Curriculum
Condensed Matter Physics: Theory and Experiment

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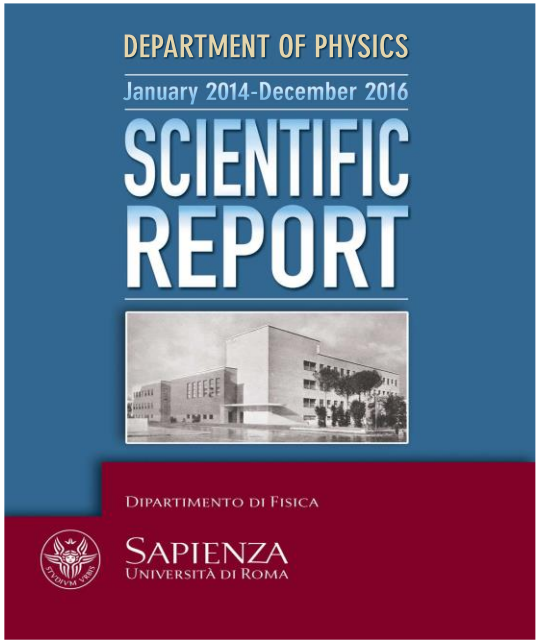
Exploring our Dept. website

DEPARTMENT OF PHYSICS SCIENTIFIC REPORT

https://www.phys.uniroma1.it/fisica/ricerca/

From 2007 to 2019 !



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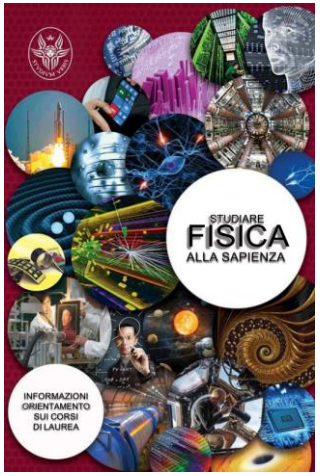
The Condensed Matter (CM) Physics group at the Physics Department of Sapienza, Università di Roma is composed by about 40 scientists with permanent positions (assistant, associate and full professors) and several affiliated researchers (mostly from CNR) who actively investigate different properties of hard matter, nano-structures, soft and bio matter, photonics and quantum technologies, or even create new frontiers of physics exporting ideas developed in and for CM physics to other (even very far) fields.



Studiare Fisica alla Sapienza

https://www.phys.uniroma1.it/fisica/didattica/orientamento/libretto-gli-studenti

Placement

https://www.phys.uniroma1.it/fisica/didattica/placement

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Important dealines

Custom tailoring your programme

Period of presentation of TRAINING PROGRAMMES AA. 2021/22:

First period: 18/10/2021-10/12/2021 (freshmen i.e. 1° year students & 2° year students to modify the training programme)

Second period: 01/02/2022 - 21/02/2022 (only for freshmen)

Information and syllabus for courses:
https://corsidilaurea.uniroma1.it/it/corso/2021/30055/cds

Curriculum

Standard:

Mandatory (6) and eligible courses (6) chosen within the groups: A(1), B(2) , C(1), free choice (2)

Notice: 2 non-FIS courses are required!

5 curricula recommended:

- Complexity Science
- Disordered systems: liquid, glassy and soft matter
- Photonics and Quantum Technologies
- Superconductivity, Strongly Correlated Systems, and Functional Materials
- Surface Physics and Nanostructures

Customized

Mandatory courses are always mandatory but eligible courses can be chosen more freely. The individual plan must be motivated and possibly discussed with the responsible of the curriculum.

Corso di laurea in Fisica (LM-17) - Curriculum Condensed matter physics: Theory and experiment							
N.	**Insegnamenti**	**CFU**	**anno**	**sem.**	**SSD**	**eng**	**ambito**
1	Introduction to Quantum Field Theory	6	1	1	FIS/02	Y	caratt.
2	Condensed Matter Physics	6	1	1	FIS/03	Y	caratt.
3	Physics Laboratory I (propedeutico a Physics Laboratory II) *	6	1	1	FIS/01	Y	caratt.
4	Physics Laboratory II *	9	1	2	FIS/01	Y	caratt.
5	Condensed Matter Physics II	6	1	2	FIS/03	Y	caratt.
6	Computing Methods for Physics *	6	1	1	INF/01	Y	aff.-int.
7	English Language	4	1	2		Y	AAF
8	Elective (within group A)	6	1 / 2	1 / 2		Y	aff.-int.
9	Elective (within group B)	6	1 / 2	1 / 2	FIS/03	Y	caratt.
10	Elective (within group B)	6	1 / 2	1 / 2	FIS/03	Y	caratt.
11	Elective (within group C)	6	1 / 2	1 / 2		Y	aff.-int.
12	Elective (free choice)	6	1/2	1/2			
13	Elective (free choice)	6	1/2	1/2			
14	Internship	3	2	1		Y	AAF
15	Thesis Project	38	2	2		Y	AAF

* internal multiple choice

Corso di laurea in Fisica (LM-17) - Curriculum Condensed matter physics: Theory and experiment

N.	Insegnamenti	CFU	anno	sem.	SSD	eng	ambito
1	Introduction to Quantum Field Theory	6	1	1	FIS/02	Y	caratt.
2	Condensed Matter Physics	6	1	1	FIS/03	Y	caratt.
3	Physics Laboratory I (propedeutico a Physics Laboratory II)	6	1	1	FIS/01	Y	caratt.
4	Physics Laboratory II	9	1	2	FIS/01	Y	caratt.
5	Condensed Matter Physics II	6	1	2	FIS/03	Y	caratt.
6	Computing Methods for Physics	6	1	1	INF/01	Y	aff.-int.
7	English Language	4	1	2		Y	AAF
8	Elective (within group A)	6	1 / 2	1 / 2		Y	aff.-int.
9	Elective (within group B)	6	1 / 2	1 / 2	FIS/03	Y	caratt.
10	Elective (within group B)	6	1 / 2	1 / 2	FIS/03	Y	caratt.
11	Elective (within group C)	6	1 / 2	1 / 2		Y	aff.-int.
12	Elective (free choice)	6	1/2	1/2			
13	Elective (free choice)	6	1/2	1/2			
14	Internship	3	2	1		Y	AAF
15	Thesis Project	38	2	2		Y	AAF

Corso di laurea in Fisica (LM-17) - Curriculum Condensed matter physics: Theory and experiment

N.	Insegnamenti	CFU	anno	sem.	SSD	eng	ambito
1	Introduction to Quantum Field Theory	6	1	1	FIS/02	Y	caratt.
2	Condensed Matter Physics	6	1	1	FIS/03	Y	caratt.
3	Physics Laboratory I (propedeutico a Physics Laboratory II)	6	1	1	FIS/01	Y	caratt.
4	Physics Laboratory II	9	1	2	FIS/01	Y	caratt.
5	Condensed Matter Physics II	6	1	2	FIS/03	Y	caratt.
6	Computing Methods for Physics	6	1	1	INF/01	Y	aff.-int.
7	English Language	4	1	2		Y	AAF
8	Elective (within group A)	6	1 / 2	1 / 2		Y	aff.-int.
9	Elective (within group B)	6	1 / 2	1 / 2	FIS/03	Y	caratt.
10	Elective (within group B)		/ 2	1 / 2	FIS/03	Y	caratt.
11	Elective (within group C)		/ 2	1 / 2		Y	aff.-int.
12	Elective (free choice)	6	1/2	1/2			
13	Elective (free choice)	6	1/2	1/2			
14	Internship	3	2	1		Y	AAF
15	Thesis Project	38	2	2		Y	AAF

1 non-FIS

1

Gruppo A (aff.– int.)							
1	Statistical Mechanics and Critical Phenomena	6	1	1	FIS/02	**Y**	
2	Physics of liquids	6	1	2	FIS/03	**Y**	
3	Physics of solids	6	2	1	FIS/03	**Y**	

1

Gruppo A (aff.– int.)							
1	Statistical Mechanics and Critical Phenomena	6	1	1	FIS/02	**Y**	
2	Physics of liquids	6	1	2	FIS/03	**Y**	
3	Physics of solids	6	2	1	FIS/03	**Y**	

2

Gruppo B (caratt.)							
1	Soft and Biological Matter	6	1	1	FIS/03	Y	
2	Nonlinear and Quantum Optics	6	1	1	FIS/03	**Y**	
3	Photonics	6	1	2	FIS/03	**Y**	
4	Physics of liquids	6	1	2	FIS/03	Y	
5	Spectroscopy Methods and Nanophotonics	6	1	2	FIS/03	**Y**	
6	Superconductivity and Superfluidity	6	1	2	FIS/03	Y	
7	Many Body Physics	6	2	1	FIS/03	**Y**	
8	Physics of solids	6	2	1	FIS/03	**Y**	
9	Physics of Complex Systems	6	2	1	FIS/03	Y	
10	Surface Physics and Nanostructures	6	2	1	FIS/03	Y	

1

Gruppo C (aff.-int..)							
1	Computational Biophysics	6	1	1	INF/01	Y	
2	Nonlinear and Quantum Optics	6	1	1	FIS/03	Y	
3	Soft and Biological Matter	6	1	1	FIS/03	Y	
4	Statistical Mechanics and Critical Phenomena	6	1	1	FIS/02	**Y**	
5	Biophysics	6	1	2	FIS/03	Y	
6	Computer architecture for Physics	6	1	2	INF/01	Y	
7	Advanced Machine Learning for Physics	6	1	2	INF/01	Y	
8	Mathematical Physics	6	1	2	MAT/07	Y	
9	Neural Networks	6	1	2	FIS/02	Y	
10	Nonlinear waves and solitons	6	1	2	FIS/02	**Y**	
11	Photonics	6	1	2	FIS/03	Y	
12	Physics of liquids	6	1	2	FIS/03	Y	
13	Spectroscopy Methods and Nanophotonics	6	1	2	FIS/03	**Y**	
14	Superconductivity and Superfluidity	6	1	2	FIS/03	**Y**	
15	Theoretical Biophysics	6	1	2	FIS/02	Y	
16	Molecular Biology	6	1	2	BIO/11	Y	
17	Quantum Field Theory	6	2	1	FIS/02	Y	
18	Physics of Solids	6	2	1	FIS/03	**Y**	
19	Medical Applications of Physics	6	2	1	FIS/01	Y	
20	Many-Body Physics	6	2	1	FIS/03	Y	
21	Physics of Complex Systems	6	2	1	FIS/03	**Y**	
22	Quantum Information and Computation	6	2	1	FIS/01	**Y**	
23	Solid State Sensors	6	2	1	FIS/01	Y	
24	Statistical Mechanics of Disordered Systems	6	2	1	FIS/02	**Y**	
25	Surface Physics and Nanostructures	6	2	1	FIS/03	Y	
26	Statistical Physics and Machine Learning	6	2	1	FIS/02	Y	

Complexity Science

ANNO	SEM.	CFU
1	1	
Introduction to Quantum Field Theory		6
Condensed Matter Physics		6
Physics Lab I		6
Computing Methods for physics (C-INF)		6
Statistical mechanics and Critical Phenomena (A)		6
		30

ANNO	SEM.	
1	2	
Physics Lab II		9
Condensed Matter Physics II		6
Meccanica Statistica del Non Equilibrio (C)		6
English Language		4
One among (Free Choice):		
Advanced Machine Learning for Physics;		
Deep learning and applied artificial intelligence (Informatica)		
		6
		31

ANNO	SEM.	
2	1	
Machine Learning (C-INF)		6
Physics of Complex Systems (B)		6
One among (free choice):		
Superconductivity and Superfluidity;		
Statistical mechanics of disordered systems;		
Introduzione alla teoria dei processi stocastici;		
Statistical physics and Machine learning		6
Internship		3
		21

ANNO	SEM.	
2	2	
Thesis project		38

Disordered systems: liquid, glassy and soft matter

ANNO	SEM.	
1	1	CFU
Introduction to Quantum Field Theory		6
Condensed Matter Physics		6
Physics Lab I		6
Computing Methods for Physics (C-INF)		6
Soft and Biological Matter (B)		6
		30

ANNO	SEM.	
1	2	
Physics Lab II		9
Condensed Matter Physics II		6
Physics of Liquids (A)		6
Biophysics (C)		6
One among:		
Deep learning and applied artificial intelligence;		
Machine Learning;		
Advanced Machine Learning for Physics;		
or another non-FIS course		6
English Language		4
Totale		37

ANNO	SEM.	
2	1	
Two among (free choice):		
Statistical mechanics of disordered systems;		
Introduzione alla teoria dei processi stocastici ed applicazioni alla fisica		
Statistical mechanics and Critical Phenomena		12
Internship		3
Totale		15

ANNO	SEM.	
2	2	
Thesis project		38

Photonics and Quantum Technologies

ANNO	SEM.	CFU
1	1	
Introduction to Quantum Field Theory		6
Condensed Matter Physics		6
Physics Lab I		6
Nonlinear and Quantum Optics (B)		6
Computing methods for physics (C-Inf)		6
		30

ANNO	SEM.	
1	2	
Physics Lab II		9
Condensed Matter Physics II		6
English Language		4
Photonics (B)		6
One among:		
Spectroscopy methods and nanophotonics;		
Nonlinear waves and solitons;		
One free choice non-FIS		6
		31

ANNO	SEM.	
2	1	
Physics of Solids (A)		6
Quantum Information and Computation (C)		6
One among:		
Solid State Sensors;		
Surface Physics and Nanostructures;		
One free choice non-FIS (required)		6
Internship		3
		21

ANNO	SEM.	
2	2	
Thesis project		38

Superconductivity, Strongly Correlated System, and Functional Materials

ANNO 1	SEM. 1	CFU
Introduction to Quantum Field Theory		6
Condensed Matter Physics		6
Physics Lab I		6
Computing methods for physics (C-Inf)		6
One among:		
Statistical mechanics and Critical Phenomena (C);		
Nonlinear and Quantum Optics (C)		6
		30

ANNO 1	SEM. 2	
Physics Lab II		9
Condensed Matter Physics II		6
English Language		4
Superconductivity and Superfluidity (B)		6
One or Two among:		
Spectroscopy methods and nanophotonics (B);		
Mathematical Physics (C-Mat);		
Photonics (C);		
Physics of liquids (C);		
another non-fis exam of group C		6 or 12
		31 or 37

ANNO 2	SEM. 1	
Physics of Solids (A)		6
Many-Body Physics (B)		6
Zero or One:	Surface Physics and Nanostructures (B);	
	Quantum Information and Computation (C);	
	Solid State Sensors (C);	
	Machine Learning (C-Inf -Informatica);	
	Advanced Machine Learning for Physics;	
	or other non-Fis exam	0 or 6
Internship		3
		21 or 15

ANNO 2	SEM. 2	
Thesis project		38

Surface Physics and Nanostructures

ANNO	SEM.	CFU
1	1	
Introduction to Quantum Field Theory		6
Condensed Matter Physics		6
Physics Lab I		6
Computing methods for physics (C-Inf)		6
One among:	Nonlinear and Quantum Optics (C);	
	Statistical mechanics and Critical Phenomena (C)	6
		30

ANNO	SEM.	
1	2	
Physics Lab II		9
Condensed Matter Physics II		6
English Language		4
Spectroscopy methods and nanophotonics (B)		6
One or two among:		
Superconducitvity and Superfluidity (B);		
Photonics (C);		
Physics of liquids (C);		
Mathematical Physics (C-mat);		
or another non-Fis exam		6 o 12
		31 or 37

ANNO	SEM.	
2	1	
Physics of Solids (A)		6
Surface Physics and Nanostructures (B)		6
One or zero among:		
Many Body Physics (B);		
Quantum Information and Computation (C);		
Solid State Sensors (elective free choice);		
Machine Learning (C-inf);		
Advanced Machine Learning for Physics;		
or another non-fis exam		6 o 0
Internship		3
		21 or 15

ANNO	SEM.	
2	2	
Thesis project		38

Superconductivity & strongly correlated systems.

Nanostructured & low dimensional systems

Teaching closely related to the research activity carried out in the Dept.

Liquids & disordered systems

Quantum information, non linear optics

Statistical Mechanics

Materials and methods for cultural heritage …

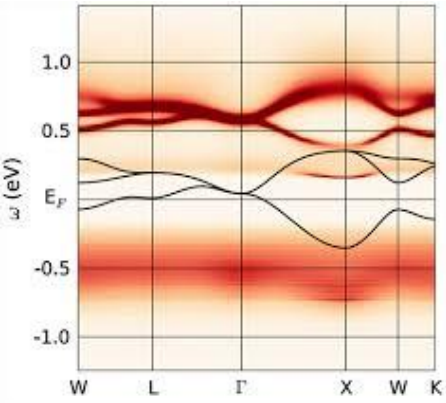
In house laboratory (Spectroscopy: optical, electron, linear, non-linear, time resolved…)

Computational and *ab-initio* methods.

Research activities and methods in condensed matter

Large scale facilities: Synchrotron and Neutron sources

What hard condensed matter theorists do?



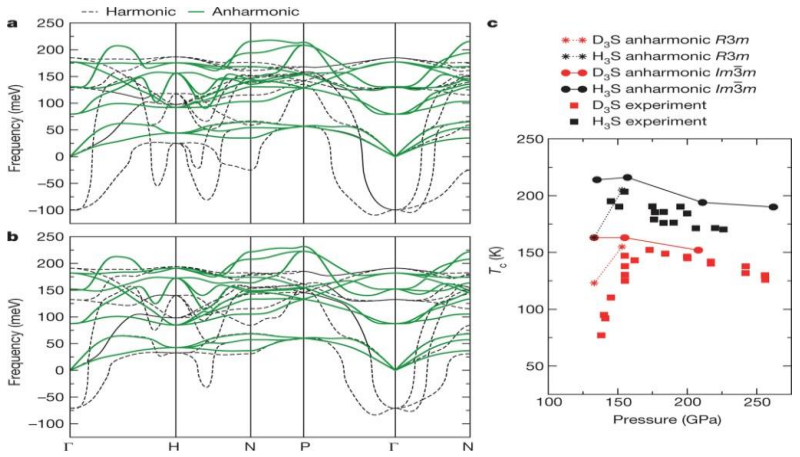
What is the electronic structure of the different solid-state materials?

Can electronic states be `topologically non trivial'?

What are the resulting physical properties? Insulator, metal, superconductor,…

How electrons and other degrees of freedom (e.g. ions) interact?

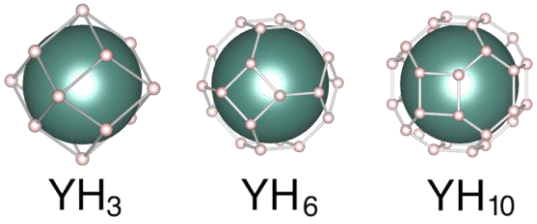
For instance new techniques can be invented to treat the anharmonic effects in solids and investigate the stability of **high-temperature superconductors under very high pressure**



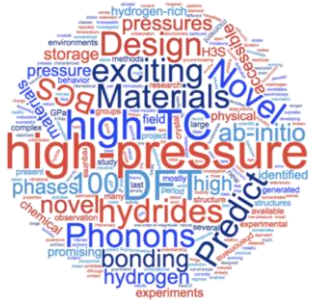
Quantum Materials Modelling

Research Goal = theory & design of complex solids, use & development of theoretical-computational methods based on quantum mechanics.

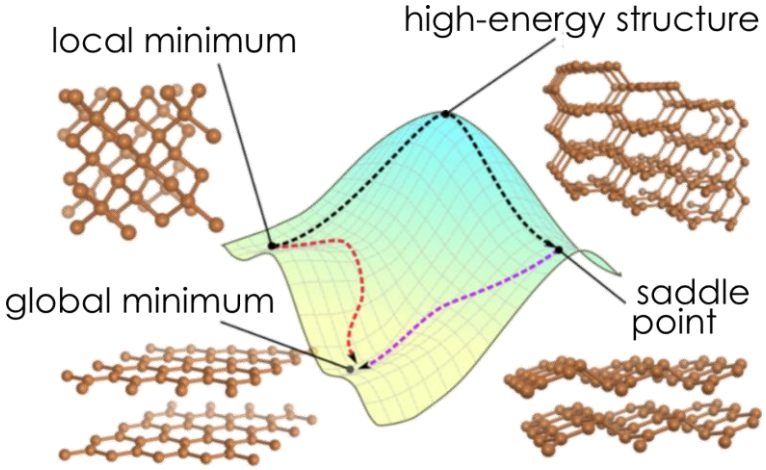
High-Tc superconductors



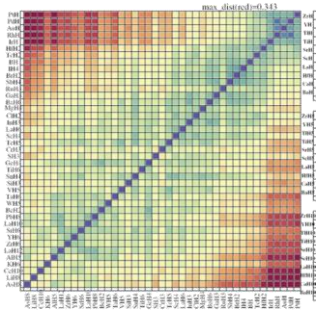
High-Pressure Physics



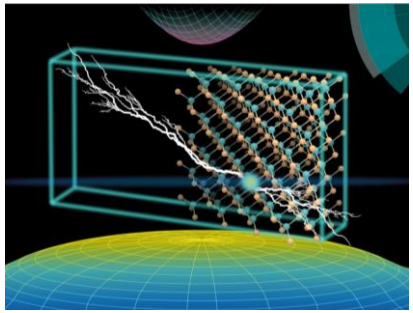
Structure prediction



Machine learning

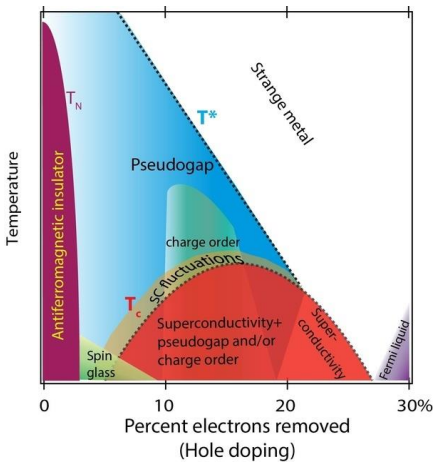


Transparent conductors



Keywords = Superconductors; Transparent conductors; Magnetic Materials; Ab-initio crystal structure prediction; Machine Learning; DFT; QMC; Pseudopots.

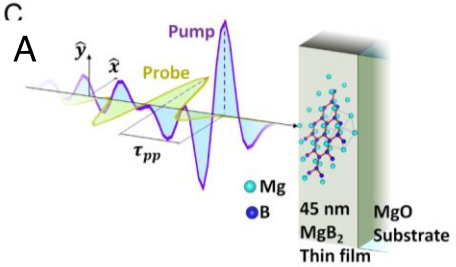
Modelling superconductivity and its enemies (disorder, cdw, …)

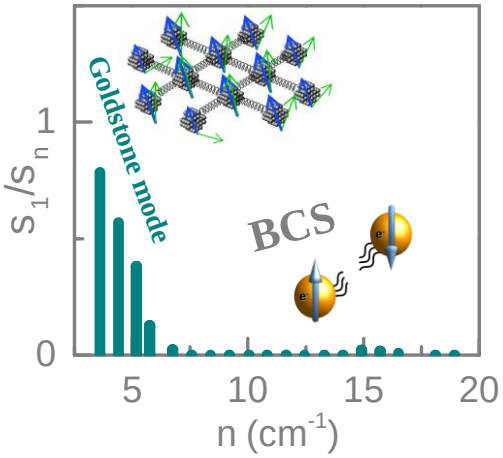


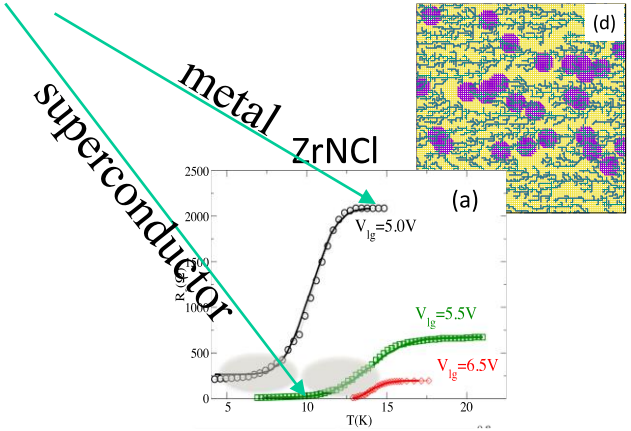
Some materials change a lot their properties by varying some parameter (e.g. electron density) and have strange properties. Why? Which ingredients are important and should be kept in a model?

Competing phases are very interesting and new features can emerge…
One of the aspects of complexity…

How electrons oscillate collectively in a superconductor? Analogies with high-energy stuff….
(Higgs, Goldstone and so on…)

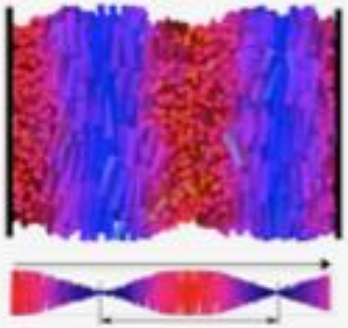






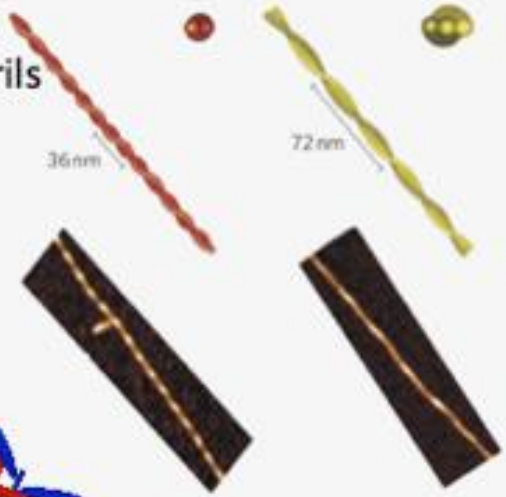
Soft Matter Modeling

DNA-made origami particles

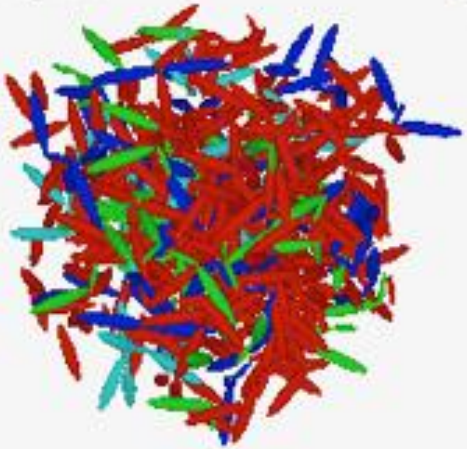


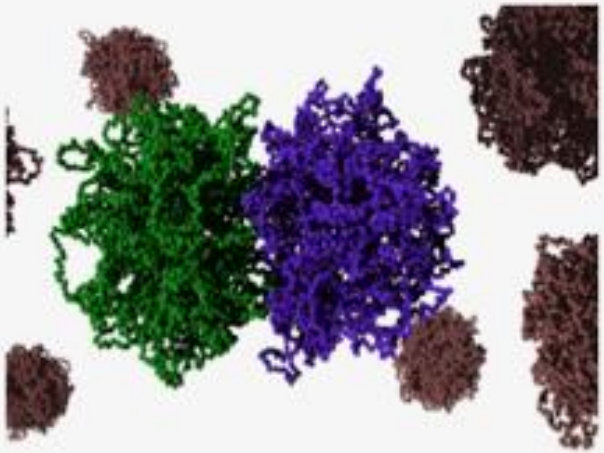
Modeling nematic phases of biological macromolecules and colloidal particles

Amyloid fibrils



Epoxy resin glues

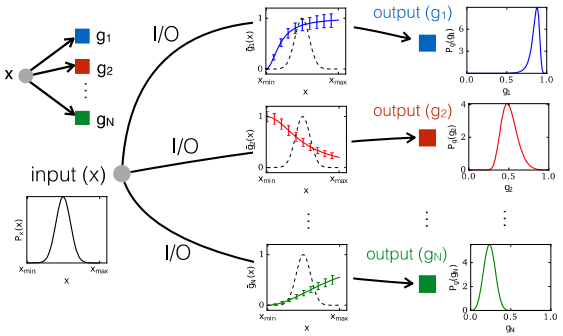




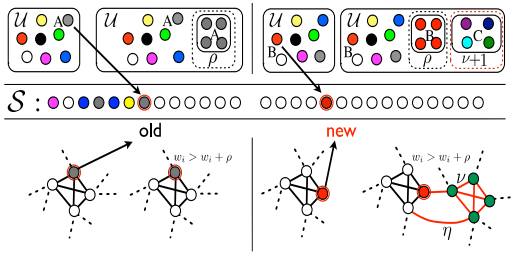
polymeric microgels

Condensed Matter Theory spin offs: The physics of `a lot of things'!

Gene expression is a complex process that should be regulated via networks of molecules (proteins or RNAs) that interact with each other

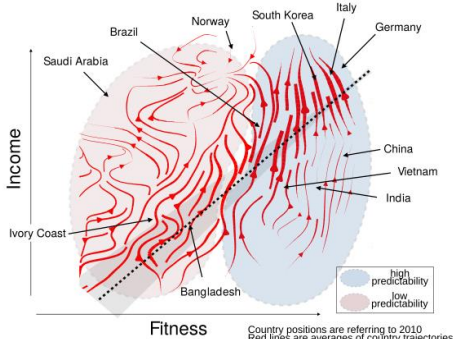


Estimate the rate at which new events occur: How networks grow? How new genes appear in a population?...



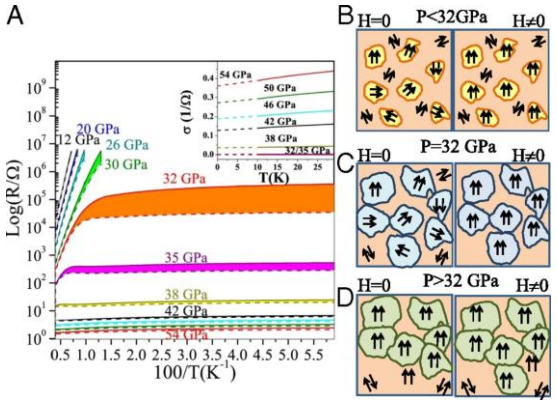
Growth of complex structures,....

Planning of urban infrastructures, containment strategies for pandemics, impact of political campaigns, measures against information pollution and misinformation.

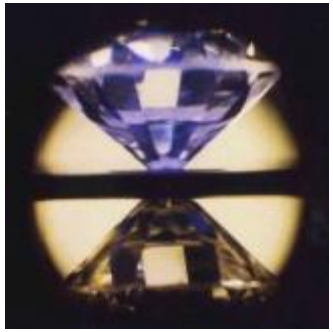


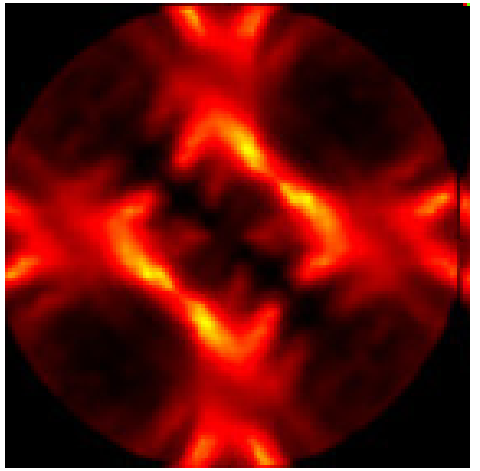
quantitative assessments of countries' competitiveness and potential of growth, through the concept of **Fitness**, and products' sophistication and technological content,

Superconductivity & strongly correlated materials



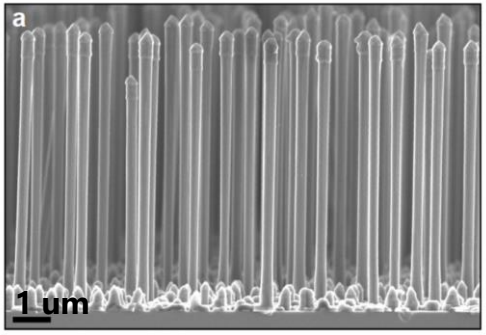
Condensed matter under extreme conditions (very high P, very high/low T)



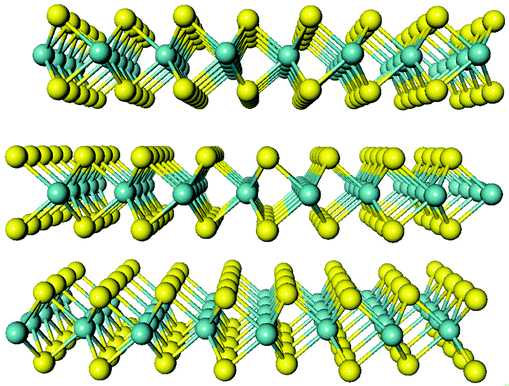


Fermi surface of the Bi2212 superconductor

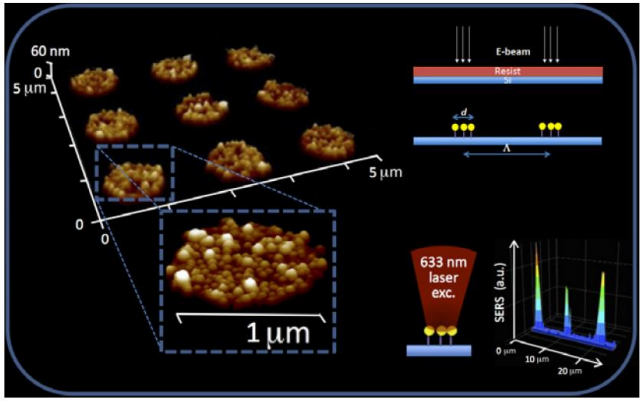
Nanostructures and low-dimensional systems



Semiconductor nanowires, Metallic nanostructure



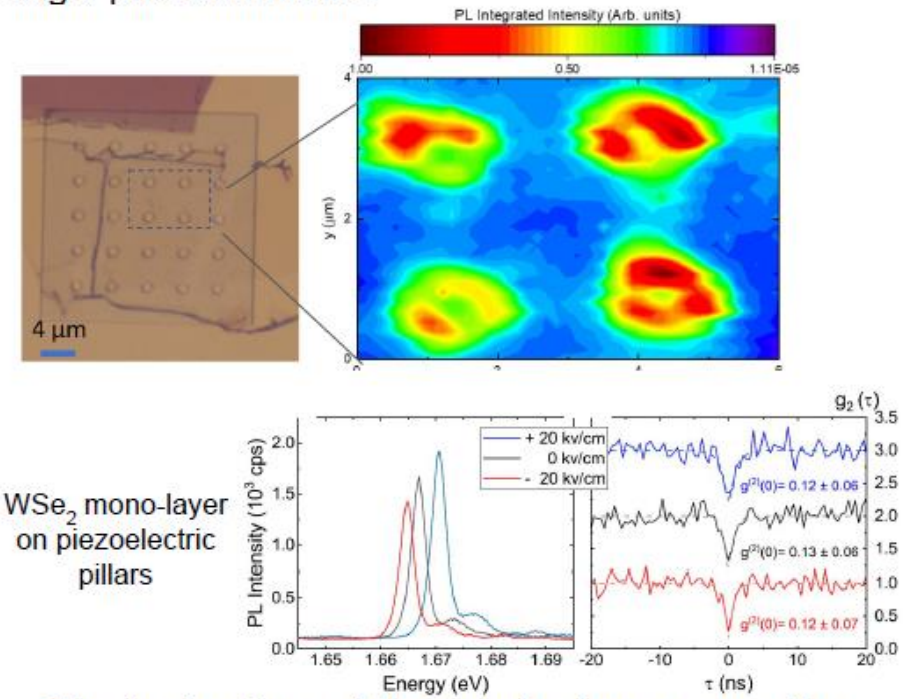
Transition metal dichalcogenides (TMDs)



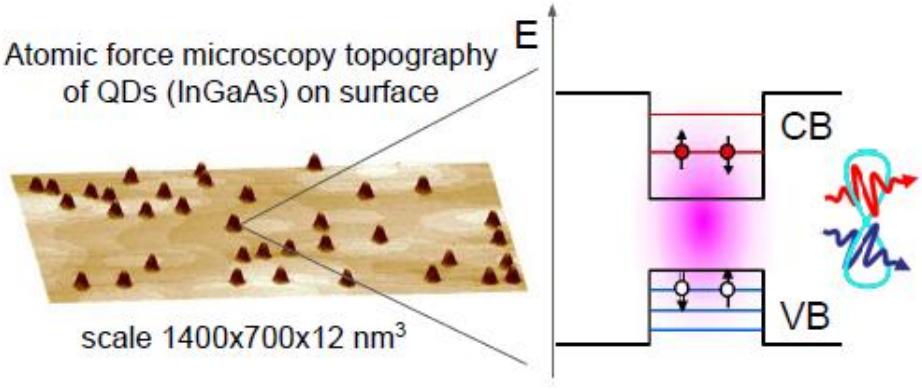
Self assembled nanoparticles

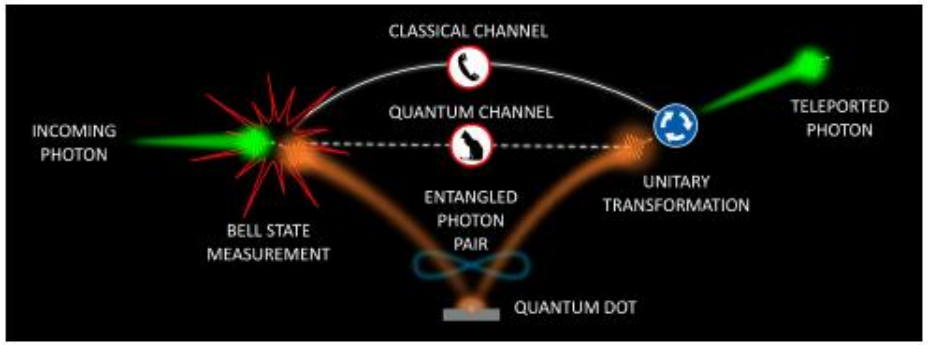
Single-photon emitters based on 2D materials

site-controlled & wavelength-tunable
single-photon **emitters**



Strain-tuning of the emission properties

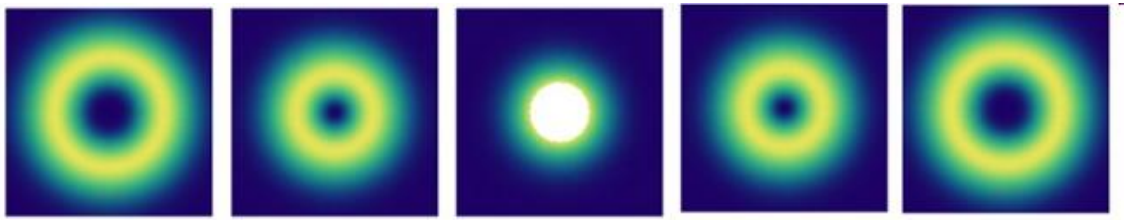




Quantum teleportation scheme

QD to be used as entangled-light sources

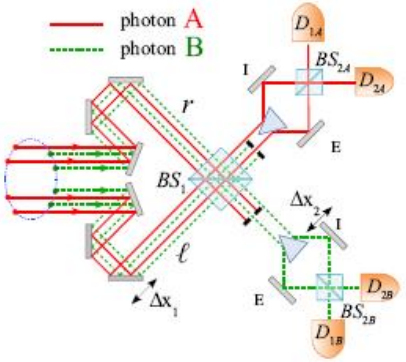
Quantum information, non-linear optics

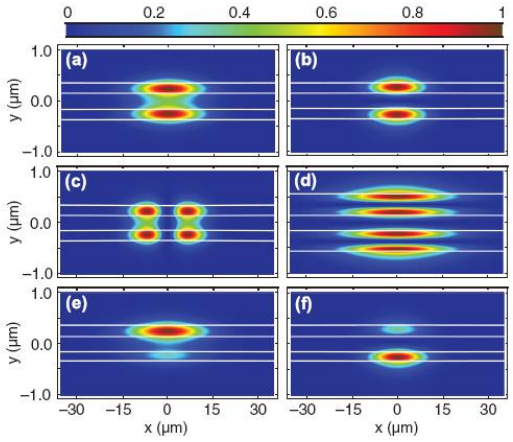


Qu-bits, quantum photonics

…

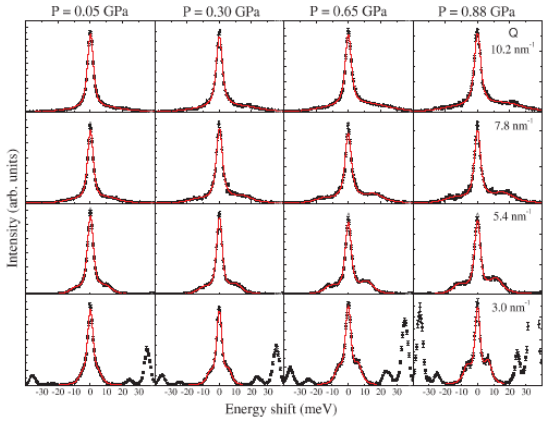
Optical technologies for quantum information.

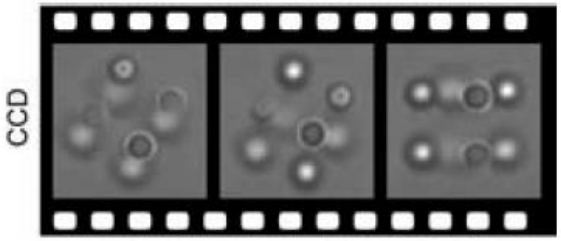


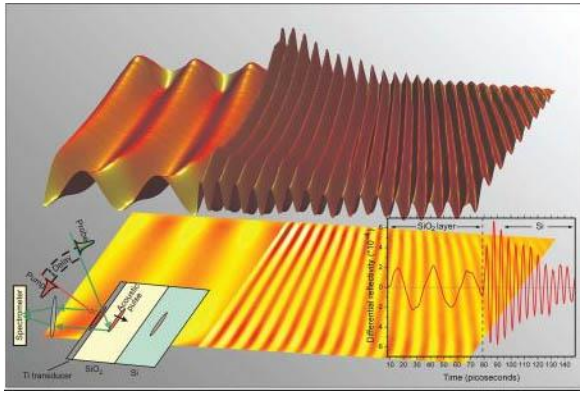


Non-linear optics, super-resolution

Liquids & disordered systems



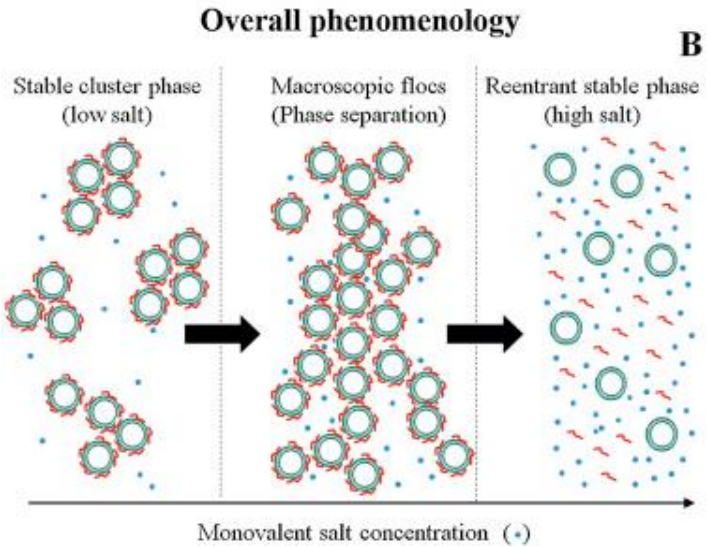




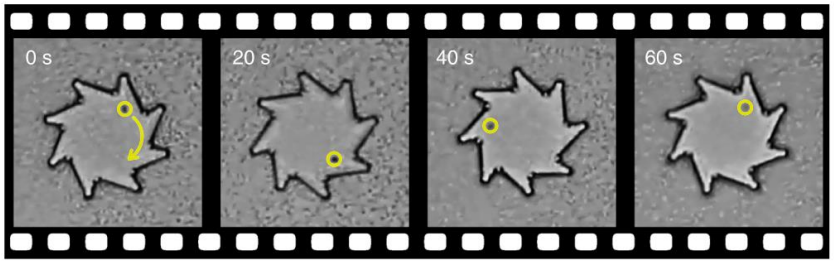
Sound velocity in liquids under extreme pressures / colloidal particle

Coherent excitation in disordered systems, femto-second spectroscopy

Colloids, interfaces

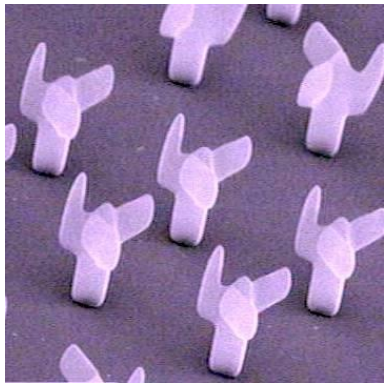


Structured matter at the microscale

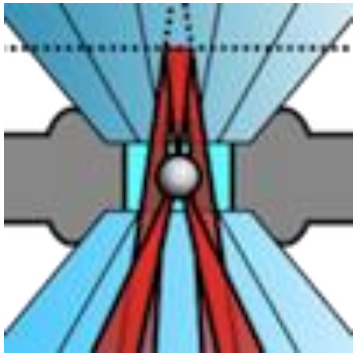


Active matter, …

…

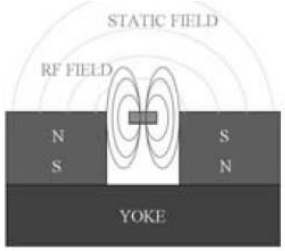


Light driven Micromotors



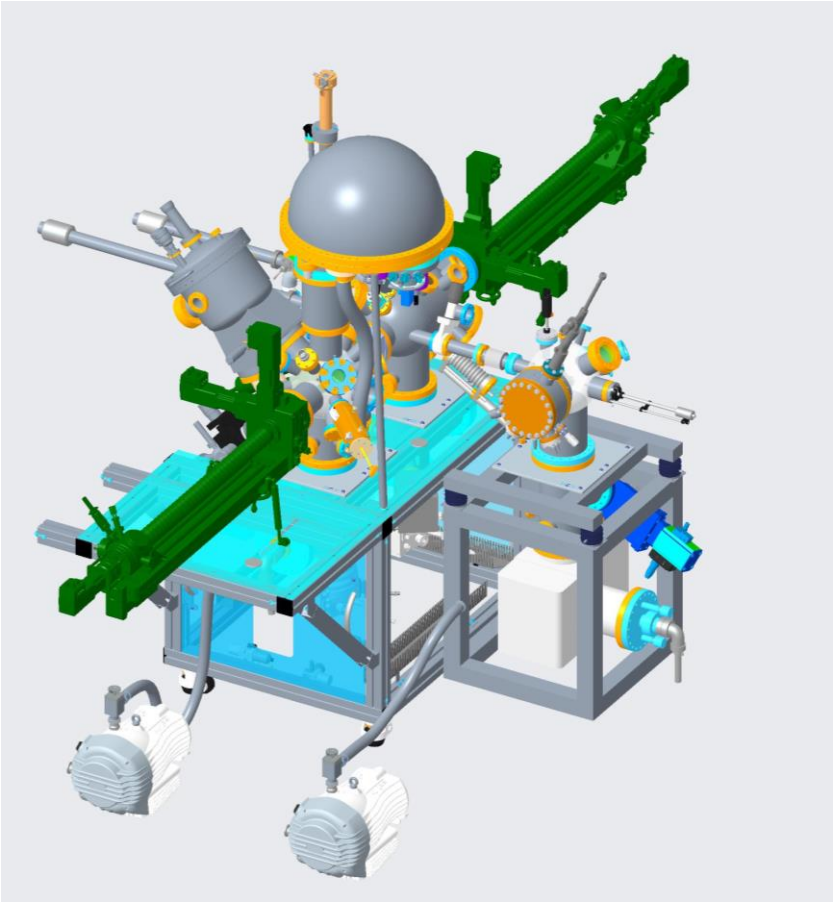
Optical trapping

Materials and methods for cultural heritage



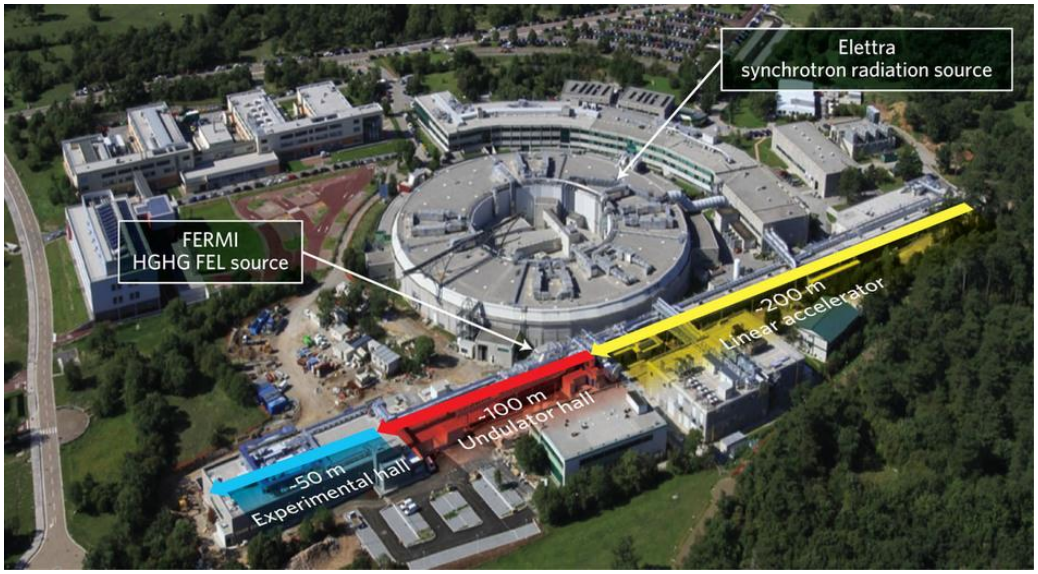
Diagnostic for cultural heritage

new Amaldi Research Center laboratory @Dipartimento di Fisica

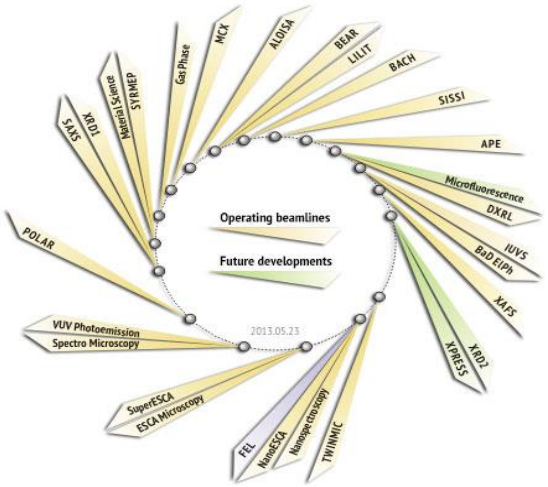


a unique spatially-resolved micro-photoemission and micro-Raman/photo-luminescence facility, with growth of 2D materials, all in vacuum… operative from ~July 2021

Synchrotron Radiation Laboratories



ELETTRA
(Trieste, Italy)



+

Fermi FEL (Free Electron Laser)

Synchrotron Radiation Laboratories

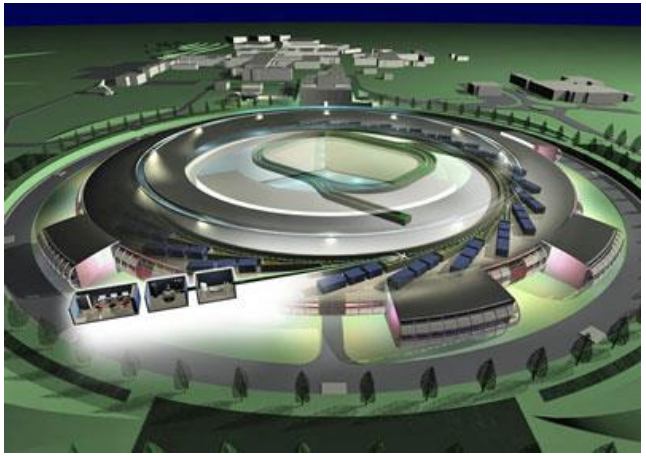
ESRF
Grenoble (France)

Synchrotron Radiation Laboratories

ALBA
Barcelona (Spain)

Synchrotron Radiation Laboratories

DIAMOND
Oxforshire (United Kindom)



Synchrotron Radiation Laboratories

SOLEIL
Paris (France)