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EXAFS at the future diffraction limited storage ring PETRA IV

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DESY, like many other synchrotron sources around the world, is planning the next upgrade of its current 3rd generation storage ring PETRA III. Today PETRA III is a 6 GeV machine with a circumference of 2.3 km. Since the emittance is proportional to 1/R (with R being the radius of the storage ring) [1] the large circumference gives DESY a unique position among the existing high energy storage rings to build a diffraction limited storage ring (DLSR) source for hard X-rays in the existing tunnel. The current design goal for PETRA IV is a machine operated at an electron energy of 6 GeV with a horizontal and vertical emittance of 10 pmrad. Today PETRA III has a horizontal emittance of 1 nmrad, thus the emittance will be a factor of 100 smaller than today and will result in a nearly round synchrotron radiation beam with a high degree of transverse coherence. The photon beam produced in such a machine will reach the diffraction limit up to ~10 keV.
The resulting higher brilliance of the beam opens new and exciting experimental possibilities for XAFS spectroscopy on the one hand [2]. Experimental methods that require a small intense beam like XAFS tomography, inelastic scattering, EXAFS on single nano particles etc. will definitely profit from the smaller emittance and the resulting smaller photon beam. On the other hand, the large circumference and the resulting length of the beamlines make it impossible to use sources with larger divergence, that can produce large homogeneous beams for standard EXAFS applications like the 3 pole wiggler which are considered for the ESRF [3] after an upgrade to a DLSR. For standard or routine EXAFS measurements the significantly more brilliant beam will increase the experimental challenges that are already existent at today's 3rd generation storage ring beamlines.
Therefore a XAFS beamline at a DLSR must utilise the unique properties of such a source. The talk will discuss the current status of planning and a tentative beamline design for a XAFS beamline at PETRA IV. The main experimental advantage, compared to a XAFS beamline at a current 3rd generation storage ring, is the chance to focus more intensity into a smaller spot on the sample. Such a beamline, equipped with new, state of the art detectors and infrastructure for in-situ experiments, will open the opportunity to investigate the chemical and physical properties of single nano particles in catalytic chemistry, energy storage materials and other novel materials under operando conditions and with unprecedented spatial resolution.
It can be expected that the integral power load and the power density on the optical components will not be much higher than at current 3rd generation beamlines [3]. The main technical challenge, that must be addressed by the beamline design, is the stability of the beam position on the sample, which must be guaranteed in the vertical and in the horizontal direction to make full use of the smaller beamsize.

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[2] A.I. Frenkel, J. A. van Bokhoven (2014) J. Synchr. Rad., 21, 1084-1089.
[3] J. Susini et al. (2014) J. Synchr. Rad., 21, 986 – 995.

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