Future Nanoscope facility: towards sub-micron spatial resolution

Aleksandr Chumakov

ESRF-The European Synchrotron, Grenoble, France

chumakov@esrf.fr

The Extremely Brilliant Source (EBS) of the new ESRF machine and the maintenance of beamline optics allowed the Nuclear Resonance beamline ID18 to improve the beam size from ~15 × 15 μm^2 [*] available in 2018 to ~2 × 8 μm^2 in 2020. The new Nanoscope facility will continue this development, providing sub-micron spatial resolution requested by high-pressure experiments in the TPa range, studies of inclusions in diamonds, investigations of cloudy zone of meteorites, studies of nano-objects, *etc*.

The Nanoscope includes the nano-platform and the short-focal Kirkpatrick-Baez mirror (KBM). Commissioning of the nano-platform with the accuracy of linear positioning of ~10 nm has been completed. The KBM is expected to come in autumn 2021. The Nanoscope will be delivered to users by end of 2021.

Thanks to the new EBS machine and the operational nano-platform, we determined typical slope errors of high-resolution optics in measurements of the size of the beam focussed by high-quality parabolic compound refractive lenses (CRLs). Previously, these data were not available because the spot size was dominated by geometrical demagnification and/or slope errors of existing KBMs.

For 14.4 keV x rays (^{57}Fe), the beam size of 580 × 700 nm^2 has been obtained with CRLs demagnification of ~1/75.8. Extrapolation of the results to a future short-focal KBM with horizontal and vertical demagnifications of 1/309 and 1/567, respectively, (including contributions of the KBM slope errors) gives the following estimations of the beam size: 170 × 110 nm^2 for ideal optics, 220 × 420 nm^2 for 0.5 meV high-resolution monochromator, and 620 × 660 nm^2 for synchrotron Mössbauer source.

The Nanoscope will provide sub-micron resolution nearly without losses of intensity, as the horizontally- and vertically-focusing mirrors will intercept ~180% and ~150% of FWHMs of the corresponding beam size. The sample space will be about 70 mm.

In order to assure stable operation with extreme spatial resolution, the Nanoscope will be located in a hutch with thermal isolation and temperature stability of about 0.1°C.

In future, the Nanoscope facility is expected to be upgraded by a KBM for 21.541 - 25.614 keV (^{151}Eu, ^{149}Sm, ^{119}Sn, ^{161}Dy) and another KBM for 67.4 keV radiation (^{61}Ni) with the expected beam sizes of 0.7 × 1.2 μm^2 and 0.87 × 0.55 μm^2, respectively. This will require additional budget and resources.

* All data are given as full widths at half maximum (FWHMs), for horizontal × vertical sizes.