Hard-x-ray imaging mirror optics using concave and convex mirrors

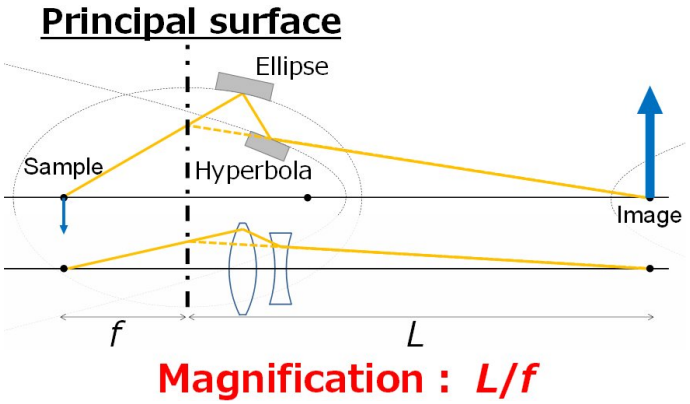
Jumpei Yamada*[1], Satoshi Matsuyama[1], Yasuhisa Sano[1], Yoshiki Kohmura[2], Makina Yabashi[2], Tetsuya Ishikawa[2], and Kazuto Yamauchi[1]

[1]*Osaka University, Japan*

[2]*RIKEN/SPring-8 Center, Japan*

**yamada@up.prec.eng.osaka-u.ac.jp*

Kirkpatric-Baez (KB) mirror which utilize two concave mirrors at glancing-incidence arrangements in both the vertical and horizontal axes, are well known and established for collecting and focusing X-rays. In contrast to the case of X-ray focusing, KB mirror is unsuitable for image forming because it suffers from coma aberration. Advanced Kirkpatrick-Baez (AKB) mirror [1] or Kirkpatrick-Baez amélioré (KBA) [2] optics that consist of four concave mirrors can eliminate the coma aberration by satisfying the Abbe's condition. Thus, these imaging mirrors have been used for an achromatic full-field X-ray microscopy [3]. However, the AKB system possesses disadvantage in versatility because it is difficult to obtain sufficiently large magnification factor. From the viewpoint of effective pixel size of an image detector, the magnification factor of the objective is also important for the high-resolution imaging, as well as the numerical aperture. To overcome the problem, the X-ray imaging mirror system consisting of two pairs of concave and convex mirrors was proposed [4]. One-dimensional configuration of proposed mirror system (Figure below) is similar to the Wolter type III optics and the retrofocus lens in visible light region, and therefore the magnification factor can be optimized by shifting the principal surface. In the demonstration experiments, a point spread function with FWHM of about 40 nm could be obtained with considerably compact setup of 2 m. We will present the latest status of the development.



Cross section of AKB optics using concave and convex mirrors.

References

[1] R. Kodama *et al.*, Opt. Lett. **21**, 1321-1323 (1996).

[2] R. Sauneuf *et al.*, Rev. Sci. Instrum. **68**, 3421-3420 (1997).

[3] S. Matsuyama *et al.*, Sci. Rep. **7**, 46358 (2017).

[4] J. Yamada *et al.*, Appl. Opt. **56**(4), 967-974 (2017).