Dottorato di Ricerca in Fisica

Matti e disperatissimi

Seminari dei futuri Dottori di Ricerca

9 febbraio 2015

Aula A, Via Irnerio 46

Orario	Dottorando	Relatore
9.00	**Maria Zangoli**	Prof. Galli
	Measurement of the B0 - antiB0 and B0s - antiB0s production asymmetries in pp collisions at 7TeV and 8 TeV with the LHCb experiment	
9.30	**Stefano Chiodini**	Prof. Fraboni
	In-situ and real time scanning probe microscopy of organic ultra thin films	
10.00	**Nicolò Tosi**	Prof. Navarria
	Il nuovo rivelatore di alone del fascio per l'esperimento CMS ad LHC	
10.30	**Andrea Ciavatti**	Prof. Fraboni
	Transport Properties and Novel Sensing Applications of Organic Semiconducting Crystals	
11.00	**Andrea Castiglioni**	Prof. Del Bianco
	Misura dell'energia di adesione tra film stretch di polietilene	
11.30	**Fabio Valerio Massoli**	Prof. Sartorelli
	The XENON1T experiment: Monte Carlo background estimation and sensitivity curves study	
12.00	**Giulia Menichetti**	Prof. Remondini
	Statistical Mechanics Formalism and Methods for the Analysis of Real Netwoks	
12.30	**Martina Perani**	Prof. Cavalcoli
	Nanocrystalline Silicon Based Films for Renewable Energy Applications	
15.00	**Federica Mingrone**	Prof. Vannini
	Radiative neutron capture cross section on 238U at the n TOF CERN facility: a high precision measurement	
15.30	**Francesco Rossi**	Prof. Turchetti
	Numerical and Analytical Methods for Laser-Plasma Acceleration Physics	
16.00	**Emanuele Soncini**	Prof. Zucchini
	Higher Chern-Simons gauge theory	

Measurement of the B0 - antiB0 and B0s - antiB0s production asymmetries in pp collisions at 7TeV and 8 TeV with the LHCb experiment

Maria Zangoli

The production rate of b and $\bar{b}$ hadrons in pp collisions are not expected to be strictly identical, due to imbalance between quarks and anti-quarks in the initial state. This phenomenon can be naively related to the fact that the $\bar{b}$ quark produced in the hard scattering might combine with a u or d valence quark from the colliding protons, whereas the same cannot happen for a b quark As a consequence, it can be expected to register a slight excess in production of B^+ and B^0 mesons over B^- and $\bar{B}^0$ mesons, giving rise to an asymmetry effect, which is referred to as the production asymmetry. This thesis presents the analysis performed to determine the production asymmetries of B^0 and B_s^0. The analysis relies on data samples collected by the LHCb detector at the Large Hadron Collider (LHC) during the 2011 and 2012 data takings at two different values of the centre of mass energy $\sqrt{s} = 7$ TeV and at $\sqrt{s} = 8$ TeV, corresponding respectively to an integrated luminosity of 1 fb^{-1} and of 2 fb^{-1}. The production asymmetry is one of the key ingredients to perform measurements of CP violation in b-hadron decays at the LHC, since CP asymmetries must be disentangled from other sources. The measurements of the production asymmetries are performed in bins of p_{T} and η of the B-meson. The values of the production asymmetries, integrated in the ranges $4 < p_{\mathrm{T}} < 30$ GeV/c and $2.5 < \eta < 4.5$, are determined to be:

$$A_{\mathrm{P}} = (-1.00 \pm 0.48 \pm 0.29)$$

$$A_{\mathrm{P}} = (\ \ 1.09 \pm 2.61 \pm 0.61)$$

where the first uncertainty is statistical and the second is systematic. The measurement of $A_{\mathrm{P}}(B^0)$ is performed using the full statistics collected by LHCb so far, corresponding to an integrated luminosity of 3 fb^{-1}, while the measurement of $A_{\mathrm{P}}(B_s^0)$ is realized with the first 1 fb^{-1}, leaving room for improvement. No clear evidence of dependences on the values of p_{T} and η is observed. The results presented in this thesis are the most precise measurements available up to date.

In-situ and real time scanning probe microscopy of organic ultra thin films

Stefano Chiodini

Il lavoro di ricerca ha principalmente riguardato le seguenti due tematiche:
1) lo studio della crescita di strati organici molecolari (alpha-sexithiophene), sublimati in ambiente di ultra alto vuoto su substrato amorfo (ossido di silicio nativo). La crescita è stata visualizzata in-situ e in tempo reale mediante Microscopia a Forza Atomica (AFM) al variare della temperatura del substrato (da temperatura ambiente a 120 C).
2) la modellizzazione dell'interazione elettrostatica tra la punta conduttiva di un microscopio AFM ed una superficie metallica, eventualmente ricoperta di un sottile strato isolante. Il lavoro, in particolare, ha riguardato il calcolo della capacità del sistema punta AFM-substrato, attraverso la soluzione dell'equazione di Laplace in coordinate non standard.

Il nuovo rivelatore di alone del fascio per l'esperimento CMS ad LHC.

Nicolò Tosi

Nella primavera 2015 l'acceleratore LHC al CERN sarà riattivato con un energia di collisione di 13 TeV ed una maggiore luminosità, a seguito dei numerosi miglioramenti apportati alla macchina. La maggiore energia ed intensità dei fasci provocherà un incremento della quantità di particelle provenienti da interazioni indesiderate lungo le linee di fascio (alone), che costituiscono un fondo per l'esperimento CMS.
Un nuovo rivelatore, chiamato Beam Halo Monitor (BHM), è stato progettato per misurare direttamente l'alone del fascio. Questo rivelatore si basa sulla natura direzionale dell'effetto Cherenkov per identificare le particelle dell'alone distinguendole da quelle provenienti da altre sorgenti. L'ottima velocità di risposta permette inoltre di associare l'alone ad un particolare bunch di protoni dell'acceleratore.
Saranno presentate una descrizione del rivelatore e una panoramica delle attività di caratterizzazione dei prototipi avvenute prima della costruzione che è al momento in corso al CERN.

Transport Properties and Novel Sensing Applications of Organic Semiconducting Crystals

Andrea Ciavatti

The present thesis is focused on the study of Organic Semiconducting Single Crystals (OSSCs) and crystalline thin films. In particular solution-grown OSSC, e.g. 4-hdroxycyanobenzene (4HCB) have been characterized in view of their applications as novel sensors of X-rays, gamma-rays, alpha particles radiations and chemical sensors.
In the field of ionizing radiation detection, organic semiconductors have been proposed so far mainly as indirect detectors, i.e. as scintillators or as photodiodes. I first study the performance of 4HCB single crystals as direct X-ray detector i.e. the direct photon conversion into an electrical signal, assessing that they can operate at room temperature and in atmosphere, showing a stable and linear response with increasing dose rate.
A dedicated study of the collecting electrodes geometry, crystal thickness and interaction volume allowed us to maximize the charge collection efficiency and sensitivity, thus assessing how OSSCs perform at low operating voltages and offer a great potential in the development of novel ionizing radiation sensors.
To better understand the processes generating the observed X-ray signal, a comparative study is presented on OSSCs based on several small-molecules: 1,5-dinitronaphthalene (DNN), 1,8-naphthaleneimide (NTI), Rubrene and TIPS-pentacene.
In addition, the proof of principle of gamma-rays and alpha particles has been assessed for 4HCB single crystals.
I have also carried out an investigation of the electrical response of OSSCs exposed to vapour of volatile molecules, polar and non-polar.
The last chapter deals with rubrene, the highest performing molecular crystals for electronic applications. We present an investigation on high quality, millimeter-sized, crystalline thin films (10 – 100 nm thick) realized by exploiting organic molecular beam epitaxy on water-soluble substrates. Space-Charge-Limited Current (SCLC) and photocurrent spectroscopy measurements have been carried out. A thin film transistor was fabricated onto a Cytop® dielectric layer. The FET mobility exceeding 2 cm2/Vs, definitely assess the quality of RUB films.

Misura dell'energia di adesione tra film stretch di polietilene

Andrea Castiglioni

Il film estensibile (stretch film) è una diffusa applicazione dei film in polietilene (PE), usata per imballare e proteggere prodotti di vario numero, dimensione e pesi. Una caratteristica chiave è la loro proprietà adesiva grazie alla quale il film può essere chiuso facilmente su se stesso. Questo comportamento adesivo è molto simile a quello dei più noti "pressure-sensitive adhesives" (PSAs).
Tradizionalmente l'adesivo è un costituente del sistema complessivo che può essere analizzato e studiato. Nei film di PE invece questo fa parte della complessa microstruttura e non è separabile dal film per poterlo studiare a parte.
Il lavoro di ricerca ha riguardato lo studio delle proprietà di adesione tra film di PE ipotizzando la presenza di una "fase adesiva". L'adesione è stata valutata mediante peel testing secondo l'interpretazione basata sulla meccanica della frattura: questo approccio ha permesso di ricavare l'energia di adesione Gc, indipendente dalla geometria e propria solo delle proprietà fisiche dell'interfaccia tra film e substrato. Le misure a diverse temperature (T=223 – 296K) possono essere sovrapposte a costruire delle mastercurves. Queste mostrano valori di Gc che, in funzione della velocità ridotta RaT, variano da 0.3 J/m2 fino a 300 J/m2.
La dipendenza dalla velocità di prova e temperatura di Gc è stata discussa sulla base della letteratura esistente in termini delle proprietà viscoelastiche del materiale. In particolare è stato identificato un rilassamento meccanico (β, T_β 240 K) la cui intensità è direttamente collegata al massimo valore raggiunto da Gc. A sua volta, le proprietà meccaniche dell'adesivo (struttura macromolecolare), sono fondamentali nel regolare Gc.

The XENON1T experiment: Monte Carlo background estimation and sensitivity curves study

Fabio Valerio Massoli

Despite the scientific achievement of the last decades in the astrophysical and cosmo- logical fields, the majority of the Universe energy content is still unknown. A potential solution to the missing mass problem is the existence of dark matter in the form of WIMPs. Due to the very small cross section for WIMP-nuleon interactions, the number of expected events is very limited (1 ev/tonne/year), thus requiring detectors with large target mass and low background level. The aim of the XENON1T experiment, the first tonne-scale LXe based detector, is to be sensitive to WIMP-nucleon cross section as low as $10 - 47$ cm2. To investigate the possibility of such a detector to reach its goal, Monte Carlo simulations are mandatory to estimate the background. To this aim, the GEANT4 toolkit has been used to implement the detector geometry and to simulate the decays from the various background sources: electromagnetic and nuclear. From the analysis of the simulations, the level of background has been found totally acceptable for the experiment purposes: about 1 background event in a 2 tonne-years exposure. Indeed, using the Maximum Gap method, the XENON1T sensitivity has been evaluated and the minimum for the WIMP-nucleon cross sections has been found at $1.87 \cdot 10 - 47$ cm2, at 90% CL, for a WIMP mass of 45 GeV/c2. The results have been independently cross checked by using the Likelihood Ratio method that confirmed such results with an agreement within less than a factor two. Such a result is completely acceptable con- sidering the intrinsic differences between the two statistical methods. Thus, it has been proven that the XENON1T detector will be able to reach the designed sensitivity, thus lowering the limits on the WIMP-nucleon cross section by about 2 orders of magnitude with respect to the current experiments.

Statistical Mechanics Formalism and Methods for the Analysis of Real Netwoks

Giulia Menichetti

Network theory investigates the global topology and structural patterns of the interactions among the constituent elements of a number of complex systems including social groups, infrastructure and technological systems, the brain and biological networks. Over the last fifteen years, a large body of literature has attempted to disentangle noise and stochasticity from non-random patterns and mechanisms, in an attempt to gain a better understanding of how these systems function and evolve. In this talk a general introduction to networks and multilayer networks will be presented, together with real case studies.

Nanocrystalline Silicon Based Films for Renewable Energy Applications

Martina Perani

The work that will be presented summarizes the results obtained in my PhD thesis, which is focused on the study of innovative Si-based materials for third generation photovoltaics. In particular, silicon oxi-nitride (SiOxNy) thin films and multilayer of Silicon Rich Carbide (SRC)/Si have been characterized in view of their application in photovoltaics.
SiOxNy is a promising material for applications in thin-film solar cells as well as for wafer based silicon solar cells, like silicon heterojunction solar cells. However, many issues relevant to the material properties have not been studied yet, such as the role of the deposition condition and precursor gas concentrations on the optical and electronic properties of the films, the composition and structure of the nano-crystals. The results presented in the thesis aim to clarify the effects of annealing and oxygen incorporation within nc-SiOxNy films on its properties in view of the photovoltaic applications.
Silicon nano-crystals (Si NCs) embedded in a dielectric matrix were proposed as absorbers in all-Si multi-junction solar cells due to the quantum confinement capability of Si NCs, that allows a better match to the solar spectrum thanks to the size induced tunability of the band gap. Despite the efficient solar radiation absorption capability of this structure, its charge collection and transport properties has still to be fully demonstrated. The results presented in the thesis aim to the understanding of the transport mechanisms at macroscopic and microscopic scale.
Experimental results on SiOxNy thin films and SRC/Si multilayers have been obtained at macroscopical and microscopical level using different characterizations techniques, such as Atomic Force Microscopy, Reflection and Transmission measurements, High Resolution Transmission Electron Microscopy, Energy-Dispersive X-ray spectroscopy and Fourier Transform Infrared Spectroscopy.
The deep knowledge and improved understanding of the basic physical properties of these quite complex, multi-phase and multi-component systems, made by nanocrystals and amorphous phases, will contribute to improve the efficiency of Si based solar cells.

Radiative neutron capture cross section on 238U at the n TOF CERN facility: a high precision measurement

Federica Mingrone

The aim of this work is to provide a precise and accurate measurement of the 238U reaction cross section. This reaction is of fundamental importance for the design calculations of nuclear reactors, governing the behaviour of the reactor core. In particular, fast neutron reactors, which are experiencing a growing interest for their ability to burn radioactive waste, operate in the high energy region of the neutron spectrum. In this energy region inconsistencies between the existing measurements are present up to 15%, and the most recent evaluations disagree each other. In addition, the assessment of nuclear data uncertainty performed for innovative reactor systems shows that the uncertainty in the radiative capture cross-section of 238U should be further reduced to 1 - 3% in the energy region from 20 eV to 25 keV. To this purpose, addressed by the Nuclear Energy Agency as a priority nuclear data need, complementary experiments, one at the GELINA and two at the n TOF facility, were scheduled within the ANDES project within the 7th Framework Project of the European Commission.
The results of one of the 238U measurement performed at the n TOF CERN facility are presented in this work, carried out with a detection system constituted of two liquid scintillators. The very accurate cross section from this work is compared with the results obtained from the other measurement performed at the n TOF facility, which exploit a different and complementary detection technique.
The excellent agreement between the two data-sets points out that they can contribute to the reduction of the cross section uncertainty down to the required 1 – 3%.

Numerical and Analytical Methods for Laser-Plasma Acceleration Physics

Francesco Rossi

Theories and numerical modeling are fundamental tools for understanding, optimizing and designing present and future laser-plasma accelerators (LPAs). Laser evolution and plasma wave excitation in a LPA driven by a weakly relativistically intense, short-pulse laser propagating in a preformed parabolic plasma channel, is studied analytically in 3D including the effects of pulse steepening and energy depletion. At higher laser intensities, the process of electron self-injection in the nonlinear bubble wake regime is studied by means of fully self-consistent Particle-in-Cell simulations. Considering a non-evolving laser driver propagating with a prescribed velocity, the geometrical properties of the non-evolving bubble wake are studied. For a range of parameters of interest for laser plasma acceleration, The dependence of the threshold for self-injection in the non-evolving wake on laser intensity and wake velocity is characterized. Due to the nonlinear and complex nature of the Physics involved, computationally challenging numerical simulations are required to model laser-plasma accelerators operating at relativistic laser intensities. The numerical and computational optimizations, that combined in the codes INF&RNO and INF&RNO/quasi-static give the possibility to accurately model multi-GeV laser wakefield acceleration stages with present supercomputing architectures, are discussed. The PIC code jasmine, capable of efficiently running laser-plasma simulations on Graphics Processing Units (GPUs) clusters, is presented. GPUs deliver exceptional performance to PIC codes, but the core algorithms had to be redesigned for satisfying the constraints imposed by the intrinsic parallelism of the architecture. The simulation campaigns, run with the code jasmine for modeling the recent LPA experiments with the INFN-FLAME and CNR-ILIL laser systems, are also presented.

Higher Chern-Simons gauge theory

Emanuele Soncini

La teoria delle stringhe ha introdotto nella fisica teorica componenti fondamentali a dimensione non nulla, come le stringhe e le brane. Teorie fisiche che coinvolgono questi oggetti richiedono la definizione di "teorie di Gauge superiore" (higher gauge theory), cioè teorie di gauge in cui la simmetria di gauge non è governata da un gruppo di Lie ma da un "gruppo superiore" (higher group). Matematicamente, gli strumenti necessari allo studio di queste teorie sono elementi della teoria delle categorie superiori. In questa tesi viene definito e studiato, sia dal punto di vista classico che quantistico, un modello di Chern-Simons a gauge superiore. Questo modello presenta sia diverse analogie con il modello di Chern-Simons ordinario che elementi di novità che non sono del tutto compresi.