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 – 2008

(last updated on 29/2/2008)

Courses offered primarily for the *PhD program in fundamental and applied physics*:

- **Advanced astrophysics**, G. Longo
- **Advanced Spectroscopies in strongly correlated systems**, M. Salluzzo
- **Cosmology: theory and observations**, G. Mangano
- **Data acquisition and analysis**, G. Mettivier
- [**Detection Principles and Techniques in Quantum Optics**, A. Porzio] (not offered in 2008, planned for 2009)
- **Effective theories in elementary particle physics**, G. D'Ambrosio
- **Electrodynamics of novel materials**, A. Andreone
- **Fluctuation relations and nonequilibrium thermodynamics**, L. Peliti, A. Imparato
- **From classical to quantum gravity**, G. Esposito
- **From nuclear forces to nuclear structure**, A. Covello
- **Green's functions and many-body physics**, V. Cataudella, G. De Filippis, V. Marigliano, C. Perroni
- **Heavy Meson Physics**, P. Santorelli
- **Heavy Quark Effective theory**, G. Ricciardi
- [**High-energy astrophysics**, B. D'Ettorre Piazzoli, G. Fiorillo] (not offered in 2008, planned for 2009)
- [**High energy physics at the Large Hadron Collider (LHC)**, L. Rolandi] (not offered in 2008, planned for 2009)
- **High resolution techniques in Optics: from Near-field Optics to Quantum Systems**, A. Ambrosio, Virginia D'Auria
- **Introduction to SuSy**, F. Nicodemi
- **Introduction to the physics of nanostructures: phenomenology, applications and theoretical aspects**, G. Cantele
- **Introduction to the physics of the quantum Hall regime**, G. Cristofano, A. Naddeo
- **Issues in condensed matter physics**, A. Tagliacozzo
- **Lattice QCD**, G. Ricciardi
- **Lectures of fluid-dynamics with applications in astrophysics**, M. Capaccioli, E. Piedipalumbo, C. Rubano
- **Light Scattering: Theory and Applications**, A. Bruno, X. Wang
- **Non-commutative geometry**, F. Lizzi
- **Nuclear astrophysics**, L. Gialanella, L. Coraggio
- **Nuclear fission**, G. La Rana
- **Nuclear matter theory**, L. Coraggio
- **Optical and transport properties of metals and semiconductors**, G. Iadonisi
- **Optical techniques for the analysis of micro- and nano-sized systems**, G. Rusciano
- **Parton Model and Structure functions**, G. Ricciardi
- **Physics of plasmas and particle beams in Laboratory and Space**, R. Fedele
- **Physics of soft matter**, G. Abbate
- **Physics of strong interactions**, G. Ricciardi
- **Physics of superconductor and spintronic devices**, G. Pepe
- [**Quantum field theories**, F. Pezzella] (not offered in 2008, planned for 2009)
- **Quantum Information**, S. Solimeno
- [**Statistics and data analysis for (high-energy) physicists**, S. Mele] (not offered in 2008, planned for 2009)
- **String and brane theories**, F. Pezzella
- **Surface physics: basic principles, analysis techniques and applications**, S. Lettieri
- **Techniques of scanning microscopy**, M. Iavarone
- **Waves and interactions in nonlinear media**, R. Fedele

Other courses offered by the Doctorate School in Physical Sciences (primarily offered for the *PhD program in seismic risk* but open also to physics students):

- **Comportamento sismico delle strutture**, A. Baratta, 2 CFU
- **Metodi della meccanica statistica per la frattura di materiali e la sismologia**, L. De Arcangelis, 4 CFU
- **Segnali e sistemi**, L. Milano, 4 CFU
- **Sorgente sismica con applicazioni alla simulazione del moto del suolo**, G. Festa, 4 CFU
- **Elementi di geotecnica sismica, G. Fabbrocino e F. Santucci**, 4 CFU
- **Principi di sismologia con applicazioni al problematiche di early-warning sismico**, A. Zollo, 2 CFU
- **Rischio sismico e normativa**, G. Zuccaro, 3 CFU
- **Theory of probability and its application in earthquake engineering**, I. Iervolino e F. Jalayer, 4 CFU
- **Metodi inversi**, A. Emolo, 4 CFU

Courses offered by other Doctorate Schools that are of likely interest for physics PhD students (cross-listed courses):

- **Metodi Matematici per l'Apprendimento Statistico**, E. De Vito (Doctorate School in Mathematical and Information Sciences)
- **Dinamiche non lineari**, S. Crescitelli, M. di Bernardo, C. Serpico (Doctorate School of Industrial Engineering)
- **Thermomechanics of Soft Matter**, G. Marrucci (Doctorate School of Industrial Engineering)

  Please note that this list of cross-listed courses is obviously not complete: you are invited to look at the catalogs of other Doctorate Schools in the University and if you find something interesting you are free to insert it in your proposed study plan

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).

Advanced astrophysics	
Instructor(s):	Prof. Giuseppe Longo (University, Giuseppe.longo@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	
Description:	The course will cover three topics: - Observational aspects and theoretical models for dark matter - Formation of planets: theory and constrains from exo-planets - Supernovae: observations and models.

Advanced Spectroscopies in strongly correlated systems	
Instructor(s):	Dr. Marco Salluzzo (CNR-INFM, salluzzo@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	None. One or two lessons (depending on the students background) will be dedicated to the few needed concepts of solid state physics.
Description:	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. 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. 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. The detailed program will include: 1) Introduction to the Physics of complex, strongly correlated materials 2) Electrons and X-rays as probes of the electronic density of states 3) Introduction to the synchrotron light a. X-ray Absorption and X-ray Photoemission Spectroscopies b. Examples: HTS and other metal transitino oxides c. Resonant Inelastic X-ray Scattering d. Angle resolved Photoemission Spectroscopy 4) Introduction to the Scanning Probe Spectroscopy a. Tunnelling b. Scanning Tunnelling Spectroscopy c. Other scanning probe Spectroscopy's d. Examples: The problem of the HTS superconductivity e. Doping and phase separation in Manganites

Cosmology: theory and observations	
Instructor(s):	Dr. Gianpiero Mangano (INFN, mangano@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	Knowledge of basics of General Relativity is welcome, though the issue is also covered in the first lectures
Description:	The basic structures of General Relativity The Standard Cosmological Model Primordial Nucleosynthesis Inflation Linear Perturbations The Cosmic Microwave Background radiation Large Scale Structure

Data acquisition and analysis	
Instructor(s):	Dr. Giovanni Mettivier (University, mettivier@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	
Description:	- Introduction to data acquisition system - Sensors and data acquisition from system - Signal conditioning (amplification, sampling, filtering,.) - Analogic to digital conversion, digital to analogic conversion, resolution - Traditional and Computer Based instrument, plug-in board instrument, virtual instrument - Data transmission protocol - Wired protocols (USB, FireWire, Ethernet, RJ485, RS232, RS422, GPIB) - Wireless protocols (WiFi, EDGE, GSM, GPRS, UMTS, Bluetooth, Irda) - C language - Software Development Kit: LabVIEW, LabWindows. - Data Elaboration software: Matlab, ImageJ References -- J.Y. Beyon, "LabVIEW programming, data acquisition, and analysis", Prentice Hall, New York, 2001. -- B.W. Kernigham, D.M. Ritchie. "Linguaggio C", Jackson Libri Matlab, Language of Technical computing, Matworks (Programming Manual). Lesson notes

[Detection Principles and Techniques in Quantum Optics] (not offered in 2008, planned for 2009)	
Instructor(s):	Dr. Alberto Porzio (CNISM, Napoli alberto.porzio@na.infn.it)
Credits (planned):	2
Planned hours:	12
Prerequisites:	Not specified
Description:	The quantum field: from Maxwell eqs to the quantum Hamiltonian (Phenomenology and formal approach). The observables for the quantum field. (Photon Number and Field Quadratures). Photodetection. The standard quantum limit (shot noise). Photon counting. Homodyne and Heterodyne (classical and quantum). Quantum tomography of the radiation state. Quantum non-demolition measurements.

Dinamiche non lineari (cross-listed, course offered by the Doctorate School of Industrial Engineering)	
Instructor(s):	Profs. Silvestro Crescitelli, Mario di Bernardo, Claudio Serpico (University, crescitelli@unina.it))
Credits (planned):	3
Planned hours:	16
Prerequisites:	Not specified
Description:	**1**-Sistemi dinamici: generalità Sistemi fisici, idealizzati (modelli matematici) ed astratti (sistemi dinamici) Orbite e diagrammi di fase Transitori e regimi **2**-Sistemi dinamici:definizioni e classificazione Definizione formale di sistema dinamico Classificazione dei sistemi dinamici (discreti, continui; conservativi, dissipativi …) Mappe di Poincaré di sistemi continui **3**-Geometria e stabilità di sistemi lineari Richiami di teoria dei sistemi (lineari) Autospazi: stabili, instabili e centrali Condizioni di stabilità Attrattori, repulsori, selle ed altro **4**-Geometria e stabilità per sistemi non lineari Stabilità (locale) di orbite e linearizzazione Varietà stabili, instabili e centrali di punti di equilibrio ed orbite periodiche Orbite limitate: attrattori, repulsori, selle ed altro Bacini di attrazione **5**-Stabilità strutturale e biforcazioni Equivalenza topologica globale e locale Stabilità strutturale Biforcazioni: generalità e classificazioni Metodologie di studio delle biforcazioni: varietà centrali e forme normali **6**-Biforcazioni locali di equilibri di sistemi continui Biforcazioni sella/nodo, forcone, transcritica ed Hopf Diagrammi delle soluzioni di regime Stabilità delle biforcazioni e diagrammi delle biforcazioni **7**-Biforcazioni locali per sistemi discreti e di cicli limite di sistemi continui Biforcazioni fold, forcone, transcritica, flip, Naimark-Sacker Biforcazioni di cicli limite Biforcazioni globali Vie al caos **8**-Metodologie numeriche per lo studio dei sistemi dinamici Metodi di continuazione MATCONT Esempi ed applicazioni

Effective theories in elementary particle physics	
Instructor(s):	Dr. Giancarlo D'Ambrosio (INFN, gdambros@na.infn.it)
Credits (planned):	3
Planned hours:	18-20
Prerequisites:	Not specified.
Description:	Effective theories; 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 Supersimmetry and breaking schemes (gauge and gravity nediation, split supersymmetry) GIM mechanism and Physics Beyond the Standard Model (Minimal Flavour violation) Large tangent beta effects

Electrodynamics of novel materials (course offered jointly with the Doctorate School of Industrial Engineering)	
Instructor(s):	Prof. Antonello Andreone (University, andreone@na.infn.it)
Credits (planned):	3
Planned hours:	20
Prerequisites:	Background in solid state physics and applied electromagnetism.
Description:	PART I: - Electrodynamics of metals and superconductors: basic principles - Electrodynamics of dielectric, ferroelectric, and ferromagnetic media: basic principles - How to measure the surface impedance, e.m. permittivity and susceptibility - Exemplary r.f. and microwave applications: particle accelerating cavities, telecomms devices, NMR antennas PART II: - A short introduction to metamaterials - Composite and nanocomposite structures with negative parameters: Wire media and plasmonic structures. - Electromagnetic band gap (EBG) crystals and quasi-crystals - Some applications of EBG based structures to telecomms devices - Metamaterials at optical frequencies and photonic devices

Fluctuation relations and nonequilibrium thermodynamics	
Instructors:	Prof. Luca Peliti (University, peliti@na.infn.it), Dr. Alberto Imparato (CNR-INFM, alberto.imparato@na.infn.it)
Credits (planned):	3
Planned hours:	18 (three weeks)
Expected to be held in	February – March 2008
Prerequisites:	knowledge of classical equilibrium statistical mechanics at an introductory level (theory of ensembles, statistical representation of thermodynamics)
Description:	• 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.

From classical to quantum gravity	
Instructor(s):	Dr. Giampiero Esposito (INFN, gesposit@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	Physics degree with a thesis on classical or quantum field theory
Description:	The aim of the course is to introduce Ph.D. students to the quantization of gravity and other fundamental interactions with the help of functional integrals, in a manifestly covariant way. Brief outline: [1] Physical motivations for quantum gravity [2] Basic differential geometry (Riemann curvature; Lie groups; fibre bundles) [3] Functional integrals and space of histories for gauge theories [4] Zeta-function regularization; gravitational instantons; effective action; BRST symmetry For references: see on arXiv:0711.2445 http://arxiv.org/PS_cache/arxiv/pdf/0711/0711.2445v1.pdf

From nuclear forces to nuclear structure	
Instructor(s):	Prof. Aldo Covello (University, covello@na.infn.it)
Credits (planned):	2
Planned hours:	12
Prerequisites:	Basic knowledge of quantum mechanics, nuclear and subnuclear physics
Description:	The aim of the course is to give a concise survey of some key topics in modern nuclear physics. The main arguments that will be discussed are: 1) Introduction to nucleon-nucleon interaction 2) Modern nucleon-nucleon potentials 3) Realistic nuclear structure calculations 4) Results of realistic shell-model calculations and comparison with experimental data, with special focus on nuclei far from stability ("exotic nuclei")

Green's functions and many-body physics	
Instructor(s):	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
Prerequisites:	second quantization
Description:	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. - 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 Meson Physics	
Instructor:	Dr. Pietro Santorelli (University, pietro.santorelli@na.infn.it)
Credits (planned):	2-3
Planned hours:	14 – 16
Prerequisites:	Basic concepts of Quantum Field Theory
Description:	This course will provide an introduction to effective field theory of the QuantumChromoDynamics for heavy quarks and its application to weak decays of heavy mesons. The following arguments will be discussed 1. Short review of the Standard Model 2. Integrating out heavy particles, scale separation, radiative corrections 3. Heavy Quark Effective Theory 4. Semileptonic and rare decays of B mesons 5. Non-leptonic two body decays 6. CP violation

Heavy Quark Effective theory	
Instructor(s):	Dr. Giulia Ricciardi (University, ricciard@na.infn.it)
Credits (planned):	1
Planned hours:	6-8 (can be made longer on request)
Prerequisites:	experimentalists or theoreticians in high energy theory
Description:	Introduction to effective theories, focus on heavy quarks effective theory and applications to high energy processes. Students are required to study during the course, which will be compact, and give the exams shortly after the end of the course (within one week fronm the end of the copurse).

[High-energy astrophysics] (not offered in 2008, planned for 2009)	
Instructor(s):	Prof. Benedetto D’Ettorre Piazzoli (University) and Dr. Giuliana Fiorillo (University, giuliana.fiorillo@na.infn.it)
Credits (planned):	to be defined
Planned hours:	to be defined
Prerequisites:	Not specified
Description:	• Neutrino Physics (Fiorillo) • Gamma astronomy (D'Ettorre Piazzoli) Main topics covered: Cosmic rays, gamma sources, neutrino physics, massive neutrinos, neutrinos from accelerators and reactors, neutrinos from astrophysical sources.

[High energy physics at the Large Hadron Collider (LHC)] (not offered in 2008, planned for 2009)	
Instructor(s):	Dr. Luigi Rolandi (CERN) [course organized by Prof. Leonardo Merola, leonardo.merola@na.infn.it]
Credits (planned):	4
Planned hours:	24
Prerequisites:	Basic knowledge of subnuclear physics and detectors
Description:	Status of Standard Model before LHC (2 h) Beyond the Standard Model and LHC (1 h) The challenge of the LHC accelerator (2 h) Experimentation at LHC and the physics benchmarks for detector design (1 h) The ATLAS detector conception, status and basic performance (2 h) The CMS detector conception, status and basic performance (2 h) ATLAS-CMS comparison (1 h) Calorimeter Calibrations (1 h) Tracking Vertexing and Alignment (2 h) Jets, electrons, muons and energy flow (2 h) Trigger (1 h) Example: New Physics from Dijets (1 h) Tau tagging and b tagging (1 h) Example: Associated production of MSSM heavy neutral Higgs Boson bbarH(a) with H(a)-->tau tau (1 h) Missing Energy (1 h) Example: low mass Supersimmetry (1 h) LHC and Astrophysics (2 h)

High resolution techniques in Optics: from Near-field Optics to Quantum Systems	
Instructors:	Dr. Antonio Ambrosio (CNR-INFM CRS-COHERENTIA, antonio.ambrosio@na.infn.it), Dr. Virginia D'Auria (Ecole Normale Superieure de Paris, dauria@spectro.jussieu.fr)
Credits (planned):	3
Planned hours:	18
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 scanning probe microscopy 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 make it possible both high resolution lithography and spectroscopy of single nano-objects. High resolution in image processing will be also treated in the context of quantum optics, by explaining how the use of non-classical light allows beating the limits imposed by classical diffraction. A detailed analysis of performances of quantum light as a tool for measurements with sensitivity beyond the standard classical limits will then be illustrated: in particular applications to phase measurements, absorption measurement and quantum clocks.

Introduction to SuSy	
Instructor(s):	Prof. Francesco Nicodemi (University of Napoli, francesco.nicodemi@na.infn.it)
Credits (planned):	2
Planned hours:	10-12
Prerequisites:	It is required a knowledge of the elements of quantum field theory.
Description:	1) Motivations for SuSy 2) SuSy Algebras 3) Aspects of SuSy in Quantum Mechanics 4) Non perturbative effects and spontaneous breaking of SuSy 5) Superspace and superfieds in 4 dim: scalar and gauge theories in SuSy 6) Some properties of SuSy theories in 4 dim.

<table>
<tr><td colspan="2">Introduction to the physics of nanostructures: phenomenology, applications and theoretical aspects (offered jointly with the Doctorate School of Industrial Engineering)</td></tr>
<tr><td>Instructor(s):</td><td>Dr. Giovanni Cantele (CNR-INFM, giovanni.cantele@na.infn.it)</td></tr>
<tr><td>Credits (planned):</td><td>3-4</td></tr>
<tr><td>Planned hours:</td><td>18-24</td></tr>
<tr><td>Prerequisites:</td><td>Basic knowledge of quantum mechanics. One or two lessons (depending on the students background) will be dedicated to the few needed concepts of solid state physics.</td></tr>
<tr><td>Description:</td><td>This course is intended to be an overview of the basics and applications of nanostructured materials. The first part is dedicated to the most recent developments of nanotechnology and its interest in applications. Moreover, the main observable phenomena in nanostructured materials will be described (optical and transport properties) as well as their applications (optoelectronics, single electron transistors, etc.). In the second part, these phenomena will be described in terms of electron and hole quantum confinement, highlighting the effect of the dimensions and dimensionality of the system. The main models needed to describe the optical and electronic response in nanostructured materials will be analyzed.

Introduction:
- nanotechnology and its relationship with microelectronics
- synthesis techniques
- investigation instruments: STM and AFM

Nanostructured systems:
- atomic nanoclusters: physical and structural properties
- quantum dots: electronic properties and devices (quantum dot lasers, single-electron transistor)
- nanostructured carbon: nanotubes, fullerenes, graphene

Optical and electronic properties:
- elementary excitations in solids
- the quantum confinement
- transport in nanostructures

The students can give indication for topics of their interest that could be part of the program of the course.

See also at the web page: http://people.na.infn.it/~cantele/index.php?n=Teach.Nano</td></tr>
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Introduction to the physics of the quantum Hall regime	
Instructors:	Prof. Gerardo Cristofano (University, cristofano@na.infn.it), Dr.ssa Adele Naddeo (CNISM, Salerno
Credits (planned):	3
Planned hours:	20
Prerequisites:	Basic knowledge of condensed matter physics
Description:	The aim of the course is to give an overview of the main experimental findings and of the most important theoretical developments for a quantum Hall fluid. Today it is one of the most fascinating and remarkable research topics: on one side it appears deeply related to fundamental principles of physics, while on the other side it exhibits an interesting interplay between gauge fields, two dimensionality and topology. The first part of the course is devoted to a summary of the main experimental results and to a phenomenological account of all the relevant physics with an emphasis to topological and non perturbative aspects. In the second part we illustrate the main theoretical approaches adopted in order to describe all the relevant phenomenology, with an emphasis on the relationships between them. More in detail the outline of the course could be the following. 1. Introduction. Summary of experimental facts. Classical and quantum mechanics of a single two-dimensional electron in an external magnetic field. 2. The integer quantum Hall effect. Laughlin gauge argument. Exact quantization of the Hall conductance. 3. The fractional quantum Hall effect. Laughlin wave functions. One-component plasma interpretation. Charge fractionalization. Fractional statistics and anyons. 4. Phase transition between Hall plateaux. Scaling theories. Delocalized states and dissipation. Global phase diagram. Extended duality. Law of Corresponding States. 5. Theoretical approaches. Chern-Simons Landau-Ginzburg theory. Two-dimensional conformal field theory: bosonization, Coulomb gas vertex operators. Quantum Hall effect on a torus: Bloch wave functions, magnetic translations. Topological order. Edge states and conduction properties.

Issues in condensed matter physics	
Instructor(s):	Prof. Arturo Tagliacozzo (University, arturo@na.infn.it), Dr. Procolo Lucignano (University), Dr. Domenico Giuliano (Cosenza University), Dr. Ciro Nappi (CNR, Pozzuoli)
Credits (planned):	to be defined
Planned hours:	to be defined
Prerequisites:	Not specified
Description:	Few cornerstone problems of many body theory for condensed matter physics, with applications to mesoscopic physics and superconductivity will be presented. They will be chosen among the ones appearing in the following list, according to the interests of the students. - The Hubbard model in the large U limit - Magnetic instability and spin waves - Superconducting phase transition - The Kondo problem with application to quantum transport in Quantum Dots - Vortices in thin superconducting films and Kosterlitz and Thouless phase transition - Quantum phase transition in Josephson Junctions and dissipation - The Luttinger liquid paradigm - Quantum transport in mesoscopic systems The discussion will require second quantization and Feynman functional integration. A quick overview of these tools will be given on demand.

Lattice QCD	
Instructor(s):	Dr. Giulia Ricciardi (University, ricciard@na.infn.it)
Credits (planned):	1
Planned hours:	6-8 (can be made longer on request)
Prerequisites:	
Description:	Introduction to the theory and applications of lattice QCD. Students are required to study during the course, which will be compact, and give the exams within one week after the end of the course

Lectures of fluid-dynamics with applications in astrophysics	
Instructor(s):	Prof. Massimo Capaccioli (University), Dr. Ester Piedipalumbo (University, ester@na.infn.it), Prof. Claudio Rubano (University)
Credits (planned):	3
Planned hours:	20
Expected to be hold in:	Sept.- Dec. '08
Prerequisites:	none
Description:	Introduction 1. The microscopic description 2. Relationship between microscopic and macroscopic descriptions: the ensambles Transition to the dynamics of fluids through the statistical mechanics description 1. BBGKY and Boltzmann equations for the distribution function f 2. The momenta of f 3. The hydrodynamical equations Classical fluids 1. Continuity equations 2. The equation of motion 3. The energy bilance equation • The zeroth-order approximation. Perfect fluids 1. Euler's equations 2. Basic astrophysical approximations • The zeroth-order approximation. Imperfect fluids 1. Diffusion 2. Viscosità and heat conduction 3. Navier-Stokes equations Relativistic fluids 1. The distribution function f 2. Transport fluxes 3. Perfect fluids 4. Boltzmann's equation • Photon fluids 1. The black body 2. The grey body • Basic astrophysical approximations 1. Stellar atmospheres 2. Interstellar extinction The Fluid in a star The Fluid of stars (galaxies) The Fluid of galaxies (cosmological fluid)

Light Scattering: Theory and Applications	
Instructors:	Dr. Annalisa Bruno (University, annalisa.bruno@na.infn.it); Dr. Xuan Wang (CNR-INFM, wang@na.infn.it)
Credits (planned):	4
Planned hours:	22-26
Prerequisites:	none
Description:	The course will provide a broad overview on theory and application of light scattering from micro and nano-sized particles in different system and conditions. The course can be divided in the following parts: -- Principle of Light scattering -- Mie Scattering -- Rayleigh Scattering -- Multiple scattering (atmosphere and Medicine) -- Dynamic Light scattering (DLS) for nanosizing. -- Polymers and colloidal applications

Metodi Matematici per l'Apprendimento Statistico (cross-listed, offered by the Doctorate School in Mathematical and Information Sciences)	
Instructor(s):	Dr. Ernesto De Vito (Università di Genova, devito@dima.unige.it)
Credits (planned):	3
Planned hours:	20
Expected to be held in:	4 – 14 February 2008
Prerequisites:	Basi matematico-informatiche sufficientemente solide.
Description:	Il corso, della durata di 20 ore articolate in 8 lezioni teoriche più due esercitazioni pratiche di laboratorio, è rivolto principalmente agli studenti del Dottorato in Scienze Computazionali ed Informatiche e del dottorato in Fisica della Federico II, ma è aperto ai laureandi in materie affini all'Apprendimento Statistico e a qualunque altra persona/ricercatore interessata all'argomento. Sono richieste basi matematico-informatiche sufficientemente solide. Il corso si propone sia di dare un'introduzione ai fondamenti teorici dei più moderni metodi di apprendimento statistico, sia di discutere alcune delle problematiche legate all'apprendimento statistico, come la "feature selection" e la scelta "ottimale" dei parametri. La suddivisione in unità tematiche degli argomenti è la seguente: 1. Introduzione all'apprendimento da esempi: modelli statistici e relativi algoritmi, funzioni costo, definizioni di consistenza e generalizzazione. 2. Introduzione agli spazi di Hilbert a nucleo riproducente. 3. Metodi kernel per la regressione. 4. Classificazione mediante Support Vector Machines. 5. Problema delle selezione delle "features" ed algoritmi di sparsità. 6. Scelta "ottimale" dei parametri.

Non-commutative geometry	
Instructor(s):	Prof. Fedele Lizzi (University, fedele.lizzi@na.infn.it)
Credits (planned):	4
Planned hours:	24
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:	Module 1: 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 Module 2 Field Theories on Noncommutative Spaces Noncommutative Geometry of Spacetime at Planck's Lenght Twisted Symmetries of Quantum Field Theory on Noncommutative Spaces and connections with Quantum Groups Note: The second module deals with topics in rapid evolution, and therefore the programme will decided based on the most recent results, as well as the students' interest.

Nuclear astrophysics	
Instructor(s):	Dr. Lucio Gialanella (INFN, lgialanella@na.infn.it), Dr. Luigi Coraggio (INFN)
Credits (planned):	6
Planned hours:	36
Prerequisites:	None.
Description:	a) Basics in Astrophysics: Observations – Cosmological models – Formation of stars - Physical basis of stellar evolution b) Nuclear physics in nuclear astrophysics: The nucleon-nucleon potential and nuclear stability - The semiempirical mass formula - The equation of state of the nuclear matter -The independent-particle model - The nuclear shell model - Electromagnetic transitions - The scattering theory - Nuclei far from stability - Definitions and general properties of nuclear reactions – Resonant and not resonant reaction mechanisms – Electron screening – Nuclear reactions in astrophysical environment c) Nucleosynthesis and stellar evolution: Big Bang nucleosynthesis – Hydrogen stellar burning - Helium stellar burning – Advanced burning stages – *r* and *s* processes - Supernovae type I and II – Neutron stars and black holes d) Experimental techniques in Nuclear Astrophysics: Direct measurements – Indirect measurements – Experimental procedures – Data analysis – Determination of the reaction rate at astrophysical relevant energies

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:	-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. -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.

Nuclear matter theory	
Instructor(s):	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.

Optical and transport properties of metals and semiconductors	
Instructor(s):	Prof. Giuseppe Iadonisi (University, iadonisi@na.infn.it)
Credits (planned):	3-4
Planned hours:	18-24
Prerequisites:	Knowledge of the basic physics about the metals, semiconductors and lattice vibrations.
Description:	The main purpose of the course is the description of the optical and transport properties of metals and semiconductors from the classical and quantum point of view. The course is devoted to students interested to work in the theory or the experiments on solids also of small dimensions.

Optical techniques for the analysis of micro- and nano-sized systems	
Instructor(s):	Dr. Giulia Rusciano (CNISM, giulia.rusciano@na.infn.it)
Credits (planned):	3
Planned hours:	16
Prerequisites:	Not specified
Description:	The course will provide a broad overview on optical techniques for the investigation of micro- and nano-sized systems. The first part will be devoted to the treatment of many optical tools for the analysis of single, micro-sized objects, including classical spectroscopic techniques and Optical Tweezers. In the second part, the course will be focused on the techniques for the investigation of single molecules. The main points of this course are summarized in the following: ▪ Principles of Optical Microscopy; contrast mechanisms (phase-contrast, Differential Interference Contrast, dark field, wild field, confocal fluorescence microscopy) ▪ Manipulation of micro-sized objects: Optical and Magnetic Tweezers ▪ Raman-based spectroscopic techniques: theory and applications to diagnostic detection ▪ Fluorescence microscopy: confocal detection and autocorrelation spectroscopy ▪ Breaking the diffraction limit: scanning probe microscopy ▪ Techniques for single-molecules studies: general overview ▪ Single-molecule Fluorescence Detection; molecular dynamics investigation ▪ Surface Enhanced Raman Spectroscopy (SERS) ▪ Single-molecule Fluorescence Resonance Energy Transfer (FRET) ▪ Single Molecules Near-Field Optics (NFO)

Parton Model and Structure functions	
Instructor(s):	Dr. Giulia Ricciardi (University, ricciard@na.infn.it)
Credits (planned):	1
Planned hours:	6-8 (can be made longer on request)
Prerequisites:	basics of fundamental interactions
Description:	Introduction to parton model and structure functions, with applications. Students are required to study during the course, which will be compact, and give the exams shortly after the end of the course (within one week from the end of the course)

Physics of plasmas and particle beams in Laboratory and Space	
Instructor(s):	Prof. Renato Fedele (University, renato.fedele@na.infn.it)
Credits (planned):	5
Planned hours:	32
Prerequisites:	General Physics, Fundamentals of Quantum Mechanics
Description:	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. In particular, the course includes the following topics: - 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(s):	Prof. Giancarlo Abbate (University, abbate@na.infn.it)
Credits (planned):	2-3
Planned hours:	12-18
Expected to be held in	Oct. – Nov. '08
Prerequisites:	Not specified
Description:	- 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 strong interactions	
Instructor(s):	Dr. Giulia Ricciardi (University, ricciard@na.infn.it)
Credits (planned):	2
Planned hours:	12 (can be made longer on request)
Prerequisites:	Not specified
Description:	The course is addressed to graduate students, with theoretical or experimental background, who are interested in Elementary Particles. The aim of the course is to provide the necessary background to fully understand and work on processes involving hadrons. Therefore the choice of the subjects, and their relative weight, can vary on the basis of the actual preparation of the students and on their research necessities. Program: -Non abelian gauge theories: QCD -Renormalization group, infrared and ultraviolet divergencies -Asymptotic freedom and confinement -Fundamental applications of perturbative QCD -Deep Inelastic Scattering; Parton Model -Structure Functions; DGLAP equations, their solution and interpretation -Introduction to the lattice -Experimental data interpretation: statistical approaches, comparison between Frequentist and Bayesian methods

Physics of superconductor and spintronic devices (course offered jointly with the Doctorate School of Industrial Engineering)	
Instructor(s):	Prof. Giampiero Pepe (University, gpepe@na.infn.it)
Credits (planned):	4
Planned hours:	24
Prerequisites:	Basic knowledge of physics of matter
Description:	• Superconducting electronics: general characteristics – the tunnel effect between superconductors and tunnelling devices. The Josephson effect and related devices. Josephson electrodynamics. Macroscopic quantum effects, π junctions. The interaction between the radiation and the superconducting matter: theoretical and experimental aspects. Superconductor detectors. Applications in Nuclear Physics and Astrophysics. SQUIDs and magnetic sensors: principle of operation, properties, applications in medical physics and in analysis of materials. • High temperature superconductivity (HTS): unconventional properties, the symmetry of the order parameter, anisotropy, unconventional aspects in Josephson effects. • Superconducting spintronics elements. Superconductivity and ferro-magnetism: theoretical and experimental aspects. Materials and fabrication techniques for spintronic devices. Giant magnetoresistance, spin valves and tunneling spin-based devices.

[Quantum field theories] (not offered in 2008, planned for 2009)	
Instructor(s):	Dr. Francesco Pezzella (INFN, pezzella@na.infn.it)
Credits (planned):	5
Planned hours:	30
Prerequisites:	Quantum Mechanics. Special Relativity and its covariant formalism. Basic knowledge of the phenomenology of fundamental interactions.
Description:	This course is addressed to those students who intend to make research (both theoretical and experimental) in Elementaty Particle Physics. The aim is to provide a knowledge of the perturbative aspects in some main examples of Field Theories by using functional methods. The plan of the course is the following: • Path Integral Quantization in Field Theories. • Renormalization (φ^4, abelian and non abelian gauge theories) • One-loop renormalization in QED • Renormalization group equations • Symmetries of QCD. Chiral Invariance. Anomalies

Quantum Information	
Instructor(s):	Prof. Salvatore Solimeno (University, solimeno@na.infn.it)
Credits (planned):	
Planned hours:	
Prerequisites:	
Description:	

[Statistics and data analysis for (high-energy) physicists] (not offered in 2008, planned for 2009)	
Instructor(s):	Dr. Salvatore Mele (INFN, salvatore.mele@cern.ch)
Credits (planned):	4
Planned hours:	20 hours of lectures + 10 hours of student seminars as exams
Prerequisites:	None
Description:	o Statistics - Probability distributions - Inference and confidence intervals - The maximum-likelihood method and applications - The least-squares method and applications - Upper and lower limits and examples o Monte Carlo techniques - Principles of Monte Carlo techniques - Application of Monte Carlo simulations o Neural networks - Introduction to neural networks - Examples of use of neural networks - Other multivariate analysis techniques

String and brane theories	
Instructor(s):	Dr. Francesco Pezzella (INFN, pezzella@na.infn.it), Raffaele Marotta (INFN)
Credits (planned):	5
Planned hours:	30
Prerequisites:	Quantum Mechanics, Special Relativity and its covariant formalism. Basic knowledge of Quantum Field Theory.
Description:	This course can be divided in two parts. In the first one classical and quantum aspects of bosonic strings and superstrings are discussed. In the second one more recent aspects about non-perturbative effects are discussed: D-branes, dualities between different superstring models and gauge/gravity correspondence.

Surface physics: basic principles, analysis techniques and applications	
Instructor(s):	Dr. Stefano Lettieri (CNR-INFM, lettieri@na.infn.it)
Credits (planned):	3
Planned hours:	20
Prerequisites:	Basic knowledge of solid state physics. One or two introductory lessons on basic principles of solid state physics can be planned, if required, at the beginning of the course.
Description:	The course is centered on optical and electronic properties of the solid surfaces and interfaces and on their interaction with the gaseous surrounding environment. In particular, we will consider surface/interface properties of semiconductors and metal oxides and their applications in gas sensing. The first part of the course will deal with the basic elements of surface physics (nomenclature, electronic states, surface bands) and with the description of the most important surface characterization techniques, based on optical nonlinear effects (surface second harmonic generation), near-field optics (NSOM) and electron diffraction. The second part will deal with the interaction between surfaces and gases (chemisorption, physisorption, adsorption kinetics), considering in particular novel metal-oxide nanostructures whose properties are very promising in view of applications in gas sensing and monitoring. The topics of the course are: • Surface electrons: nomenclature, reconstruction, surface states, charge localization, surface band-bending. • Surface characterization techniques (I): electron diffraction (LEED, RHEED) and photoelectron spectroscopy (XPS, UPS). • Optical properties at surfaces: surface plasmons, surface second harmonic generation • Surface characterization techniques (II) NSOM, surface SHG. • Surface - gas interactions: chemisorption, physisorption, adsorption kinetics, work function measurements. • Solid state gas sensors and metal oxides. • Novel metal oxide nanostructures for innovative solid state gas sensing devices At the end of the frontal lessons listed above, we some seminar session in which the PhD students will discuss some research papers (selected from recent literature) pertaining to the topics examined during the course. The main goal of these seminar meetings will be the stimulation and encouragement of critical listening and brief exposing ability of the students. The students will be encouraged to choose by themselves the seminar topic, after a discussion with the Instructor who in any case will retain the right to modify the student's proposals.

Techniques of scanning microscopy (course offered jointly with the Doctorate School of Industrial Engineering)	
Instructor(s):	Dr. Maria Iavarone (Argonne National Laboratory, Illinois, USA)
Credits (planned):	2
Planned hours:	10
Prerequisites:	The lectures will attempt to keep the description at a basic level. Students from Physics, Chemistry, Biology and Engineering background are encouraged to attend, although not everybody will be able to follow all aspects of every lecture.
Description:	The objective of this course is to give an overview of Scanning Probe Microscopy Techniques, so that participants can gain a deeper understanding of scientific literature where SPM is used and they can judge if SPM is interesting to apply to their own research. The lectures will cover basic principles of operation, various modes of operation and fundamental limitation of the technique. More attention will be dedicated to Scanning Tunneling Microscopy, Atomic Force Microscopy and Magnetic Force Microscopy. The students will be asked to find related technical papers and information under my guidance and they will write an essay that summarizes the research area. The goals of these projects are: - Make the students aware of the most recent research areas; - Develop research ideas by discovering and evaluating the literature; - Help students acquire satisfactory communication skills.

Thermomechanics of Soft Matter (cross-listed, course offered by the Doctorate School of Industrial Engineering)	
Instructor(s):	Prof. Giuseppe Marrucci (Università, giuseppe.marrucci@unina.it)
Credits (planned):	3
Planned hours:	16
Expected to be held in	February '08
Prerequisites:	
Description:	Significant constitutive information on continuous media, both in the linear and nonlinear range, can be derived from the analysis of thermal motion at the molecular or Brownian level. Typical examples are rubber elasticity, polymer viscoelasticity, and, more generally, soft matter. **List of topics**: 1. Generalities on "soft matter". Why matter can be hard or soft? A crude simple formula for the modulus of elasticity. 2. One example of soft matter is rubber. Rubber is made up of polymer chains forming a network. A detailed theory of rubber elasticity is based on statistical mechanics. The polymer chain as a random walk. Mean square end-to-end distance of the chain. Distribution of the end-to-end vector. Entropy of the chain. The elastic force in a chain. Ensemble averages. Free energy of rubber. Stretching a rubber band. Elastic modulus of a rubber. 3. Stress and deformation tensors. Generalities on tensors. Various deformation tensors. Stress tensor in polymeric systems. The stress constitutive equation of rubber. Response of a rubber to a shear deformation. 4. Viscoelasticity. Frequency response. Response to a step strain. Relaxation modulus. Boltzmann superposition. The constitutive equation of linear viscoelasticity. Maxwell equation. Polymeric liquids are viscoelastic. The dumbbell model. Kinetic equation for a Brownian particle. Kinetic equation for the dumbbell model. Rouse model. 5. Another example of soft matter (or of "complex liquids") is that of surfactants or amphiphiles. Polar/nonpolar, hydrophilic/hydrophobic interactions. Micelles and bilayers. Membranes and vesicles. Block copolymers. Associating polymers. Impermanent networks. 6. Entangled polymers also form impermanent networks. Dynamics is based on the concept of tube of constraints. Reptation. Other relaxation processes. Branched polymers. 7. Other complex liquids are suspensions of rodlike particles. Particle interactions (due to excluded volume or otherwise) may break the isotropic symmetry, and generate nematic liquid crystals. Mean field treatment of such phenomena.

Waves and interactions in nonlinear media	
Instructor(s):	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 quasididtribution. 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.