Synchrotron Infrared Beamlines at Ultra-Low Emittance Facilities: challenges and perspectives

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Many breakthrough advances at the cutting edge of technological development will take place in a near future at ultra-low emittance storage rings. After the first operational facility (MAX IV), others are in construction (SIRIUS), and several under consideration or conception design (ESRF-EBS, SLS-2, APS-U, ALS-U, Diamond II, Electra 2.0, HEPS, SOLEIL-U, SPring-8-II). Many concerns have been expressed regarding the performances and/or survival of low energy beamlines using the constant field emission of bending magnets. Lattice design evolution from Double Bend Achromat (DBA) to Multiple Bend Achromat (MBA) have resulted in compact sections including several bending magnets, quadrupoles, sextupoles, but with low magnetic field (roughly close to 0.5T). These two factors (compactness= medium length of bending magnets) and low magnetic field, restrict the capabilities of extracting long wavelengths, typically those which are prototypical in the infrared energy domain. Infrared beamlines are exhibiting a tremendous activity of many disciplines, and are among the most demanded beamlines from users. The performances of future infrared beamlines at these new Diffraction Limited Storage Rings (DLSR) are under investigation and questioning. This talk is aiming at providing some solutions and numbers for keeping such infrared activity lively and performants.

The bending magnet radius being inversely proportional to the electron energy and the magnetic field, it reaches values of several tens of meters for such facilities (40 meter for 0.5 T and E=6 GeV, for example). As a result, collecting large horizontal constant field emission, as it is the most source of infrared emission among all facilities, become impossible and restricts markedly the flux expected. As infrared photons are generated by two main sources: edge radiation (ER), and constant field emission (BM), edge radiation becomes an important source of infrared which should receive increasing interest. One additional restricting factor is the height of photon chamber in dipole vessel. They are quite narrow (for example, 6 mm at ESRF-EBS and SIRIUS). The vertical angle of infrared emission, even with an ER emission, requires a vertical collection angle of 10 to 20 mrad, depending upon the electron energy. Modifying the dipole chamber geometry has been considered at SIRIUS, and this will be discussed for other facilities. SRW simulations of the beam shape and flux will be presented during this talk.

Considering a “pure” ER radiation, the photons flux is exploitable, and scale as, roughly half of the BM photons. This will be shown using SRW simulation. However, despite the reduced flux, the use of ER emission has a marked advantage on brightness. Large horizontal collection of infrared photons at present facilities still requires a dedicated optics to collect and propagate all emitted photons to the sample. Such specific optics design has been only implemented at LNLS [1]. In the case of ER, the source can be considered as a 2D source, and therefore, the brightness is increased compared to actual beamline. The simulations show that, roughly, the future infrared beamline at DLSR can conserve their performances in microscopy in the mid infrared region. The far infrared region (THz) requesting a larger vertical angle for extraction, may suffer more severely, but several dipole chamber design at DLSR are under consideration, and this can release the constraints imposed for far-IR exploitation.

References

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