

COST Action MP1302 Nanospectroscopy
Training School on Raman Spectroscopy, Zagreb, Croatia, September 23-25, 2015

School Program 1st day, section Raman spectroscopy of molecules and crystals, SERS

Morning 8:30 to 12:30, Lecture hall 1 of Ruđer Bošković Institute (RBI)

8:30 Mile Ivanda

Welcome Address

Historical introduction of the Raman spectroscopy

9:30 Vlasta Mohaček Grošev

Theory of Raman spectroscopy on molecules and crystals

- Vibrations of molecules
- Normal coordinate calculations
- Basic theory of symmetry and applications to the Raman scattering on molecules and crystals
- Examples of the complete solutions of vibrational analysis on small molecules

10:30 – 10:50 Break

10:50 Vedran Verek and Lara Mikac

Surface enhanced Raman spectroscopy and applications

- Introduction to plasmonics
- Raman scattering enhancement by localized plasmonic resonances and coupled plasmonic resonances
- Preparation of SERS active materials (metallic colloidal suspensions, metallic nanoparticles grown on silicon substrates)
- SERS measurements in micro and macro Raman configurations – possible applications and limitations

Afternoon 14:30 to 18:30; Raman Lab, Wing VI of RBI

Raman spectroscopy practicum by the Raman spectrometer Jobin Yvon T64000

Group 1: Description of the instrument and measurements (D. Ristić and H. Gebavi)

- i) Laser excitations
- ii) Macro Raman scattering chamber
- iii) Micro Raman scattering technique
- iv) CCD and photomultiplier signal detections
- v) 90° geometry and back scattering measurements
- vi) Additive and subtractive spectrometer configurations
- vii) Polarization measurements
- viii) Raman spectroscopy of c-Si, a-Si, SiO₂, SiO_x,

Group 2: Methods of measurements and preparation (V. Mohaček, L. Mikac, V. Verek)

- i) Description of temperature dependent measurements using Linkam
- ii) Preparation of SERS substrates

School Program 2nd day, Raman spectroscopy on nanoparticles and disorder materials

Morning 8:30 to 12:30, Lecture hall 3 of Ruđer Bošković Institute

8:30 Mile Ivanda

Raman spectroscopy of nanoparticles

- Introduction to the vibrations of nanoparticles
- Spherical acoustic vibrational modes
- Phonon confined effects and Raman scattering of optical modes of nanoparticles
- Different examples of applications – free and matrix embedded nanoparticles, Raman scattering on acoustic and optical modes of nanoparticles

9:20 Davor Risti

Raman scattering on disordered materials

- Selection rules in Raman scattering of disordered materials
- Raman scattering on glasses and amorphous materials
- Boson peak in Raman spectra – comparison to other experimental techniques
- Raman scattering on fractons

10:10 – 10:30 Break

10:30 Prof. Philippe Colomban, guest speaker from UPMC Paris, France

Raman Spectroscopy of advanced materials (fibre, composites, films ...) for aerospace and energy application

11:30 Josef Sedlmeier, Renishaw

Raman AFM solution for Nanomaterials research from Renishaw/Bruker

Afternoon 14:00 to 16:30, Raman Lab, Wing VI of RBI

Group 1: Practicum of low frequency Raman spectroscopy on different nanoparticles (D. Risti, H. Gebavi, M. Ivanda)

- i) Free nanoparticles of metal oxide and semiconductor nanoparticles (TiO₂, SnO₂, ZrO₂, CdS)
- ii) Nanoparticles embedded in matrix (Cd_xSe_{1-x} in Schott glass, Si in SiO₂)
- iii) Porous silicon

Group 2: Preparation of colloidal silver for SERS, CVD techniques (L. Mikac, V. Čerek)

17:00 PICNIC for all participants of the School, in the front of the RBI restaurant (near swimming pool).

School Program 3rd day, selected complementary techniques to Raman spectroscopy

Morning 8:30 to 11:30

8:30 Hrvoje Skenderevi , Institute of Physics, Zagreb

Time-resolved techniques with ultrashort pulses in examination of specific vibrational states of matter

9:20 Marina Kveder, Laboratory for Magnetic Resonances, RBI

Application of ESR spectroscopy in probing of vibrational states of disordered materials

10:10 – 10:30 Break

10: 30 Goran Baranovi , Laboratory of Molecular Spectroscopy, RBI

Experimental methods and applications of Fourier-Transform-Infra-Red (FTIR) Spectroscopy

Afternoon 13:30 to 18:30; Guided visits in 3 groups to the following laboratories (meeting point near swimming pool)

- 1) Laboratory of Molecular Spectroscopy, RBI, demonstrations of FTIR spectroscopy technique, measurements, signal processing and interpretations, **Goran Baranovi**
- 2) Laboratory for Magnetic Resonances, RBI, demonstrations of ESR spectroscopy technique, measurements, signal processing and interpretations, **Nadica Maltar Strme ki**
- 3) Laboratory for Femtosecond Laser Spectroscopy, Institute of Physics; demonstrations of pump and probe technique, measurements, signal processing and interpretations, **Hrvoje Skendereovi**