BENDABLE X-RAY OPTICS AT THE ALS:
DESIGN, TUNING, PERFORMANCE AND APPLICATIONS

V. V. Yashchuk,*) M. N. Church, J. W. Knight, M. Kunz, A. A. MacDowell,
W. R. McKinney, N. Tamura, T. Warwick
Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

We review the development at the Advanced Light Source (ALS) of bendable x-ray optics widely used for focusing of beams of soft and hard x-rays – Fig. 1.

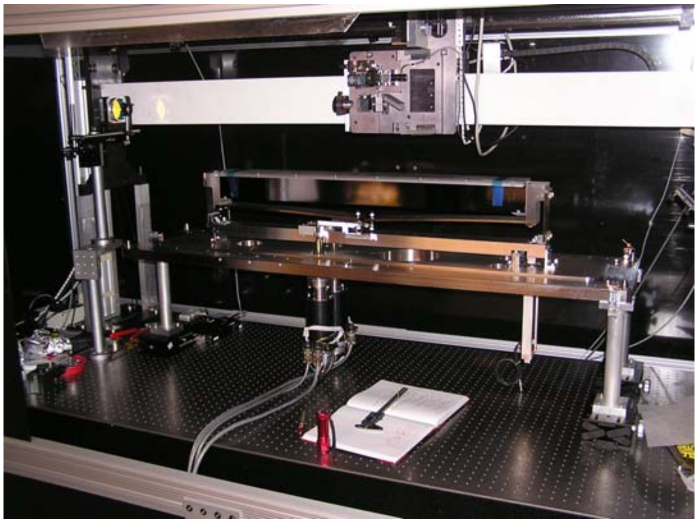

Figure 1: An example of a bendable optic used at ALS beamline 5.0.2. The mirror with a 900mm long substrate is shown on the Long Trace Profiler (LTP) optical table to be adjusted to the desired spherical shape with radius of curvature of about 2300 m.

Typically, the focusing is divided in the tangential and sagittal directions into two elliptically cylindrical reflecting elements, the so-called Kirkpatrick-Baez (KB) pair [1]. Because fabrication of elliptical surfaces is complicated, the cost of directly fabricated tangential elliptical cylinders is often prohibitive. This is in contrast to flat optics, that are simpler to manufacture and easier to measure by conventional interferometry. The figure of a flat substrate can be changed by placing torques (couples) at each end. Equal couples form a tangential cylinder, and unequal couples can approximate a tangential ellipse or parabola.

We review the nature of the bending, requirements and approaches to the mechanical design, and describe a technique developed at the ALS Optical Metrology

Laboratory (OML) for optimal tuning of bendable mirrors before installation in the beamline [2].

The tuning technique adapts a method previously used to adjust bendable mirrors on synchrotron radiation beamlines [3]. However, in our case, optimal tuning of a bendable mirror is based on surface slope trace data obtained with a slope measuring instrument - in our case, the long trace profiler (LTP). We show that due to the near linearity of the bending problem, the minimal set of data, necessary for tuning of two benders, consists of only three slope traces measured before and after a single adjustment of each bending couple. We provide an algorithm that was used in dedicated software for finding optimal settings for the mirror benders. The algorithm is based on the method of regression analysis with experimentally found characteristic functions of the benders. The resulting approximation to the functional dependence of the desired slope shape provides nearly final settings for the benders. Moreover, the characteristic functions of the benders found in the course of tuning, can be used for retuning of the optics to a new desired shape without removing it from the beamline and re-measuring with the LTP.

The result of practical use of the developed technique to precisely tune a KB mirror used at the ALS for micro-focusing is also presented. We also describe a simple ray trace using the profiler data which shows expected performance in the beamline and compare the simulation with experimental data.

In summary, we also discuss the next steps in the systematic improvement of optical performance for the application of KB pairs in synchrotron beamlines at the ALS.

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References

[1] P. Kirkpatrick, and A. V Baez, *Journal of the Optical Society of America* **38**, 766-774 (1948).

[2] W. R. McKinney, S. C. Irick, J. L. Kirschman, A. A. MacDowell, T. Warwick, V. V. Yashchuk, *Proc. SPIE* **6704**, 67040G (2007).

[3] O. Hignette, A. Freund, E. Chinchio, *Proc. SPIE* **3152**, 188-199 (1997).

*) vvyashchuk@lbl.gov