Basic Course

Reference for timetable Prof. Fabrizio Frezza (fabrizio.frezza@uniroma1.it)

Corso di scrittura tecnico-scientifica (3 CFU) Emilio Matricciani (Politecnico di Milano),

gennaio-febbraio 2018

ELETTROMAGNETISMO

E1 Artificial Materials, Metamaterials and Plasmonics for electromagnetic applications (3 CFU) - II sem Professor Fabrizio Frezza (Sapienza Università di Roma)

Program: Frequency Selective Surfaces (FSS) and applications. Photonic

(PBG) or Electromagnetic (EBG) Crystals and applications.

Metamaterials and applications. The wire medium. Surface Plasmons and applications.

E2 Nanophotonics and Plasmonics (2 CFU) - II sem Professor Concetta Sibilia (Sapienza Università di Roma) The part of seminars related to Nanophotonics aims to introduce to students some exciting concepts that differ from conventional wave optics, with particular emphasis to the role of the evanescent fields in many practical applications, such as near field optical microscopy.

The field of plasmonics (interaction of light with electrons in metals) has attracted a great deal of interest over the past two decades, but despite the many fundamental breakthroughs and exciting science it has produced, it is yet to deliver on the applications that were initially targeted as most promising. The seminars proposed examine the primary fundamental hurdles in the physics of plasmons that have been hampering practical applications and highlights some of the promising areas in which the field of plasmonics can realistically deliver.

E3 Basics of Nonlinear Optics (2 CFU) - II sem.

Professor Concetta Sibilia (Sapienza Università di Roma) Nonlinear Optics (NLO) is the study of phenomena that occur as a consequence of the modification of the optical properties of a material system by the presence of light. Basics and more recent applications of NLO to new light sources and devices will be presented in a series of seminars.

From the curriculum Mathematics for Engineering:

Partial differential equations and applications Daniele Andreucci, 12 hours (M3)

List of useful courses from the Master degree:

Master E1: Advanced Electromagnetics and Scattering (6 CFU), I sem.
Professor Fabrizio Frezza (Sapienza Università di Roma)

Master E2: Nanostructured materials and components for electromagnetic applications (6 CFU) –
II semester - Professor Fabrizio Frezza (Sapienza Università di Roma)

Master E3: Laser fundamentals (6 CFU) - II semester Professor Concetta Sibilia
(Sapienza Università di Roma)

Master E4: C. Mariani (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie),
TECNOLOGIE DI FABBRICAZIONE DI NANOSTRUTTURE E PROCESSI DI AUTOASSEMBLAGGIO
secondo semestre, 6 cfu

Master E5: M. Rossi (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie),
"Microscopie e tecniche di nanocaratterizzazione"
9 cfu

Master E6: G. Zollo Modelli e Tecniche di simulazione automistica

MATHEMATICS FOR ENGINEERING

Course M1

Giovanni Cerulli Irelli, Andrea Vietri
30 ore
secondo semestre
(15+15 ore)

TITLE: Graphs: from combinatorics to representation theory

First part: Graceful labellings and edge-colourings of graphs.

After a general introduction to graphs, with no specific background required, the first part of the course proceeds with two distinct topics, Graceful Labellings and Edge-Critical Graphs, which have attracted much interest from decades and provide numerous open questions. Classical constructions are shown along the course. Some of the current research issues are presented together with the state of the art and the known techniques. The students are hopefully expected to give their personal contribution to the development of the themes.

Programme

Basic definitions on graphs. Topic 1) Graceful labellings. Decomposition of a complete graph using a graceful labelling. The Ringel conjecture on trees. Rosa's necessary condition. Graceful collages. Graceful polynomials. Topic 2) Edge colouring and critical graphs. Vizing's theorem and the Classification problem. Colouring of bipartite graphs. Planar graphs.
Critical graphs. Geometrical interpretation of criticality. Construction of critical graphs.

Texts:

V.Bryant, Aspects of Combinatorics, A Wide-ranging Introduction, Cambridge University Press, 1993.
J.A.Gallian, A Dynamic Survey of Graph Labeling, Electr.J.Comb. 16, DS6 (on-line source).

Second part: Representations.

The second part is more algebraic. We will develop the theory of representations of oriented graphs (which in this context are called quivers). This theory has been developed since the late 60s, and it is now a central topic of research in algebra and representation theory. We will provide an introduction to the theme, starting from basic notions of homological algebra. The goal of the course is the proof of the famous Gabriel's theorem: "a quiver has only finitely many isoclasses of indecomposable representations if and only if it is an orientation of a simply-laced Dynkin graph of type A, D or E". We will mainly follow the book "Quiver Representations" by R. Schiffler. Time permitting we will also develop some basics of the theory of quiver Grassmannians.

Prerequisites: Linear algebra.

Objectives: the category of quiver representations is a perfect object to start working with functors and derived functors. The student will acquire familiarity with those concepts by several examples and applications.
Standard facts of linear algebra will be applied in unexpected ways and hence rediscovered.

Exams (for both parts):

The exam will consist in the solution of weekly exercises and a short talk on a theme compatible with the interest for the student.

Course M2

Boundary value problems in domains with irregular boundaries.

Professors Maria Rosaria Lancia e Maria Agostina Vivaldi (Sapienza Università di Roma)

20/24 hours.

Program: A list of the topics

- Variational solutions to boundary value problems
- Regularity results
- Homogenization and asymptotic analysis
- numerical approximation with the finite element method
- problems with dynamic boundary conditions
- parabolic boundary value problems

Course M3

"Nonlinear diffusion in inhomogeneous environments''

Professors
Anatoli Tedeev
(South Mathematical Inst. of VSC Russian Acad. Sci.Vladikavkaz Russia) and
Daniele Andreucci
(Sapienza Università di Roma)
2018, April-June. About 24 hours

Nonlinear diffusion in inhomogeneous environments

In many problems of diffusion the spatially inhomogeneous character of the medium is important and affects the qualitative behavior of the solutions.

The course will cover problems in unbounded domains of the Euclidean space or in non-compact Riemannian manifolds, providing a general introduction to the basic theory and then focusing on the asymptotic behavior of solutions for large times.

The prerequisites are standard knowledge of Sobolev spaces and basic theory of Riemannian manifolds. Many results in this field will be recalled in the course.

1) Linear and non-linear diffusion equations; the concept of solutions and the variety of possible behaviors. The energy method.
2) Sobolev spaces on manifolds. Interplay between geometry and embedding results.
3) Heat kernels on manifolds and related estimates. The relevance of volume growth at infinity.
4) Specific properties of nonlinear, possibly degenerate, diffusion.
5) The case of space-dependent coefficients; blow up of interfaces.
6) Asymptotics for large times: classical results in the Euclidean space. The asymptotic profile in linear and nonlinear diffusion.
7) The case of the Neumann problem in subdomains of the Euclidean space.
8) Asymptotic behavior in manifolds.

Course M4

An introduction to the functions of bounded variation and existence results for elliptic equations with p-laplacian principal part (p greater or equal to 1) and singular lower order terms

Professors Virginia De Cicco (Sapienza Università di Roma) and Daniela Giachetti (Sapienza Università di Roma) From January to March 2018

Program

The first part of the course deals with an introduction to the functions of bounded variation.

We first consider only functions of one variable, we give some definitions, some examples, we present some characterizations, properties, and we recall a brief history. Then we consider the functions of bounded variation of several variables: we present the definition, we point out some properties, the main theorems, and some applications.

The second part of the course deals with some existence results for elliptic equations with p-laplacian principal part (p greater or equal to 1) and singular lower order terms, with the following program:

1) the case p=2, mild singularity and strong singularity, definition of solutions, existence, stability and uniqueness.

2) results for the case1<p, p different from 2.

3) the case p=1.

SCIENZE DEI MATERIALI

Title

S1 Metodi sperimentali per la determinazione di struttura e proprietà elettroniche di sistemi aggregati di bassa dimensionalità

Experimental Methods for the Determination of the Structure and the Electronic Properties of Low-Dimensional Solid Systems

- Docenti / Teachers

Prof.Carlo Mariani (Sapienza Università di Roma) and Prof. Francesco OFFI / Prof. Alessandro RUOCCO (Roma Tre)

- from February to June 2018

- Modulo di Base (obbligatorio) / Basic Module (mandatory)
  32 ore / 32 hours (4 CFU / 4 ECTS):

INTERAZIONE DI RADIAZIONE E PARTICELLE CON LA MATERIA e Spettroscopie di fotoemissione e fotoemissione risonante

"Interaction of Electromagnetic Radiation with Matter and Photoelectron Spectroscopy and Resonant Photoemission"

- Programma

Introduzione alle spettroscopie di collisione: collisione di elettroni.

Introduzione alle spettroscopie di fotoemissione: basi teoriche, il modello a tre stadi, atomi e molecole, sistemi solidi a bassa dimensione, esperimenti risolti in angolo, esperimenti risolti in tempo. Strumentazione:

particelle cariche, spettroscopia Auger e fotoemissione risonante.

Basi della teoria dell'assorbimento. Teoria della diffusione multipla: un metodo per il calcolo di stati elettronici e osservabili spettroscopiche.

Superfici e sistemi a bassa dimensione, proprietà elettroniche.

La fotoemissione dai livelli atomici profondi ("surface core-level shift").

Fotoemissione risolta in angolo, struttura a bande. Struttura a bande di sistemi 1D, 2D esemplari. Sorgenti di radiazione di sincrotrone. Introduzione al laser ad elettroni liberi: una sorgente coerente dall'ultravioletto ai raggi X.

- Synopsis

Introduction to the collision spectroscopies: collisions with electrons.

Introduction to the photoelectron spectroscopy: theoretical background, the three-step model, atoms and molecules, low-dimensional solid systems, experiments with angular resolution, time-resolved experiments. Instrumentation:

charged particles, Auger electron spectroscopy and resonant photoemission.

Theoretical background of absorption. Multiple scattering theory:

a method for the observation of the electronic states and spectroscopy measurements. Surfaces and low-dimensional systems, electronic properties.

Core-level photoemission and surface core-level shifts. Angular resolved photoemissione, electronic band structure. Band structure of exemplary 1D and 2D systems. Electromagnetic radiation sources, synchrotron radiation. Introduction to the free-electron laser: a coherent source of radiation from UV to X rays.

- Moduli specialistici opzionali (ognuno 2 CFU) / Optional Specialistic Modules (each 2 ECTS)
  da essere definiti in dettaglio / yet to be fully defined

a) Metodologie di scattering e di assorbimento con luce di sincrotrone / Scattering Methodologies and Absorption by Synchrotron Radiation ...

Professor Paolo POSTORINO (Sapienza): Spettroscopia Raman in sistemi di bassa dimensionalità /

S2 Raman Spectroscopy in Low-Dimensional Systems

Programma / Synopsis

1. Fondamenti della spettroscopia Raman (Effetto Raman - Sezione d'urto "Classica".

   Cenni di calcolo quantistico della sezione d'urto: approccio diagrammatici. Dispersione fononica. Regole di selezione Raman: analisi in polarizzazione ed assegnazione dei modi fononici).

2. Fondamenti della spettroscopia Raman in sistemi di bassa dimensione (Violazione delle regole di selezione: Brillouin zone folding, finite size effects, e misura della densità degli stati fononici in sistemi ad alto disordine chimico/configurazionale. Scattering Raman da eccitazioni collettive nei semiconduttori e isolanti.

   Applicazioni della spettroscopia Raman a sistemi a bassa dimensionalit‡: film sottili, nanofili di semiconduttori).

3. Fondamenti della spettroscopia Raman risonante ed elettronica (Aumento risonante della sezione dí urto. Energia di deformazione: zinc-blende vs. wurtzite.

   Interazione di Frˆhlich.

Metodi sperimentali e risultati. Scattering da cariche libere in
semiconduttori: meccanismo,
regole di selezione e cinematica. Gas di elettroni bidimensionale:
eccitazioni di densità di carica e di spin).

4. Spettroscopia Raman su nanofili semiconduttori (Spettroscopia Raman risolta spazialmente in eterostrutture di nanofili. Spettroscopia Raman dipendente dalla polarizzazione su nanofili: simmetria della struttura cristallina. Dipendenza dei modi fononici dalla composizione. Raman risonante su nanofili con diversa simmetria. Raman elettronico su gas di elettroni bidimensionali nei nanofili).

5. Spettroscopie ottiche ad altissime pressioni in cella ad incudini di diamante (Dipendenza dalla pressure della struttura a bande - Modulazione indotta dalla pressione delle interazioni elettrone-elettrone ed elettrone- fonone).

6. Metodi di termografia con scattering Raman (Raman dipendente dalla temperature. Applicazione alle nanostrutture (nanofili, nanotube di carbonio, grafene).
Combinazione della spettroscopia

Raman con misure di trasporto per la determinazione delle proprietà termoelettriche).

c) Micro e Nano Fabbricazione /

Micro and Nano Fabrication