Contribution ID: **114** Type: **Contributed talk**

Resonantly enhanced X-ray impulsive vibrational spectroscopy in trigonal tellurium

Friday, June 27, 2025 12:00 PM (20 minutes)

Laser control strategies enable perturbing selected degrees of freedom and driving matter in metastable states often inaccessible under equilibrium conditions. In the optical regime this is achieved through either nonlinear phononics or impulsive vibrational spectroscopy (IVS), in which coherent phonons are launched upon ultrashort laser excitation. The impulsive vibration of the lattice causes macroscopic changes in the system' s refraction index that can be detected using a second probe laser in a pump-probe fashion. Extending this scheme to the X-ray domain promises achieving element-selectivity in the generation process by tuning the pump pulses on-resonance with core electronic excitations.
In this contribution, we present our recent implementation of X-ray impulsive vibrational spectroscopy (XIVS) in trigonal tellurium performed at the FERMI free electron laser (FEL) in Trieste. By tuning the FEL pump photon energy either off- or on-resonant with the tellurium N4,5-edge, we demonstrate a resonant enhancement of the coherent phonon amplitude by a factor of eight that is rationalized in terms displacive excitation of coherent phonons (DECP) mechanism. Ab initio simulations including ultrafast electron and coherent phonon dynamics in presence of electron-phonon interactions show an excellent agreement with our experiment, underscoring the key contribution of band-specific electron phonon coupling (EPC) terms.
These results demonstrate the possibility of harnessing EPC to enhance the light-induced activation of specific phonons, paving the way for element-selective coherent control strategies in functional materials.

Authors: Dr DOGADOV, Oleg (Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milano, Italy); Mr CLAUDE, Remi (Laboratory for Ultrafast Microscopy and Electron Scattering (LUMES), Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne 1015 CH, Switzerland); Mr EMEIS, Christoph (Institute of Theoretical Physics and Astrophysics, Kiel University, 24118 Kiel, Germany); Dr BATIGNANI, Giovanni (Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy); Dr FUMERO, Giuseppe (Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy); Dr COSTANTINI, Roberto (Istituto Officina dei Materiali (IOM) - Consiglio Nazionale delle Ricerche (CNR), 34149 Trieste, Italy); Ms AZZOLIN, Agata (Center for Free-Electron Laser Science, DESY, Notkestraße 85, 22607 Hamburg, Germany); Ms ROCKENSTEIN, Sabine (Center for Free-Electron Laser Science, DESY, Notkestraße 85, 22607 Hamburg, Germany); Dr CASTILLO-GOMEZ1, Rebeca (Lausanne Centre for Ultrafast Science (LACUS), École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland); Mr MANZI, Matteo (Lausanne Centre for Ultrafast Science (LACUS), École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland;); Dr GIGLIA, Angelo (Istituto Officina dei Materiali (IOM) - Consiglio Nazionale delle Ricerche (CNR), 34149 Trieste, Italy); Dr NANNARONE, Stefano (Istituto Officina dei Materiali (IOM) - Consiglio Nazionale delle Ricerche (CNR), 34149 Trieste, Italy); Dr DE ANGELIS, Dario (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr PALTANIN, Ettore (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr EBRAHIMPOUR, Zeinab (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr KRSTULOVIC, Marija (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr KURDI, Gabor (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr DANAILOV, Miltcho (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science

Park, I-34149, Basovizza, Trieste, Italy); Dr GIANNESSI, Luca (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr MINCIGRUCCI, Riccardo (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr PRINCIPI, Emiliano (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Prof. CERULLO, Giulio (Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milano, Italy); Dr CREPALDI, Alberto (Dipartimento di Fisica, Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milano, Italy); Prof. DE NINNO, Giovanni (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr MASCIOVECCHIO, Claudio (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Dr FOGLIA, Laura (Elettra Sincrotrone Trieste S.c.P.A., Strada Statale 14, km 163.5, AREA Science Park, I-34149, Basovizza, Trieste, Italy); Prof. SCOPIGNO, Tullio (Dipartimento di Fisica, Sapienza Università di Roma, Roma, Italy); Prof. CARBONE, Fabrizio (Laboratory for Ultrafast Microscopy and Electron Scattering (LUMES), Institute of Physics, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne 1015 CH, Switzerland); Prof. CALEGARI, Francesca (Center for Free-Electron Laser Science, DESY, Notkestraße 85, 22607 Hamburg, Germany); Prof. CARUSO, Fabio (Institute of Theoretical Physics and Astrophysics, Kiel University, 24118 Kiel, Germany); Dr PUPPIN, Michele (Lausanne Centre for Ultrafast Science (LACUS), École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland); Dr CANNELLI, Oliviero (Center for Free-Electron Laser Science, DESY, Notkestraße 85, 22607 Hamburg, Germany)

Presenter: Dr CANNELLI, Oliviero (Center for Free-Electron Laser Science, DESY, Notkestraße 85, 22607 Hamburg, Germany)

Session Classification: Session 16 - Materials III