Synchrotron infrared emission: optimized collection, propagation and exploitation for new scientific opportunities

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The no-damaging nature of the infrared (IR) light is a unique feature in Synchrotron Radiation (SR), which allows the safe investigation of vibrational and vibro-electronic transitions for a wide variety of materials. The IRSR ultrabroad-band nature, from THz to Visible, and superior brilliance, up to three orders of magnitude higher with respect to benchtop IR sources, have been exploited over years at both second and third generation SR facilities worldwide, for covering a wide range of research fields including material science, biochemistry, cultural heritage, forensics, geology, biomedical diagnostics, and many others.

Nowadays, several SR facilities have completed/started/planned their upgrade programs to diffraction limited storage rings (DLSRs), characterized by higher brightness and coherence with respect to third generation SR. Despite these appealing properties, the extraction geometry of IRSR is facing severe constraints at DLSRs, particularly regarding the natural divergence which hardly matches with the very dense and compact ring design. Also Elettra, the SR facility in Trieste, Italy, is experiencing this transition to Elettra 2.0 and SISSI (Synchrotron Infrared Source for Spectroscopy and Imaging), the infrared beamline at Elettra, is going to be redesigned. Taking advantage from the current experience at SISSI, a general overview of the IR extraction geometries at both third generation and diffraction limited SRs will be presented. Preliminary simulations on IRSR beam extraction at SISSI@Elettra 2.0 shows that the new IR beamline must rely mostly on IR bending magnet edge emission, without significant loss in terms of brightness and flux over the entire IR range, and the superior electron-beam stability imposed for DLSRs as well as the made advances in IRSR propagation will further benefit IR programs at DLSRs, guaranteeing a superior S/N ratio with respect to third generation IR beamlines, especially favouring nano-IR programs.

Strengthening the integration of the present spectroscopy and microscopy IRSR programs with the nano-opportunities offered by near-field approaches opens new scientific opportunities. As a matter of fact, the correlation of the functionality of materials (from micrometer to millimeter scale), natural or synthetic, to the atomic and/or molecular characteristics of its constituents, unavoidably requires the understanding of mesoscale organization, from few tens up to hundreds of nanometers. To this aim, both MIR and FIR spectral regions are essential, bringing information on diverse aspects of the matter organization. Even if the MIR region is pretty well covered by lasers sources, although with restricted energy range and higher source noise, the FIR region up to the THz can basically rely only on IRSR. Selected examples ranging from life sciences to cultural heritage will be presented for highlighting the added value brought to IR programs by spatial-scale and spectral-domain integration.

References

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