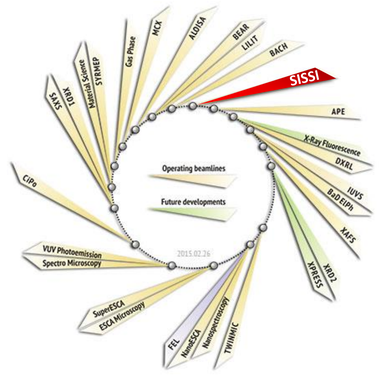
Elettra Sincrotrone Trieste



SISSI BEAMLINE

Biophysics and beyond @ SISSI
PhD Opportunities

SISSI (Synchrotron Infrared Source for Spectroscopy and Imaging) is the infrared beamline at Elettra. SISISI extracts the IR and visible components of synchrotron emission for performing spectroscopy, microspectroscopy and imaging. The applications cover a wide range of research fields, including surface and material science, biochemistry, forensics, microanalysis, geology, cell biology, biochemistry, biomedical diagnostics, microfluidics, high-pressures, time resolved IR, conservation science, chemical kinetics etc.

Federica Piccirilli, PhD in Physics
Trieste University - Cycle XXIV

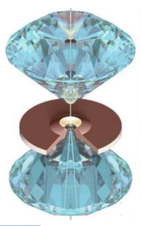
Paolo Zucchiatti, PhD in Nanotechnology
Trieste University - Cycle XXXI

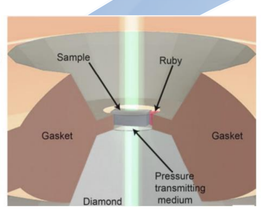
SISSI-Mat
Material Science at SISSI

SISSI-Bio
Chemical and Life Sciences at SISSI

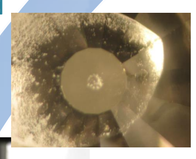
HIGH PRESSURE FTIR

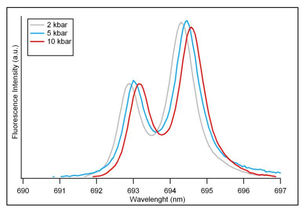
High pressure technologies are coupled to IR spectroscopy to study the thermodynamic stability of proteins. Diamond Anvil Cells are typically used. Pressure calibration is performed through the evaluation of the spectral position of ruby R1 and R2 fluorescence lines around 690 nm.



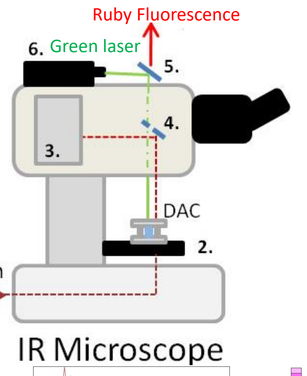


Diamond
Anvil
Cell

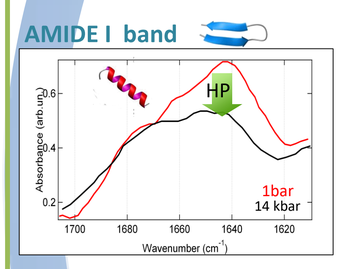


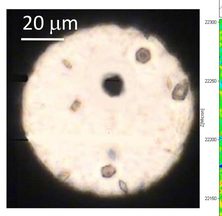


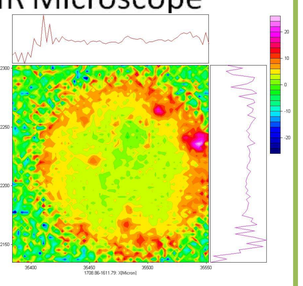
Ruby Fluorescence



AMIDE I band





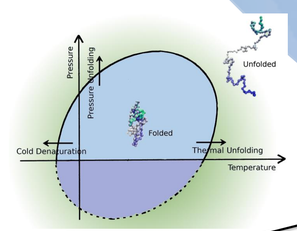


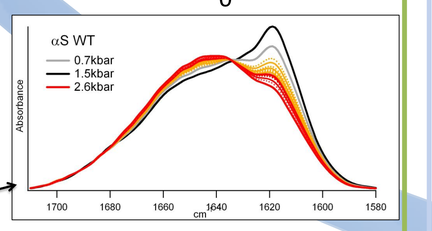
Insulin crystals formed at high pressure. The two pictures show the DAC sample compartment observed at the optical microscope and the 2D image of the integral of Amide I band acquired at the IR microscope. Ruby microsphere can be also observed.

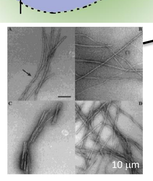
Amyloid fibrils dissociation at high pressure

Since high pressure favors the state that occupies the minimum available volume, proteins structural stability can be strongly affected by compression. Thus, proteins unfolding and oligomers and aggregates dissociation can occur and Intermediate states of folding can be stabilized as a result of electrostatic interactions and hydrophobic contacts destabilization.

$$\Delta G = \Delta G_0 + P\Delta V$$



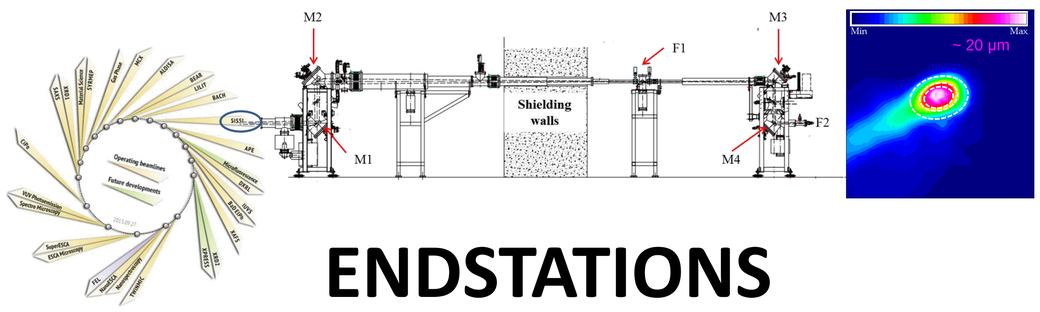




aS amyloid fibrils, hallmark of Parkinson's disease, show a surprising thermal stability. On the contrary, they can be easily dissociated by applying a pressure of 2-3 kbar.

Amyloid fibrils hallmark of Parkinson's disease

BEAMLINE LAYOUT



ENDSTATIONS

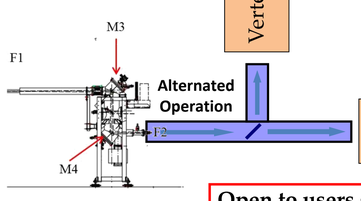
Hyperion 3000

Open to users since 2007

2nd Branch – SISSI Bio
Chemistry and Life Sciences
Optimized for FTIRM/FTIRI in the MIR
New opportunities in the FIR regime

Elettra Sincrotrone Trieste

Vertex 70v



i o m Istituto Officina dei Materiali

SAPIENZA Università di Roma

Vertex 70v

Hyperion 1000

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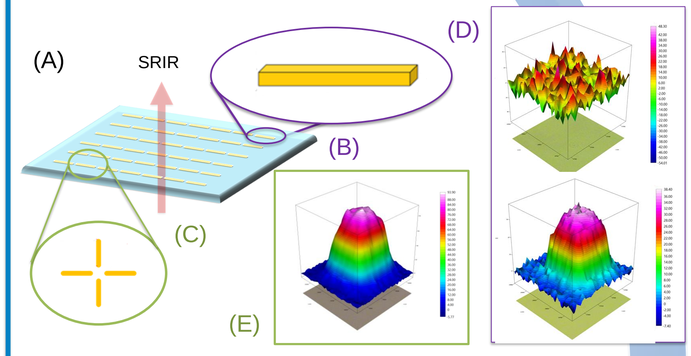
1st Branch – SISSI Mat
Material Science
Optimized for spectroscopy from Thz to Vis

Collective enhanced SRIR Absorption Microcopy for protein conformational studies

Despite its potential for biomolecule characterization, FTIR microscopy (FTIRM) of sub-micromolar samples using conventional approaches is extremely challenging.
For increasing the technique sensitivity we take advantage from the electric field enhancement associated with the excitation of plasmonic resonances from ad-hoc shaped metallic structures by exploiting the collective resonant excitation of nanoantennas assemblies, a technique called Collective Enhanced IR Absorption (CEIRA).

iit ISTITUTO ITALIANO DI TECNOLOGIA — *CEIRA substrates*

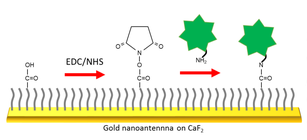
CEIRA substrates are produced with state of the art nanotechnological approaches in collaboration with IIT (Istituto Italiano di Tecnologia), Plasmon Nanotechnolgy line (A. Toma and F. De Angelis)



(A) Scheme of a single array of gold od-shaped nanoantennas (50X50 µm²) on CaF_2 substrate and two possible nanoantennas arrangements: (B) line-to-line geometry and (C) cross geometry.
(D) Focal Plane Array FTIR image of IR field enhancement of a single nanoantenna array with line-to-line geometry, with parallel (upper panel) and perpendicular (lower panel) IRSR light polarization ; (E) Focal Plane Array FTIR image of IR field enhancement of a single nanoantenna array with cross-geometry for both polarizations.

SR CEIRA microscopy offers the opportunity for addressing protein conformational studies in liquid-physiological environment at physiologically relevant protein concentrations.

Protein anchoring

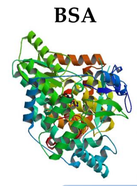


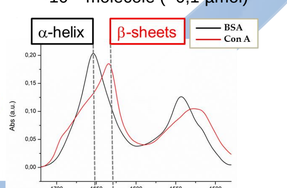
Target proteins are immobilized after surface functionalization by exploiting thiols chemistry and amide coupling immobilization protocol. This protocol allows the formation of a protein monolayer on the gold surface of the nanoantennas.

SR CEIRA *measurements*

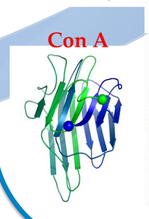
~10^{16} molecole (~0,1 µmol)

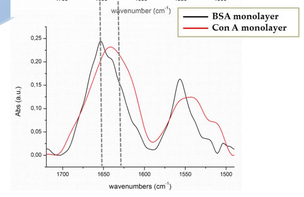
BSA





Con A





~10^5 molecole (~1 attomol)

Bovine Serum Albumin (BSA) and Concanavalin A (ConA) were chosen as standard proteins representative of a mainly alpha-helix folded protein and beta-sheet folded protein respectively. Reference spectra of these samples were collected on bulk samples.

Vibrational dynamics of biomolecules in non-aqueous glassy matrices

Maria Pachetti[a], Alessandro Paciaroni[b], Simone Capaccioli[a]

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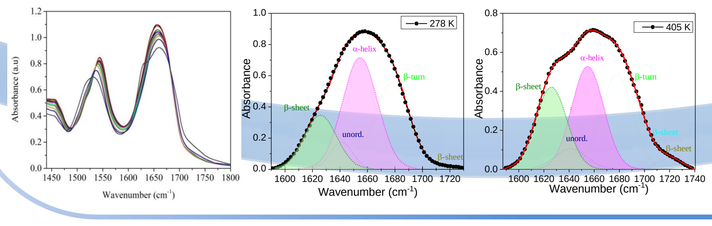
[b]Dipartimento di Fisica, Università di Perugia, Via A. Pascoli 1, 06123 Perugia, Italy

To provide a deeper understanding on the specific interactions that determine the vibrational dynamics and the collective motions of proteins embedded in glassy sugar matrices, systems very often used as excipient to bio-protect biopharmaceutical ingredients, is a fundamental step for improving their long-term storage and stability of their native structure.

MIR and FIR T-dependent studies of lysozyme in sugar matrices

Absorbance spectra of glucose + lysozyme showing the amide bands (II and I) in the 280K to 405 K T range. Deconvolution of Amide I band at different temperatures, highlighting the α-helix and a β-sheet components

FIR Absorbance of glycerol + lysozyme in the 285K to 425K T range . The inset is an enlargement of the low frequency band.

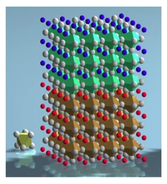


Other Research fields

Material Science branchline

- Strongly correlated systems
- Oxide heterostructures
- 2D exfoliated materials
- Surface Plasmons

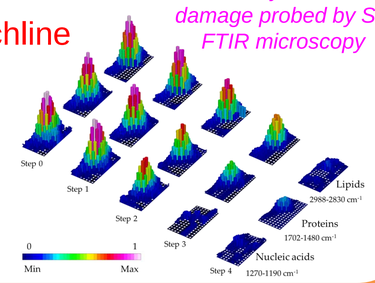
Extreme Conditions



Chemical and Life Sciences branchline

- **Cellular Biology and Microbiology**
  - Live Cell Analysis and correlative microscopies
  - Nanotoxicology
  - Cancer Research: cell differentiation and drug screening
  - Biomineralization and Bioremediation
- **Cultural Heritage**

Soft X-rays radiation damage probed by SR FTIR microscopy



Contacts
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Prof. Stefano Lupi, Sapienza – Università di Roma, Head of Material Science branch, stefano.lupi@roma1.infn.it

CERTIFICAZIONE DI SISTEMA QUALITÀ DNV·GL ISO 9001

CERTIFICAZIONE DI SISTEMA SICUREZZA DNV·GL OHSAS 18001