



UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA



# BottomUp NANO TopDown through Physics curricula

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Nanosciences use a whole range of tools and techniques coming from different disciplines and research fields to study and manipulate matter at nanoscale where many of its properties originate. Scientists work to make the most of atoms and molecules quantum behaviour to design new materials with specific and pre-designed physical and chemical properties, leading to many and appealing applications. Therefore nanosciences are an ideal playground to engage students in research topics and introduce the basics of quantum mechanics and matter physics at high school level with an hands on and intrinsically interdisciplinary approach, linking fundamental science both to actual technology and to feasible one. Long standing expertise from local University and Research Centre and new practice from European School Project joined to further enhance Nano world knowledge among teachers and their students.

•Scientists at UniMoRe Physics Dep. designed a whole set of activities straightly from personal research laboratory experience, called **"Modern Physics Laboratories"**. They were supported by the Ministry of Education University and Research in the contest of the national initiative Progetto Lauree Scientifiche (PLS) aimed at improving scientific vocations. [www.physicscom.unimore.it](http://www.physicscom.unimore.it)

•Focused mainly on **basic science and investigation techniques**, most of the proposed experiments are based on sophisticated instruments which can be used by students during stages or visits to the Department and research labs. However part of the modules can actually be implemented in school either as pre activities or as follow up.

• **Aims:** Bridging the gap between researchers and high school Physics teachers\ students. Convey the idea of quantum physics as a widely used tool in nanoscience. Improve teachers lifelong training in modern Physics and its applications as a way to reach and engage large audiences of pupils.

### Some examples:

- From optics to TEM: introducing electronic microscopy;
- From photoelectric effect to photoemission spectroscopy
- Optical tweezers: light to trap molecules

**Further action:** Autumn 2011- **NanoLab** professional development workshops for teachers in blended modality: seminars + hands-on labs

**Info and contact:** [www.physicscom.unimore.it](http://www.physicscom.unimore.it)  
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Already a partner of UniMoRe Physics Dep. in PLS, Lic.Sc. Sorbelli in 2010/2011 was selected as one of 24 pilot schools spread all over EU in NanoYOU European project . [www.nanoyou.eu](http://www.nanoyou.eu) ( free download of materials under Creative Commons licence #)

•Pupils (14-18) engaged in NanoYOU **hands-on activities** and suggested a few more, all of them low cost and easily replicable in any school science lab .

•Nanoscience and nanotechnology were introduced as a cutting edge topic permeating the whole Physics curricula integrating **interdisciplinary research** with traditional science concepts.

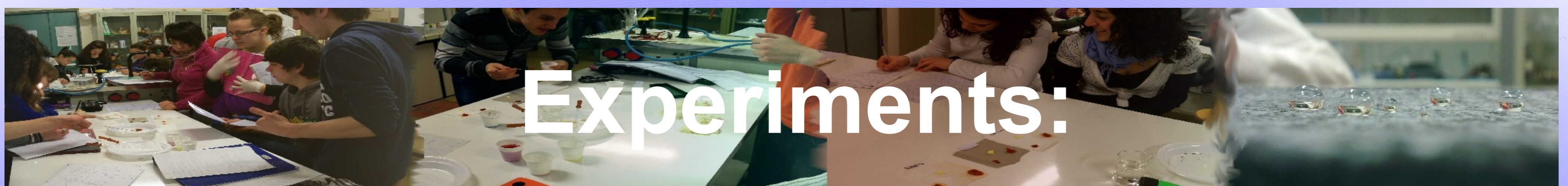
•Students worked on new materials predicting, testing, analysing data, studying possible applications. Results often challenged their „school“ Physics knowledge and enhanced their **experimental design skills**.

### Some examples:

- Synthesis of gold nanoparticles and their use as colorimetric sensor #
- Nanostructured surfaces in nature and biomimetics: Lotus effect and superhydrophobicity #
- Forces at macro and nano scale : friction, adhesion and Van der Waals'. Gecko effect.
- Tuning electrical resistance: conductive polymers and QTC (Quantum tunneling composite)
- Metals dilatation and the counterintuitive behaviour of smart alloys
- Electromagnetic spectrum and light interaction with materials and surfaces: colloids #, LCD #, aerogels

•Science Education is a fundamental tools for developing active citizenship in the knowledge society, therefore one of the main focus was nanotechnologies and sustainability and related **societal issues** .

- Organic PV and Graetzel cells
- Light transmission in nanocoated glasses and polymeric thin films against green house effect
- Thermal insulating properties of new building materials: aeroclay, aerogels
- Nanoporous materials for oil spilling containment and absorption



## Experiments:

Surfaces can be structured at the nanoscale to create Lotus effect and manufacture superhydrophobic materials

**PINZE OTTICHE: LUCE PER INTRAPPOLARE LE MOLECOLE**

**DALL'EFFETTO FOTOELETTRICO ALLA SPETTROSCOPIA DI FOTOEMISSIONE**

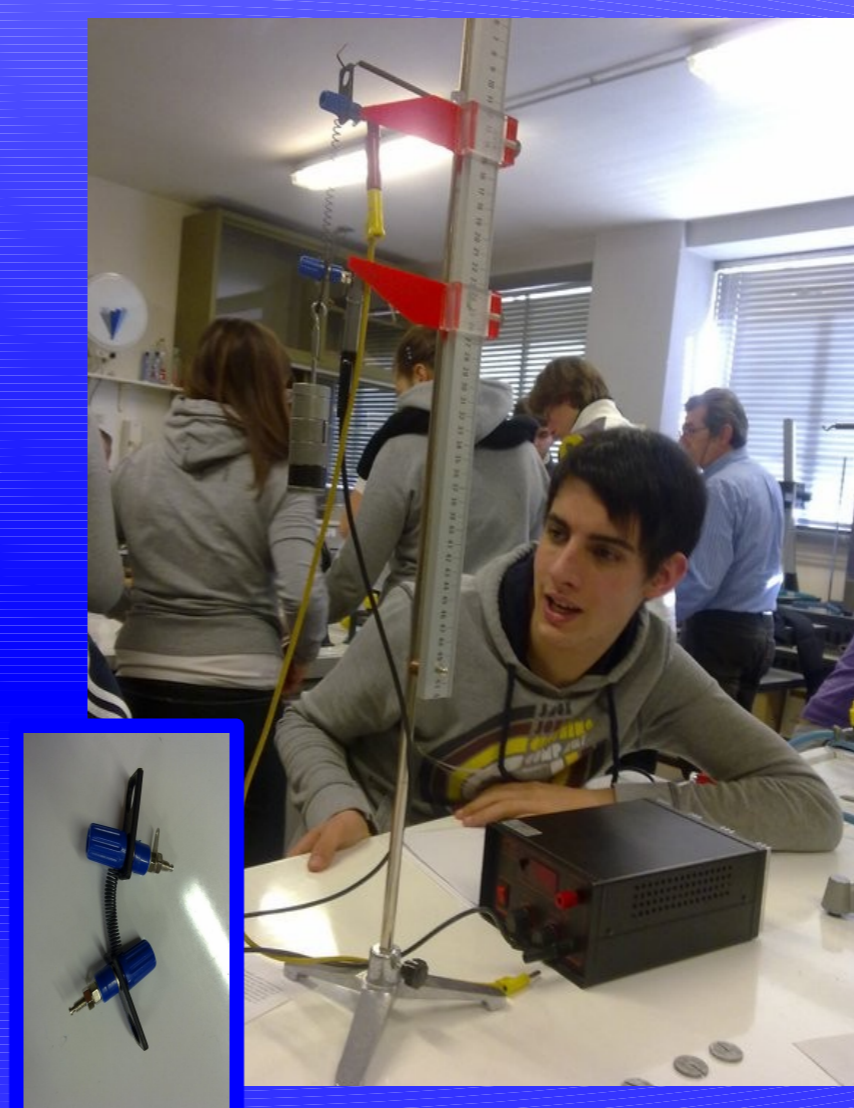
**MICROSCOPIA OTTICA ED ELETTRONICA**

Wave/particle duality, light/matter interaction, energy quantization....

The fundamentals of quantum physics are introduced in explaining experimental set ups and during activities and data interpretation.

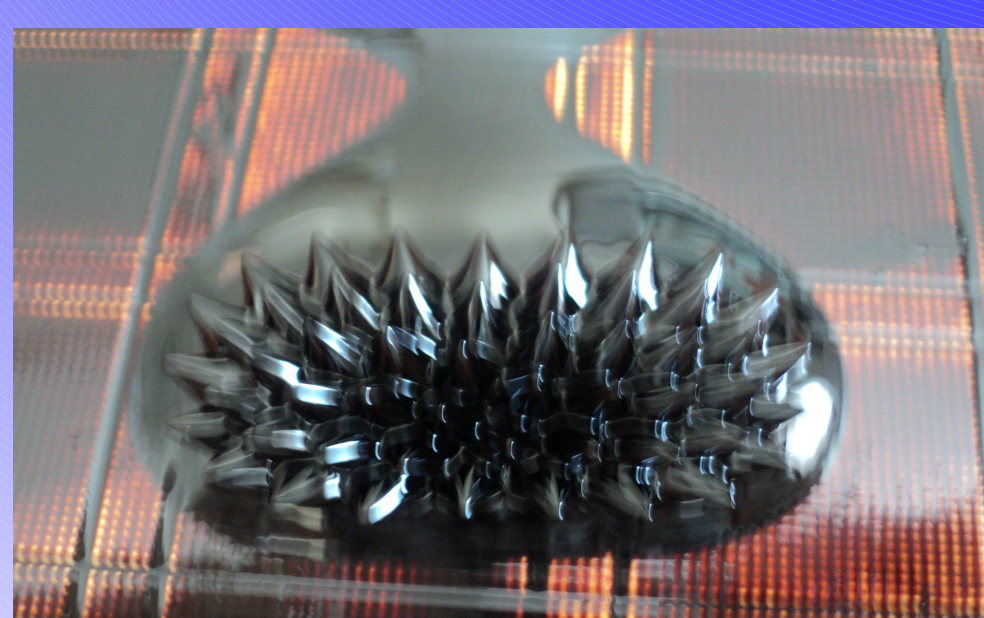
Most tools used to „see“ and work at the nanoscale are based on the very same principles.

Similarities with the macro scale are extensively exploited such as in TEM module to gain a better insight.



QTC's have the unique capability of transformation from a virtually perfect insulator to metal like conductor when deformed. The transition follows a smooth and repeatable curve, with the resistance dropping exponentially. Suitable pressure sensors such as in robotic hands.

Smart alloys such as NiTiInol contract once heated and relax as they cool down . Able to „remember“ their original shape they are excellent candidates in manufacturing electrically driven artificial muscle fibres.



Ferrofluids synthesis : density tuning through magnetic fields application and modeling new drug delivery methods.



At the nanoscale gravity is not as dominant as inter/intra molecular forces. Gecko effect is mimicked to create new adhesives .



Composed of up to 99.98 % air, aerogel is the lightest solid material on earth with incredible strenght and thermal insulator properties



Aeroclay is incredibly lightweight. Obtained by dry freezing turned out to be extremely good for oil spilling containment due to its high porosity.

Acknowledgements: firms willingly offered free samples for educational purposes.

