Documento sulla riorganizzazione di CNR SPIN: la proposta della U.O.S. di Napoli

- INTRODUZIONE
- IL PROCESSO PARTECIPATIVO
- I NUOVI PROGETTI NEL PIANO DI RIORGANIZZAZIONE SCIENTIFICA DI SPIN

INTRODUZIONE

Nuovi regolamenti CNR porteranno significative modifiche nello Statuto e nell'organizzazione interna → **auspicabile/opportuno considerare possibili nuove soluzioni organizzative**

SPIN e' un Istituto che si caratterizza fortemente per lo **studio di materiali innovativi**, e, pur essendo partito dalla tradizione forte della superconduttività, ha esteso i suoi interessi agli ossidi funzionali ed ad altri materiali innovativi, **caratterizzandosi per lo sviluppo di applicazioni e dispositivi basati su questi materiali** → una storia ricca di successi da cui partire in un possibile re-focusing scientifico dell'Istituto anche vs aree progettuali del DSFTM.

Obiettivo: pensare a **spazi scientifici ragionevolmente omogenei**, che possano essere anche **luoghi continui di scambio e possibili incubatori di collaborazioni anche traversali**, che producano nuova progettualità su base competitiva → *forte rafforzamento per l'Istituto*

IL PROCESSO PARTECIPATIVO

Il processo partecipativo verso una riorganizzazione di CNR SPIN è partito con la comunicazione del Direttore del 05 Marzo 2014, che faceva seguito al Consiglio di Istituto del 19-20 Novembre 2013, in cui furono indicate alcune linee generali lungo le quali veicolare il dibattito interno

e-mail del Direttore del 5.3.14

….Il percorso che ho individuato è quello di una discussione aperta fra tutti i ricercatori di SPIN e poi una serie di assemblee nelle varie UOS. Invito i responsabili di UOS a farsi parte attiva per iniziare un confronto interno (non confinato all'intero delle commesse già esistenti) per elaborare proposte......

la UOS di Napoli si è riunita in Assemblea il giorno 07 Aprile 2013
ampio dibattito e partecipazione (verbale su *Forum*) → formazione di una apposita Commissione di ricercatori CNR:
M. Barra, G. Cantele, F. Miletto Granozio, D. Paparo, M. Salluzzo ed E. Sarnelli, coordinata dal RUOS di Napoli

IL PROCESSO PARTECIPATIVO

Documentazione considerata dalla Commissione :

- Bozze dei nuovi regolamenti del CNR
- Piano Triennale del CNR
- Piano scientifico del DSFTM del CNR
- Documentazione relativa alla programmazione europea in ambito H2020
- Documento di indirizzo dell'International Advisory Board di SPIN
- Documento programmatico di sostenibilità scientifica elaborato all'interno del progetto MAMA
- Report scientifico di CNR SPIN 2011-13
- Documentazione di rendicontazione delle commesse attualmente presenti nella organizzazione di SPIN

Il PRS è stato presentato e discusso in Assemblea di UOS il ***19 giugno 2014*** dove sono emerse indicazioni alla Commissione per il miglioramento della bozza presentata.

IL PROCESSO PARTECIPATIVO

Esercizio che ha interessato l'**intera struttura dell'Istituto**, in un quadro di prospettiva e di rilancio. Esso nasce su **basi essenzialmente scientifiche**, e quindi richiederà necessariamente un confronto -prima della sua ultimazione- con la componente amministrativa dell'Istituto.

La Commissione era ben conscia che alcune commesse hanno riportato indicatori di valutazione tali da poter pensare ad una loro riproposizione. Tuttavia, ha ritenuto opportuno cimentarsi comunque nel ridisegnare l'organizzazione della ricerca all'interno dell'Istituto, con l'intento di stimolare (per quanto possibile) nuove aggregazioni ed interazioni

La figura del Responsabile viene intesa in modo piu' dinamico e con una maggiore responsabilità scientifica:

(i) coordinamento e *focusing* scientifico delle varie attività
(ii) esperienza nell'indirizzamento del lavoro,
(iii) capacita' di interfacciamento con le persone,
(iv) sensibilità verso tutti gli aspetti tematici coinvolti

Opportunita' di dare maggiore risalto -laddove possibile- a personale CNR nel ruolo

IL PROCESSO PARTECIPATIVO

accompagnare i progetti proposti con una descrizione scientifica per inquadrarne l'idea scientifica anche mediante dei topics di riferimento.

far emergere aspetti tematici nel rispetto di una storia di Istituto, che ha sempre puntato a coniugare tecnologie avanzate con obiettivi scientifici ambiziosi.

mettere insieme competenze diverse tra loro per una sintesi su piani scientifici nuovi e rilevanti.

dare un quadro reale e completo delle attività svolte in SPIN

rendere piu' omogenei tematicamente i progetti individuati, evitando accentramenti tematici o linee sotto inquadrate che poi sono di difficile gestione.

possibilita' di un progetto su materiali carbon-based e relativi dispositivi e sensori: l'Assemblea di Istituto, Direzione e CdI avranno un quadro generale per dare giusto peso e visibilita' a questa area scientifica

I PROGETTI

I progetti individuati all'interno del piano di riorganizzazione scientifica di SPIN elaborato dalla UOS di Napoli sono i seguenti:

1- Low dimensional and correlated systems for superconducting and semiconducting technologies, quantum electronics and spintronics

2- Innovative materials with entangled spin, orbital and charge degrees of freedom

3- Superconducting and functional materials for energy and environment

4- Light-matter interaction and non-equilibrium dynamics in advanced materials and devices

5- Electronic and thermal transport from the nanoscale to the macroscale: from fundamentals to applications

1- Low Dimensional and correlated systems for superconducting and semiconducting technologies, quantum electronics and spintronics

Low dimensional systems, like graphene, topological insulators, Van der Waals atomic crystals, 2D-superconductors, and oxide interfaces exhibiting 2D electron gases, are coming out as leading topics in condensed matter physics.

This project will fully explore the potentialities of low dimensional materials and devices in quantum technologies, with particular attention to the fields of quantum electronics and spintronics.

Interdisciplinary approach
(low-temperature transport phenomena, Josephson effect, nonequilibrium physics, advanced spectroscopies, epitaxial growth, nano fabrication technologies and device physics).

Aims
to **investigate fundamental physical phenomena**
to **generate novel functionalities and to manipulate them either by applying external stimuli**, as magnetic/electric fields, (spin-polarised) currents and light, or **resorting to atomic layer engineering and acting on them across an interface with different materials** through epitaxial strain, spin-orbital coupling, exchange bias, superconducting proximity effect and so on.

1- Low Dimensional and correlated systems for superconducting and semiconducting technologies, quantum electronics and spintronics

List of main TOPICS:

1. Novel 2D systems (such as graphene, topological insulators, Bi, LAO/STO and variants
2. Transition metal oxide artificial heterostructures for novel 2D-superconductivity and magnetism
3. Growth of low-dimensional systems with atomic-level control supported by real-time/in-situ monitoring
4. 2D Electron gases and spin polarized electron gases in oxides and other novel materials
5. X-ray spectroscopies at large scale facilities on 2D-Superconductors and complex heterostructures
6. Advanced surface and interface spectroscopies in novel materials and devices: atomistic simulations and experiments
7. Low-Temperature Transport and quantum effects in (nano)devices and interfaces based on superconducting, topological and other novel low dimensional materials
8. Spin injection and spin imbalance in superconducting heterostructures

Afferenza Programmi del Dipartimento:

- ***Innovative Materials***
- ***Devices and Sensors***
- ***Quantum Technologies***
- Lasers and Photonics
- Complexity and Biology
- Methodology and Instrumentation.

2- Innovative materials with entangled spin, orbital and charge degrees of freedom

Investigation of novel multifunctional materials characterized by entangled spin, orbital, charge and lattice degrees of freedom.

This project is mostly dedicated to the synthesis, characterization and fundamental understanding of innovative materials where conventional or unconventional spin-textures can take place: **ferromagnets, antiferromagnets, canted systems, helimagnets, bulk and artificial multiferroics,organic multiferroics, topological insulators, systems hosting magnetic spin vortices and Skyrmions**.

Addressing the way such **spin textures can be modified by** acting on different knobs, such as **spinorbital coupling, magnetoelectric coupling**, **spin-transfer-torque** , **epitaxial strain**, etc

Benefits from the expertise and instrumental endowment available in several CNR-SPIN Units for high quality samples (single crystals, bulk sintered pellets and epitaxial thin films and heterostructures).

Developing **multi/scale techniques** by exploiting the strongly established expertise in **materials modelling for studying correlation effects between the charge, spin, orbital and lattice degrees of freedom of multifunctional materials.**

2- Innovative materials with entangled spin, orbital and charge degrees of freedom

List of TOPICS:

1. Growth of high quality materials exhibiting spin/charge/orbital coupling in the form of epitaxial thin films, multilayer, heterostructures, sintered bulk pellets or single crystals;
2. 4d and 5d transition metals with perovskite and double layer structures with strong spin orbit interaction in the bulk;
3. Metal-insulator transitions induced by charge/spin/orbital ordering;
4. Non conventional spin-textures and Skyrmion physics in novel ferromagnets and artificial heterostructures;
5. Spin-orbital effects in 3d/5d oxide heterostructures (e.g. manganites/iridates);
6. Multiferroic effects based on Giant Rashba spin orbit in semiconducting systems and Topological insulators;
7. Multiferroics effects under external pressure and epitaxial strain, artificial multiferroics and improper multiferroics

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3 Superconducting and functional materials for energy and environment

Development and demonstration of improved technologies and novel superconducting materials for energy transport and novel systems for energy conversion and efficiency technology

Novel Supeconducting Materials for energy transport. The aim of this project is to investigate the fundamental mechanisms in innovative superconducting materials, to set new preparation techniques for these compounds and to explore their potential application in the development of highly efficient energy transport systems (e.g. MRI, SMES, fault current limiters, etc)

Innovative materials and devices for applications in energy sensing and environment. As primary goal, this project is aimed to the investigation of advanced functional materials and solutions of innovative systems for energy conversion and recovery. As a complementary way, it will be focused on the design of novel sensing electronic devices for the detection of physical, chemical and biological parameters of relevance for environmental monitoring.

3 Superconducting and functional materials for energy and environment

The main research guidelines of the project will deal with:

- Innovative photon-to-charge conversion materials with tailored band-gap for application in the new generations of photovoltaic systems. In this context, particular attention will be paid to compounds which can be deposited on large area substrates also by solution-based techniques;
- Development of miniaturized devices for energy recovery and storage. Specific efforts in this area will be devoted to investigate new thermoelectric materials and ionic/proton conductors for application in miniaturized fuel cells;
- Synthesis and study of novel transparent conductors for integration in solar cells and other (opto)-electronic devices;
- Fabrication and characterization of organic electronic devices and circuitry for integration on flexible/transparent substrates. The miniaturization of organic devices down to nanoscale will be also pursued;
- Development of miniaturized sensors to applied for the detection of environmental gases;
- Development of sensing devices operating in liquid ambient for the detection of chemical and biological analytes.

Afferenza Programmi del Dipartimento:

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- Quantum Technologies
- Lasers and Photonics
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4- Light-matter interaction and non-equilibrium dynamics in advanced materials and devices

Controlling quantum condensed matter with light, photoinducing phases in organic and inorganic materials that do not occur spontaneously, and understanding the properties of condensed matter away from equilibrium

new possibilities, directing various excitations along predetermined paths and acting on the macroscopic matter in ways that are only starting to be explored.

The scientific focus of the present project is twofold:

- **understanding and controlling the dynamics of complex solids with strongly correlated electrons;**
- **using light for micro/nano-structuring organic and inorganic material.**

Afferenza Programmi del Dipartimento:

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- Devices and Sensors
- ***Quantum Technologies***
- **Lasers and Photonics**
- Complexity and Biology
- Methodology and Instrumentation.

4- Light-matter interaction and non-equilibrium dynamics in advanced materials and devices

Light induced quantum phases in condensed matter. Interactions of ultrashort light pulses open a huge possibility to generate transient states of matter (new quantum phases)

Aims:

- **manipulating charge, spin and orbital order in strongly-correlated and magnetic systems** for applications in high frequency data processing devices.
- **creation and control of coherent excitations in complex solids** for sensing.
- **development of superconducting single-photon quantum detectors,** for quantum technologies and photon detectors applications.

Structuring matter and light. Create patterns or structures on surfaces at the μ- and n-scale using light, potential applications in material processing, optical absorption tuning and control, THz studies, plasmonics, surface functionalization, chemio- and bio-sensing, etc..(ex. fs laser vortex beams for the formation of sub-wavelength ring structures on glass or Si surfaces, graphene micro- and nano-disks, mass-redistribution in azopolymers)

- **Mesoscopically structured materials** for modifying the light propagation (metamaterials and microfabricated coupled resonators)

- **Single molecule-nanostructure interactions** for sensing applications.

Materials of interest: metals, correlated and non-correlated oxides, organics (bulk and heterostructures) from atomically-controlled deposition to wet-chemical routes.

5. Electronic and thermal transport from the nanoscale to the macroscale: from fundamentals to applications

The controlled and reproducible design of new functional devices for energy transport and conversion is an emerging and rapidly developing research field. The nature of the basic interactions governing the fundamental processes in these devices is far from being understood, because electronic, lattice, spin and optical (photon) processes occur and can interfere with each other.

Length scale ranges from the nanoscale (nanodevices, nanoscale circuits, nanowires and nanotubes, etc.) to the macroscale (composite materials, organic compounds, amorphous blends, etc.) ⟶ **multi-scale approach and a variety of different competencies**.

Scope: **to study, from the classical to the quantum level, the fundamental processes involved in the motion of carriers, lattice vibrations and other excitations in a large variety of materials and devices** (including new generation solar cells, thermoelectrics, nanoelectromechanic devices, etc.) **of interest for energy transport and conversion.**

adequate description from the atomistic to the microscopic level, from quantum mechanics to molecular dynamics.

5. Electronic and thermal transport from the nanoscale to the macroscale: from fundamentals to applications

Study of emerging materials (graphene, topological insulators, semiconductors with helical and chiral edge states, hybrid organic-inorganic perovskite materials, layered compounds, nano- and micro-composites, etc...) as good candidates for energy applications

Driven quantum systems are emerging as a valuable alternative in designing new and powerful microscopic devices with complex and rich thermodynamical behavior (manipulation of heat on a quantum scale for applications extending from quantum information to technological and biological device design).

In view of applications for low-power (nano)electronics, energy harvesting and conversion, one needs a better **understanding of heat production, and energy transport, dissipation and conversion from the quantum to the macroscopic scale**.

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