ore
- **Waves in heterogeneous media**, J. Virieux, 8 ore

Advanced Detectors for High Energy Physics

Instructors:	Dr. Paolo Iengo (INFN Napoli, paolo.iengo@na.infn.it), Dr. Domenico Della Volpe (Università Federico II, volpe@na.infn.it)
Credits (planned):	3
Planned hours:	18
Planned schedule:	September-November 2011
Prerequisites:	Basic knowledge of nuclear or particle physics
Description:	<p>The lecture series will focus on:</p> <ul style="list-style-type: none">- Elementary processes of matter-radiation interaction and particle detector techniques- Gaseous Detectors- Solid state detectors- Calorimetry- Particle Identification techniques- Basic design concepts of modern HEP experiments- State of the art of particle detectors (with examples from LHC, satellite and neutrino experiments)- Recent trends and current detector R&D (including micro-pattern gas detectors, novel solid state detector and recent microelectronics technology) <p>Depending on specific interest of the audience the course can be refocussed on defined topics</p>

Advanced Spectroscopies in strongly correlated systems

[course offered jointly with the PhD program on Novel Technology for Materials, Sensors and Imaging]

Instructor:	Dr. Marco Salluzzo (CNR-SPIN, salluzzo@na.infn.it)
Credits (planned):	5
Planned hours:	30
Planned schedule:	October – December 2011
Prerequisites:	None. One or two lessons (depending on the students background) will be dedicated to the few needed concepts of solid state physics.
Description:	<p>The aim of this course is to give an outline of the characteristic of the most important spectroscopy's techniques and to provide to the phd student the necessary basis to plan or to develop its own spectroscopy experiment using synchrotron light and/or scanning probe microscopy.</p> <p>Advanced spectroscopy's are the most powerful experimental tools to investigate the electronic and magnetic properties of complex materials. These techniques are based on the study of the interaction of the matter with radiation, being typically X-rays or electrons.</p> <p>Modern X-rays spectroscopy's takes advantages from the high brilliance third generation synchrotron sources. These techniques can achieve high momentum and energy resolution, but are typically unable to get spatially resolved information. Scanning tunnelling microscopy's/Spectroscopy's are on the other hand based on the extremely high spatial resolution achieved by probing the tunnelling electronic current coming from a tip in close proximity with a sample. These combined techniques can probably offer the largest possible number of information about the electronic properties of the solids. Examples of application of these techniques to different undisclosed issues in condensed matter physics will be given during the course, like the microscopic mechanism of superconductivity in the High Critical Temperature Superconductors and the exotic phase separation phenomena in manganites.</p> <p>The detailed program will include:</p> <ol style="list-style-type: none">1) Introduction to the Physics of complex, strongly correlated materials2) Electrons and X-rays as probes of the electronic density of states3) Introduction to the synchrotron light<ul style="list-style-type: none">X-ray Absorption and X-ray Photoemission SpectroscopiesExamples: HTS and other metal transitino oxidesResonant Inelastic X-ray ScatteringAngle resolved Photoemission Spectroscopy4) Introduction to the Scanning Probe Spectroscopy<ul style="list-style-type: none">TunnellingScanning Tunnelling SpectroscopyOther scanning probe Spectroscopy'sExamples: The problem of the HTS superconductivityDoping and phase separation in Manganites

An introduction to the AdS/CFT correspondence

Instructor:	Dr. Wolfgang Mueck (mueck@na.infn.it)
Credits (planned):	4
Planned hours:	24
Planned schedule:	October 2011 - January 2012
Prerequisites:	Quantum Field Theory, General Relativity and Tensor Calculus (basic knowledge)
Description:	<p>The course offers an introduction to the AdS/CFT correspondence and its applications in High Energy Physics and Condensed Matter Theory. Preliminary programme:</p> <ol style="list-style-type: none">1. Geometry of Anti-de Sitter space2. Conformal Symmetry3. Holographic Renormalization and calculation of correlation functions4. Applications<ul style="list-style-type: none">○ hydrodynamics of the quark-gluon plasma○ holographic superconductors○ quantum-critical transport○ Non-Fermi liquids and strange metals

An introduction to the Physics of Nanostructures: phenomenology, applications and theoretical aspects

[offered jointly with the Doctorate School of Industrial Engineering]

Instructor:	Dr. Giovanni Cantele (CNR-SPIN, giovanni.cantele@spin.cnr.it)
Credits (planned):	4 (about = no. hours / 6)
Planned hours:	24
Planned schedule:	June – July, or September – October
Prerequisites:	Basic knowledge of quantum mechanics. One or two lessons (depending on the students background) will be dedicated to the few needed basic concepts of solid state physics
Description:	<p>This course aims to give an overview of the basic properties and applications of nanostructured materials.</p> <p>The course can be schematically divided into two parts. The first part concerns the most recent achievements of nanotechnology and related phenomenology. The main observed phenomena occurring at the nanoscale (electronic, optical and transport properties) are described, with a focus on applications (optoelectronics, single electron transistors, and many others). Also, a short history of nanotechnology and its development is presented.</p> <p>The second part is focused on the interpretation and understanding of the observed properties in terms of basic concepts, such as electron and hole quantum confinement, effects induced by the system size and dimensionality, and so on. The main theoretical models needed to describe both the optical and electronic response and transport in nanostructured materials will be analyzed.</p> <p><u>Course outline</u></p> <p><u>Introduction</u></p> <ul style="list-style-type: none">- nanotechnology and its connection with microelectronics- synthesis techniques- new instruments and spectroscopies: STM and AFM- applications (special topics: nanopiezotronics, nanomedicine, nanoplasmonics) <p><u>Nanostructures: from zero- to two-dimensional systems</u></p> <ul style="list-style-type: none">- atomic nanoclusters: physical and structural properties- quantum dots or nanocrystals: electronic properties and devices (quantum dot lasers, single-electron transistor)- nanostructured carbon: nanotubes, fullerenes, graphene <p><u>Optical and electronic properties</u></p> <ul style="list-style-type: none">- nanocrystals, nanowires, quantum wells- elementary excitations in solids- the quantum confinement and its effects on the optical properties- transport in nanostructures <p>The students can give indication for topics of their interest that could be part of the program of the course.</p> <p>More information can be found at http://people.na.infn.it/~cantele/index.php?n=Teach.Nano</p>

Effective theories in Elementary Particle Physics

Instructor:	Dr. Giancarlo D'Ambrosio (INFN- Sez. Napoli, gdambros@na.infn.it),
Credits (planned):	3-4
Planned hours:	18-24
Planned schedule:	to be discussed
Prerequisites:	none in particular
Description:	Effective theories dimensional analysis, Fermi theory, .. Chiral perturbation theory: theoretical foundations and applications Determination of the Cabibbo-Kobayashi-Maskawa angles Flavor physics and rare decays Standard Model and Higgs instability Precision physics and electroweak parameters Physics Beyond the Standard Model: motivations Technicolor and Higgsless models, Little Higgs, extra dimensions Supersymmetry and breaking schemes (gauge and gravity mediation, split supersymmetry) GIM mechanism and Physics Beyond the Standard Model (Minimal Flavour violation) Effects for extreme values of the vacuum expectation values of the Higgs fields (Large tangent beta effects)

Experimental methods for Astroparticle Physics	
Instructor:	Prof. Giuliana Fiorillo (Università di Napoli Federico II, giuliana.fiorillo@na.infn.it),
Credits (planned):	6 (about = no. hours / 6)
Planned hours:	36
Planned schedule:	May /July 2011
Prerequisites:	Basic knowledge of particle physics and radiation detectors. Background in Cosmology is welcome, but not strictly necessary
Description:	<p>Syllabus:</p> <p>Review of the concepts of particle physics Experimental techniques for particle detectors Neutrinos</p> <ul style="list-style-type: none"> - neutrino masses and oscillations - solar and stellar neutrinos - atmospheric neutrinos - high energy neutrinos - detectors for neutrino physics <p>Contents and dynamics of the universe Cosmological parameters Dark matter: relics from the primordial universe Particle detectors for dark matter</p> <ul style="list-style-type: none"> - direct detection techniques - indirect detection techniques <p>Reference books:</p> <ul style="list-style-type: none"> • D. Perkins, 'Particle Astrophysics', Oxford University Press, ISBN 0-19-850952. • L. Bergström and A. Goobar, 'Cosmology and Particle Astrophysics', J. Wiley & Sons, ISBN 0-471-970542. • W.R. Leo, 'Techniques for Nuclear and Particle Physics Experiments', Springer-Verlag, ISBN 3-540-57280-5.

Extended theories of Gravity and the problem of Dark Energy and Dark Matter

Instructor:	Prof. Salvatore Capozziello (University,of Naples) capozziello@na.infn.it
Credits (planned):	2
Planned hours:	12
Planned schedule:	April-May
Prerequisites:	General Relativity, Cosmology, Quantum Field Theory
Description:	<p>Abstract: Extended theories of gravity can be related to several unification approaches and fundamental theories of interactions. They have recently attracted a lot of interest as alternative candidates to explain the observed cosmic acceleration, the flatness of the rotation curves of spiral galaxies, the gravitational potential of galaxy clusters, and other relevant astrophysical phenomena. Very likely, what we call “dark matter” and “dark energy” are nothing else but signals of the breakdown of General Relativity at large scales. Furthermore, PPN-parameters deduced from Solar System experiments do not exclude, a priori, the possibility that such theories could give small observable effects also at these scales. I review these results giving the basic ingredients of such an approach.</p> <p>Topics:</p> <ol style="list-style-type: none">1. Observational cosmology: an overview2. Dark Energy and dark Matter from the observations3. Physical and Mathematical Foundations of Extended Theories of Gravity4. Dark Energy and Dark Matter as Curvature Effects5. Probing Extended Theories of Gravity at Fundamental Level6. Advanced issues: GRBs to discriminate among Cosmological Models <p>References:</p> <p>S. Capozziello, V. Faraoni “ <i>Beyond Einstein Gravity</i>” Fundamental Theories of Physics, Springer, Dordrecht 2010</p>

Fluctuation relations and Nonequilibrium Thermodynamics

Instructor:	Prof. Luca Peliti (University, peliti@na.infn.it)
Credits (planned):	3
Planned hours:	18
Planned schedule:	Spring term, 2012
Prerequisites:	knowledge of classical equilibrium statistical mechanics at an introductory level (theory of ensembles, statistical representation of thermodynamics)
Description:	<ul style="list-style-type: none">• Classical theory of quasi-equilibrium. Fluctuation-dissipation theorem, Onsager relations, variational principle for steady states close to equilibrium.• Path probabilities. Work and heat production. Crook's inversion relations. Gallavotti-Cohen relation.• Jarzynski's relation and its applications.• Different forms of the fluctuation theorem: Sasa-Hitano, Seifert...• Is there an entropy out of equilibrium? Oono-Paniconi, Jona-Lasinio, Komatsu-Sasa.• Experiments and applications to biomolecules.

Formation of Cosmic Structures	
Instructor:	Dr. Giovanni Covone (Università “Federico II”, covone@infn.it)
Credits (planned):	3
Planned hours:	20
Planned schedule:	Autumn-Winter 2011 (to be agreed with students)
Prerequisites:	Basic concepts in Astrophysics and General Relativity will be introduced in the course when necessary.
Description:	<ol style="list-style-type: none"> 1. Cosmological background <ul style="list-style-type: none"> Introduction to Relativistic Cosmology Thermal history of the Universe Decoupling and the Origin of the Cosmic Microwave Background 2. Formation of cosmic structures <ul style="list-style-type: none"> Growth of fluctuations in the expanding Universe Hierarchical Structure Formation Introduction to Jeans Theory Gravitational collapse and collisionless dynamics 3. The cosmic density field <ul style="list-style-type: none"> Large scale structure and its evolution Fluctuations in the Cosmic Microwave Background Clustering of galaxies 4. Formation and structure of dark matter halos <ul style="list-style-type: none"> Press-Schechter theory Evolution of DM halos and merging tree Formation and evolution of gaseous halos Adiabatic contraction 5. Gravitational lensing as a cosmological probe <ul style="list-style-type: none"> Introduction to optical geometry in curved spacetime The lensing equation Strong and weak lensing by galaxies and clusters of galaxies Cosmic shear

From Classical to Quantum Gravity

Instructor:	Dr. Giampiero Esposito gesposit@na.infn.it (INFN)
Credits (planned):	5
Planned hours:	30
Planned schedule:	Summer or autumn 2011
Prerequisites:	Introductory courses in quantum field theory and general relativity
Description:	Functional integral approach to quantum gravity. Heat kernel method. Supergravity and braneworld.

Green's functions and many-body physics

Instructors:	Prof. Vittorio Cataudella (University, cataudella@na.infn.it), Dr. Giulio De Filippis (University, defilippis@na.infn.it), Prof. Vincenzo Marigliano Ramaglia (University, marigliano@na.infn.it), Dr. C. Antonio Perroni (University, perroni@na.infn.it)
Credits (planned):	3-4
Planned hours:	18-24
Planned schedule:	
Prerequisites:	second quantization
Description:	<p>The aim of the course is to provide a practical application of the Green's function technique to the physics of many particle systems in condensed matter.</p> <ul style="list-style-type: none">- Single-particle Green's functions: resolvent- Quantum transport: Landauer-Buettiger formalism- Green's functions at zero and finite temperature for interacting systems- Linear response and Kubo formulas- Degenerate electron gas- Electron-phonon interaction and ac and dc conductivities

Heavy Flavour Physics	
Instructor:	Dr. Giulia Ricciardi (University, giulia.ricciardi@na.infn.it)
Credits (planned):	2
Planned hours:	12
Planned schedule:	To be defined
Prerequisites:	Basics of quantum field theory and of the Standard Model. Suitable for both theoreticians and experimentalists.
Description:	<p>Flavour physics, in contrast to 'gauge physics', addresses questions such as why there are so many different species (flavours) of quarks and leptons, why they come in groups (families), why they have their masses, what their couplings are, etc. Recently, the dedicated study of b-flavoured hadrons has developed into one of the most active and promising areas of high-energy physics. Subject of this lectures are the main theoretical tools required to understand and exploit this rich source of data.</p> <p>The course is structured in 6 lectures, of about 1.5 hour each. The last lesson is dedicated to explain and update on present basic research.</p> <ol style="list-style-type: none"> 1. Introduction to flavour physics. The standard Model and the CKM matrix 2. CP violation in mixing and decays 3. The Standard analysis of the Unitarity triangle(s) 4. Effective field theories and related theoretical tools 5. Heavy Quark Effective Theory: a short exposition 6. Applications to B systems and inclusive B decays, present status of the field

High-Energy Physics at the Large Hadron Collider (LHC)

Instructors:	Dr. Luca Lista (INFN, luca.lista@na.infn.it) Prof. Vincenzo Canale (DSF – UniNapoli - canale@na.infn.it)
Credits (planned):	4
Planned hours:	24
Planned schedule:	To be agreed with participants
Prerequisites:	Basic knowledge of particle physics
Description:	<p>The course will cover the following topics:</p> <ul style="list-style-type: none">- The Standard Model of particle physics after LEP, HERA and Tevatron data- The LHC: accelerator and detectors- Hadron interactions (QCD, structure functions, underlying events, jets, diffractive physics)- The hunt for the Higgs boson- Electroweak Physics- Physics Beyond the Standard Model- Connection with Cosmology: the search for Dark Matter- Physics during the first two years of data taking

Introduction to Mesoscopic Physics	
Instructor:	Dr. Procolo Lucignano (CNR-SPIN, procolo.lucignano@spin.cnr.it)
Credits (planned):	4 – 5 Depending on the students
Planned hours:	~24 - 30
Planned schedule:	Sept/Oct/Nov 2011
Prerequisites:	Elementary quantum mechanics and solid state physics. One or two preliminary lectures to Green functions technique will be given if necessary.
Description:	<ul style="list-style-type: none"> • Quantum electron transport at the nano-scale: coherent vs. incoherent transport. • Ballistic limit: the Landauer approach and the Scattering matrix. • Diffusive limit: electron propagation in disordered media. • From Drude Boltzmann theory to Weak Localization. Universal Conductance Fluctuations. • Scaling theory of electron transport. • Random Matrix Theory of quantum electron transport: universalities and simple applications. • Quantum dots: Coulomb blockade and Kondo effect. • Impurity models, phenomenology, perturbation theory and RG. • Mesoscopic superconductivity: disordered superconductors. • Quantum Hall effect, Quantum Spin Hall effect and Topological Insulators. • Basics on photon propagation in disordered media: analogies and differences between electron and photon propagation in disordered media. <p style="margin-top: 10px;">Depending on the audience we will make a fine tuning of the proposed program.</p>

Introduction to Near-field Optics

[course offered jointly with the PhD program on Novel Technology for Materials, Sensors and Imaging]

Instructor:	Dr. Antonio Ambrosio (CNR-INFM, antonio.ambrosio@spin.cnr.it)
Credits (planned):	2
Planned hours:	12
Planned schedule:	September – October
Prerequisites:	Basic knowledge about optics and lasers
Description:	The course will be tutorial on the most recent techniques aimed at breaking the resolution limits of classical optics. Among these, general aspects of near-field optics will be treated with special focus on Scanning Near-field Optical Microscopy (SNOM). It will be discussed how near-field optics permits to overcome the diffraction limit of classical microscopy and makes it possible both high resolution lithography and spectroscopy of single nano-objects.

Introductory course on the Geant4 Simulation Toolkit

Instructor:	Dr. Gianfranca De Rosa (INFN, gderosa@na.infn.it)
Credits (planned):	3-4
Planned hours:	18-24
Planned schedule:	
Prerequisites:	Basic knowledge of computer programming in C++ language is recommended. The exercises are performed in a Linux environment.
Description:	<p>Geant4 is a software toolkit for the simulation of the interaction of particles with matter based on object oriented technology. Its application areas include high energy physics experiments, astrophysics and astroparticle physics, nuclear physics, space science, medical physics and medical imaging, radiation protection etc.</p> <p>The course provides an overview of Geant4 capabilities and teaches how to simulate an experimental set-up; the lectures are complemented by hands-on exercises. At the end of the course the students develop their own simulation applications based on the Geant4 toolkit. A topic related to the interest field of the student is encouraged.</p> <p>The course is structured in 9-12 lectures, of about 2 hour each.</p> <p>The program will include:</p> <ol style="list-style-type: none">1) Overview of Geant4 capabilities and Geant4 installation2) How to describe an experimental set-up: modelling an experimental configuration3) Particles and physics processes4) Visualisation and User interface5) Encoding simulation results: Hits and Digits6) Analyzing results from the simulation

Lectures of fluid-dynamics with applications in astrophysics

Instructor:	Dr. Ester Piedipalumbo (University, ester@na.infn.it)
Credits (planned):	3
Planned hours:	20
Planned schedule	Sept.- Dec. 2011
Prerequisites:	None.
Description:	<p>Introduction</p> <ol style="list-style-type: none">1. The microscopic description2. Relationship between microscopic and macroscopic descriptions: the ensembles <p>Transition to the dynamics of fluids through the statistical mechanics description</p> <ol style="list-style-type: none">1. BBGKY and Boltzmann equations for the distribution function f2. The momenta of f3. The hydrodynamical equations <p>Classical fluids</p> <ol style="list-style-type: none">1. Continuity equations2. The equation of motion3. The energy balance equation <ul style="list-style-type: none">• The zeroth-order approximation. Perfect fluids<ol style="list-style-type: none">1. Euler's equations2. Basic astrophysical approximations• The zeroth-order approximation. Imperfect fluids<ol style="list-style-type: none">1. Diffusion2. Viscosità and heat conduction3. Navier-Stokes equations <p>Relativistic fluids</p> <ol style="list-style-type: none">1. The distribution function f2. Transport fluxes3. Perfect fluids4. Boltzmann's equation <ul style="list-style-type: none">• Photon fluids<ol style="list-style-type: none">1. The black body2. The grey body• Basic astrophysical approximations<ol style="list-style-type: none">1. Stellar atmospheres2. Interstellar extinction <p>The Fluid in a star The Fluid of stars (galaxies) The Fluid of galaxies (cosmological fluid)</p>

Non-commutative Geometry

Instructor:	Prof. Fedele Lizzi (University, fedele.lizzi@na.infn.it)
Credits (planned):	4
Planned hours:	24
Planned schedule:	
Prerequisites:	Apart from the usual classes in Quantum Mechanics and Mathematical Methods: Quantum Field Theory (or in general some knowledge of the standard model). Also helpful, but not essential, are the courses of Classical Field Theory, Geometrical Methods, Advanced Quantum Mechanics and String Theory.
Description:	<p>Module 1:</p> <ul style="list-style-type: none">• The Noncommutative Geometry of Quantum Phase Space• Deformed Products• Mathematical Foundations of Noncommutative Geometry• Spectral Geometry• The Noncommutative Geometry of the Standard Model• Noncommutative Spaces of Physical Interest, fuzzy spaces• Basics of Quantum Groups <p>Module 2</p> <ul style="list-style-type: none">• Field Theories on Noncommutative Spaces• Noncommutative Geometry of Spacetime at Planck's Length• Twisted Symmetries of Quantum Field Theory on Noncommutative Spaces and connections with Quantum Groups <p>Note: the second module deals with topics in rapid evolution, and therefore the programme will be decided based on the most recent results, as well as the students' interest.</p>

Nuclear fission	
Instructor:	Prof. Giovanni La Rana (University, larana@na.infn.it)
Credits (planned):	4
Planned hours:	24
Prerequisites:	basic knowledge of nuclear physics
Description:	<p>- Spontaneous and low energy fission. Liquid drop model. Transitional state theory. Shell effects on fission barrier. Nilsson model. Strutinsky's prescription for shell corrections. Double humped fission barriers. Shape isomers. Super deformed bands. Experimental methods.</p> <p>- Decay of hot rotating compound nuclei. The statistical model for spherical and deformed nuclei. Rotating liquid drop model. Studies of fission dynamics. The neutron clock technique. Nuclear viscosity. One body and two body dissipation. Langevin and Fokker Planck equations. Modified statistical model. Experimental methods and overview of the studies of fission dynamics.</p>

Nuclear matter theory

Instructor:	Dr. Luigi Coraggio (INFN, coraggio@na.infn.it)
Credits (planned):	3
Planned hours:	20
Prerequisites:	none
Description:	Basic properties of the nuclear matter -The Fermi gas model - The nucleon-nucleon potential - The Brueckner theory - The reaction matrix G - The Bethe-Brandow-Petschek theorem -The Brueckner-Hartree-Fock approach - Calculation of reaction matrix with the momentum space matrix equation method - Lowest order Brueckner-Hartree-Fock theory - Microscopic derivation of the nuclear matter equation of state and neutron stars.

Ordered phases of Condensed Matter	
Instructors:	Prof. Arturo Tagliacozzo (University “Federico II”, arturo@na.infn.it), Dr. Procolo Lucignano (CNR-INFM), procolo.lucignano@spin.cnr.it , Dr. Domenico Giuliano (University of Cosenza), domenico.giuliano@fis.unical.it
Credits (planned):	5 (about = no. hours 30 / 6) or according to students request
Planned hours:	30
Planned schedule:	April –May-June four hours twice a week (tentative)
Prerequisites:	Phenomenology of Condensed Matter , Quantum Mechanics
Description:	<p>It is a theoretical overview on :</p> <p>broken symmetry in Superconductivity and Magnetism in various space dimensions, Topological order in Quantum Hall effect.</p> <p>Tools are: functional integration of Fermions and coherent spin states, non-linear sigma model and XY model, Kondo Impurity Model, Berry phase and Chern numbers , one dimensional Luttinger liquid</p>

Particle Physics at LHC	
Instructor:	Prof. Giulia Ricciardi (University, giulia.ricciardi@na.infn.it)
Credits (planned):	2
Planned hours:	12
Planned schedule:	Winter 2011 or Spring 2012
Prerequisites:	The lecture is intended for theoretical and experimental students who have been exposed to the basics of particle physics (Feynman diagrams, Standard Model, spontaneous symmetry breaking,...)
Description:	<p>For the first time since the deep inelastic experiments of the '60s the high energy physics community is approaching an energy frontier where we can expect the unexpected. The high energy physics community is shifting back to focusing on experiment-driven interpretation of collider data as we approach the era of the Large Hadron Collider, LHC.</p> <p>The course will cover some aspects of the physics at the LHC from the phenomenological point of view.</p> <p>The lectures include the following topics:QCD processes at the LHC: the Physics of the Electroweak Gauge Bosons, Top Quark Physics, Higgs Physics.</p>

Photon Detectors

[course offered jointly with the PhD program on Novel Technology for Materials, Sensors and Imaging]

Lecturer	Prof. Paolo Russo
Affiliation	Physics Department, Università <i>Federico II</i> ph. 081 676146, 081 676339, e-mail paolo.russo@na.infn.it
Course objectives	This is an introductory course to photon detectors in the visible and near infrared, providing basic information on detector technologies currently available commercially for spectroscopy and imaging, down to the photon counting regime of light intensity.
Schedule	April 4th 2011
General information	Frontal lectures, 12 lectures, 2h/lecture, 2 lectures/week. Lecture hall c/o Dipartimento Scienze Fisiche, complesso universitario Monte S. Angelo, via Cintia, Napoli.
Contents and topics	PMT (PhotoMultiplier Tubes) PSPMT (Position sensitive PMT) Flat panel PMT Photodiodes PMOS (p type Metal Oxide Semiconductor) devices CCD (Charge Coupled Devices), including TDI-CCD (Time-Delay Integration) and EM-CCD (Electron Multiplier CCD) CMOS (Complementary MOS devices APD (Avalanche photodiode detectors) HPD (Hybrid photon detectors) SiPM (MPPC) Silicon photomultipliers
Evaluation	Slide presentation and discussion of the characteristics of a specific photon detector device
Course weight	3 FC

Physics of Plasmas and Particle Beams in Laboratory and Space	
Instructor:	Prof. Renato Fedele (University, renato.fedele@na.infn.it)
Credits (planned):	5
Planned hours:	32
Prerequisites:	General Physics, Fundamentals of Quantum Mechanics
Description:	<p>This course provides an introduction to the physics of both plasmas and charged particle beams in the presence of collective effects. The course contains a short preparatory part on kinetic theory and statistical mechanics, then develops the subject matter on the basis on the kinetic and fluid theories within the contexts of both classical and quantum physics, with emphasis on the relevant applications to plasma-based particle accelerators, condensed matter physics and astrophysics.</p> <p>In particular, the course includes the following topics:</p> <ul style="list-style-type: none"> - nonlinear stability and confinement theorems; - collective waves and instabilities in laboratory and space physics; - coherent electromagnetic radiation generation by free electron lasers; - nonlinear processes and particle acceleration in astrophysical environments; - nonlinear processes related to compact plasma-based accelerator concepts.

Physics of Soft Matter

[course offered jointly with the Doctorate School of Industrial Engineering]

Instructor:	Prof. Giancarlo Abbate (University, abbate@na.infn.it)
Credits (planned):	2-3
Planned hours:	12-18
Expected to be held in	May 2011
Prerequisites:	Not specified
Description:	<ul style="list-style-type: none">- Atomic and molecular arrangements.- The order parameter: (a) The order parameter space; (b) The specific order parameter of liquid crystals: the director; (c) Optics of anisotropic media: application to director fields.- Phase transitions in liquid crystals.- Phase transitions in polymers: (a) Polymer crystallization; (b) Crystalline and amorphous polymers: melting and glass transitions.- Surface phenomena: (a) In isotropic media; (b) In anisotropic media- Optical Fréederiks transition.- Trends of scientific research in the field of soft matter physics

Physics of Superconducting and Spintronic Devices

[course offered jointly with the Doctorate School of Industrial Engineering]

Instructor:	Prof. G.P. Pepe (University, gpepe@na.infn.it)
Credits (planned):	4
Planned hours:	24
Planned schedule:	
Prerequisites:	None
Description:	Introduction to Superconductivity. Nonequilibrium superconductivity and advanced detectors. The Josephson effect, and aspects of Josephson electro-dynamics, macroscopic quantum physics and applications in the field of quantum computation. dc SQUID: theory and applications to biomagnetism, non destructive testings of materials and structures, electronics. Spintronics: general aspects, main devices based on the spin control (GMR, TMR, etc.). Aspects of superconductive spintronics.

Quantum Information	
Instructor:	Prof. Salvatore Solimeno (University, solimeno@na.infn.it)
Credits (planned):	3
Planned hours:	18
Planned schedule:	To be agreed with interested students
Prerequisites:	Basic quantum mechanics
Description:	<p>Sketch of the syllabus (to be adjusted and modified):</p> <p>Classical information, basics. Quantum mechanics: entanglement and EPR paradox, Bell's inequalities, hidden variables theory. Entropy and information: Shannon entropy, Binary entropy, conditional, mutual, relative entropy and information von Neumann entropy. Markovian processes, information correlation in Markovian processes and density matrix formalism. Qubits and their evolution: entanglement and decoherence. Entangled two-qubit systems. Quantum gates. Quantum algorithms. Quantum communication and cryptography.</p>

Statistical Methods for Data Analysis	
Instructor:	Dr. Luca Lista (INFN, luca.lista@na.infn.it)
Credits (planned):	2-3
Planned hours:	12-18
Planned schedule:	To be agreed with participants
Prerequisites:	Basic knowledge of the concept of probability. Examples and exercises will be done in C++, so basic knowledge of computer programming is recommended.
Description:	<p>Statistical methods for data analysis:</p> <ul style="list-style-type: none"> • Statistics and probability distributions • Parameter estimates and maximum likelihood (ML) and extended ML methods • The Bayes theorem: frequentistic and Bayesian approaches • Computation of upper limits • Combining measurements • Monte Carlo techniques • Fit quality with Toy Monte Carlo • Multivariate discrimination methods • Artificial Neural Networks <p>Introduction to statistics application frameworks based on ROOT toolkit:</p> <ul style="list-style-type: none"> • RooFit • TMVA

String and brane theories

Instructors:	Dr. Franco Pezzella (INFN, pezzella@na.infn.it), Dr. Raffaele Marotta (INFN, imarotta@na.infn.it)
Credits (planned):	5
Planned hours:	30
Planned schedule:	
Prerequisites:	Special Relativity and its covariant formalism, Quantum Mechanics, basic knowledge of Quantum Field Theory.
Description:	Classical and quantum aspects of bosonic strings and superstrings are discussed together with more recent topics as D-branes, dualities and gauge/gravity correspondence.

Theoretical Astroparticle Physics

Instructor:	Dr. Gianpiero Mangano (INFN - mangano@na.infn.it)
Credits (planned):	8
Planned hours:	12
Planned sched.:	→ April 4th 2011
Prerequisites:	
Description	<p>1) Cosmologia Standard (Lezioni I,II) 1.1 Résumé di Cosmologia Standard. 1.2 Storia termica dell'Universo.</p> <p>2) Termodinamica dell'universo in espansione e fenomeni di non equilibrio (Lezioni III-XII) 2.1 Insiemi microcanonico, canonico e gran-canonico. 2.2 Equilibrio cinetico e chimico. Potenziali termodinamici. Conservazione dell'entropia. 2.3 Teoria cinetica. Bilancio dettagliato. Quantità conservate. Approccio all'equilibrio. 2.4 Equazione di Boltzmann relativistica. Condizione di disaccoppiamento. 2.5 La Nucleosintesi Primordiale. Disaccoppiamento dei neutrini. I neutrini del fondo. 2.6 Bariogenesi. Teorema di Sakharov e modelli proposti. 2.7 La superficie di ultimo scattering e la CMB. 2.8 Evidenze per la materia oscura. 2.9 I WIMP's ed il calcolo della densità fossile. 2.10 Candidati per la materia oscura. Misure indirette di materia oscura.</p> <p>3) Inflazione (Lezioni XIII-XX) 3.1 Il background e la soluzione dei problemi della Cosmologia Standard. 3.2 Slow roll. Modelli di inflazione. 3.3 Le perturbazioni e le condizioni iniziali per la CMB e le strutture a larga scala. Trasformazioni di gauge e potenziali di Bardeen. 3.4 Onde gravitazionali. 3.5 Perturbazioni scalari. Spettro invariante di scala di Harrison-Zeldovich.</p> <p>4) Il Power Spectrum, le anisotropie della radiazione cosmica di fondo e la determinazione dei parametri cosmologici (Lezioni XXI-XXX) 4.1 Evoluzione delle perturbazioni. 4.2 Il power spectrum e la sua dipendenza dai parametri cosmologici. Le anisotropie della radiazione di fondo. 4.3 Determinazione dei parametri cosmologici nel modello "vanilla". 4.4 Effetto dei neutrini massivi. 4.5 La Dark energy. 4.6 BAO, Baryon Acoustic Oscillations.</p> <p>5) Cenni sull'evoluzione non lineare delle perturbazioni (Lezioni XXXI-XXXII)</p>

- 5.1 Formulazione euleriana. Termini non lineari.
- 5.2 Propagatore. Contributi ad 1-loop. Tecniche diagrammatiche di risommazione.
- 5.3 Simulazioni N-body.

Indicazioni bibliografiche

Testi di riferimento:

- R1) K. Huang, Statistical Mechanics, John Wiley
- R2) V. Mukhanov, Physical Foundations of Cosmology, Cambridge University Press
- R3) F. Bernardeau, S. Colombi, E. Gaztanaga e R. Scoccimarro, Large-Scale Structure of the Universe and Cosmological Perturbation Theory, astro-ph/0112551

Testi supplementari:

- S1) E. W. Kolb e M. S. Turner, The Early Universe, Westview Press
- S2) S. Dodelson, Modern Cosmology, Academic Press
- S3) S. Weinberg, Cosmology, Oxford University Press

Waves and Interactions in Nonlinear Media	
Instructor:	Prof. Renato Fedele (University, renato.fedele@na.infn.it)
Credits (planned):	4
Planned hours:	25
Prerequisites:	Classical Electrodynamics, Fundamentals of Quantum Mechanics, Fundamentals of Statistical Mechanics
Description:	The course is interdisciplinary and gives a general description of the propagation of waves in nonlinear media and their interactions (three and four waves parametric processes). Some physical examples in nonlinear optics (Kerr media, optical fibers), surface gravity waves (ocean waves), large amplitude waves in plasmas (Langmuir wave packets) and matter waves physics (Bose-Einstein condensates) are given. From these examples, a unified description modelled by suitable nonlinear Schrödinger equations is extrapolated. Such a description is then extended to phase space by means of the Wigner quasi-distribution. Particular attention is devoted to both theoretical and experimental aspects of the modulational instability and the related stabilizing role of the Landau damping for an ensemble of partially incoherent waves.