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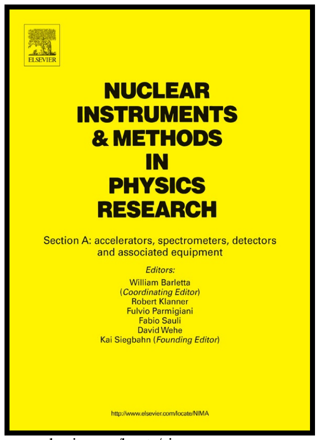

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Compensation for gravitational sag of bent mirror

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Abstract

The gravitational sag of aspheric bent mirrors with face-up or face-down geometry produces a nonnegligible optical error. As an effective compensation, width optimization is used to match the combined effects of the gravitational and bending moments. This method is described by analytical expressions and two calculation algorithms. The results of theoretical simulations and finite element analysis have proved that this method can reduce the slope error resulting from gravitational sag to the level of nano radians.

Keywords: X-ray optics, bent mirror, gravitational sag, slope error, compensation

1. Introduction

The third-generation synchrotron radiation facilities produce high-quality X-rays for the analysis of the structure, elemental mapping and chemical information for advanced materials and biological samples. Due to small source size and low emittance, high–spatial-coherence flux can be preserved by the optical system. Dynamical bending devices for X-ray focusing [1-9] and collimating are widely used as conventional equipment in various beamlines. For a bending mirror with face-up or face-down geometry, especially for long mirrors, the gravitational moment is regarded as a nonnegligible factor. It varies nonlinearly with the coordinate along the reflecting surface. Normally, gravity effect of a substrate with 1 meter length and 4 centimeters thickness may produce a slope error of one hundred μrad. In order to compensate this gravity effect, some methods were used to solve this problem. These methods include: (1) add extra mechanism to compensate the gravitational moment, such as multi-point support compensation [4-8] and bimorph mirror [9]. These methods effectively reduce the slope error caused by gravity to 1 μrad, but inevitably increase the mechanical complexity and cost. Especially for bimorph mirror, it needs an accurate at-wavelength metrology measurement [10]; (2) reconfigure parameters of substrate, such as increasing thickness and reducing length. These methods can effectively reduce but cannot completely eliminate the slope error. Thicker substrate increases the bending moment significantly, and are in contradiction to the mechanical design requirements of small bending radius; (3) optimize the width of substrate to match the combined effects of the gravitational and bending moments. Warwick et. al. has mentioned the feasibility of this method [8]. This method is sufficiently effective to reduce the slope error without increasing the complexity of the mechanical design.