PyXLA ray-tracing software for modelling Lobster-Eye optics

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Abstract:

Collimation of X-rays is challenging, especially in a wide field of view. One of the wide-field optics is the Lobster-Eye type in Schmidt's arrangement, which will be considered for simulations. Recent space missions carrying the Lobster-eye optics proved they are good wide-field optics, and it is worth researching this kind of optics. This poster discusses a newly developed simulation program, PyXLA, dedicated mainly to designing these optics. It is written in Python for multiplatform usage, focusing on accurate results and optical design LE optics and X-ray detector Timepix which can be interchanged for another type. The current state of the PyXLA software can simulate Lobster-eye optics with flat mirrors and give its parameters as reflective coefficients depending on the grazing angle of incidence. The results of the software can be an image of a point-spread function or an image containing several point sources both at a defined energy. Also, getting a physical arrangement of the setup is possible to construct the actual experiment.

Lobster-Eye optics

The name of Lobster-Eye (LE) optics comes from the same animal, a Lobster. It is a reflecting kind of optics which focuses all incoming rays into the focus point F. The X-rays are attenuated depending on the grazing angle of incidence; thus, most X-ray optics are up to 1°. LE can be optics for observing in wide angle, theoretically up to 360°.

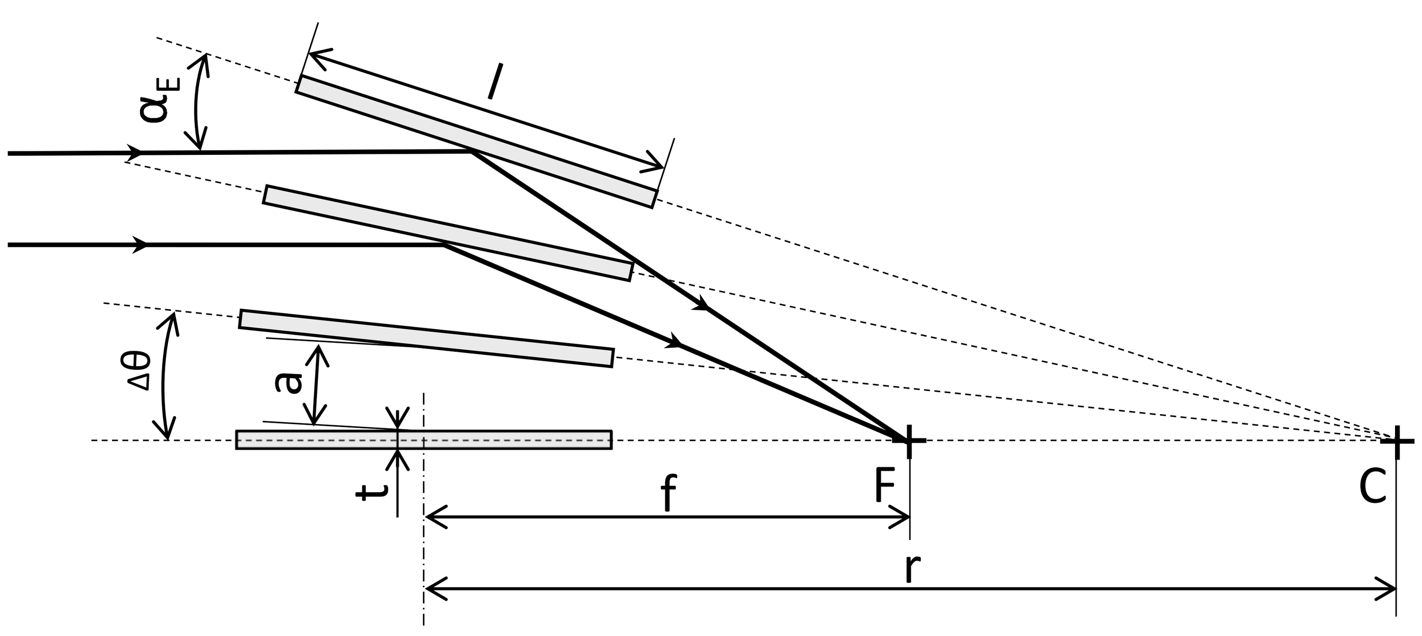

Figure: Principle schematics of a Lobster-Eye optics

Arrangement and ray-tracing process

The presented arrangement is for LE 1D optics with 47 mirrors, a thickness of 0.35 mm, spacing between them of 0.75 mm, mirror's length of 150 mm and optic's focal length of 965 mm. The golden coating is selected as a reflective layer. A Timepix X-ray detector was set.

PyXLA can process parallel beams as individual rays with predefined spacing regarding the detector and intensity. To simulate the point spread function is great to set the intensity to 1 and treat it as uniform parallel beams. On the other hand, it is possible to define multiple sources to simulate a constellation of stars as point sources to simulate actual behaviour.

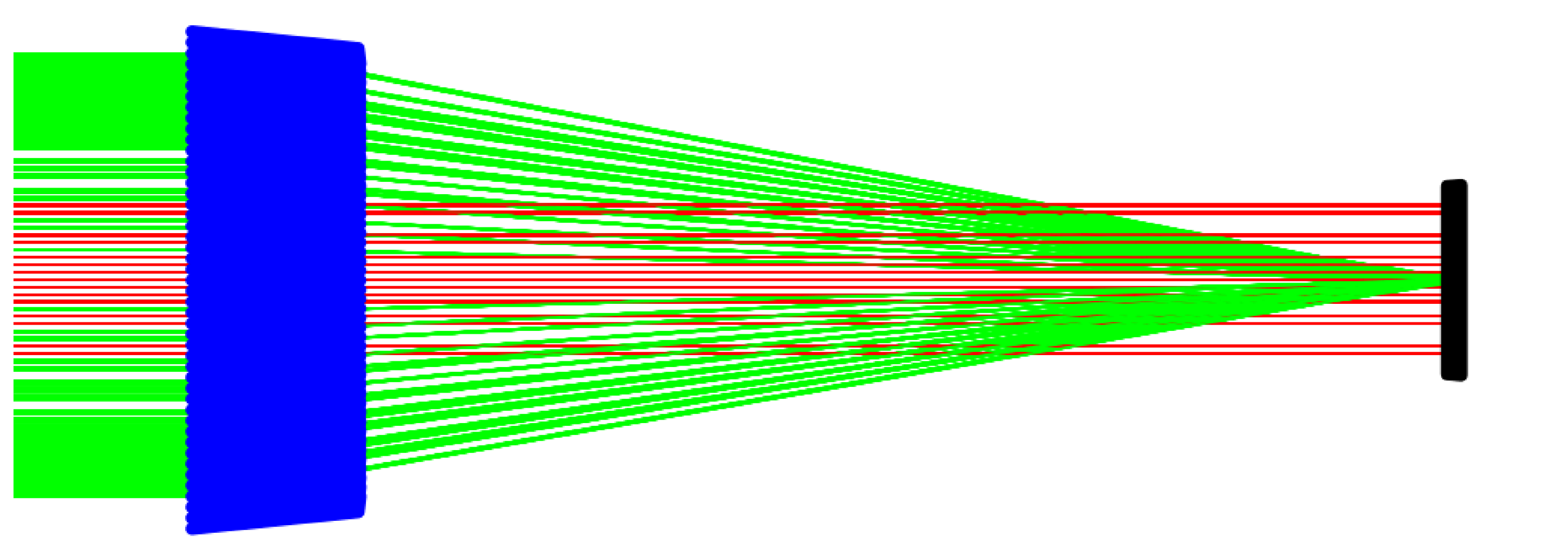

Figure: An arrangement of a setup with the incoming beams, LE optics and Timepix detector. Green lines are reflected rays, and red lines are direct rays.

Results

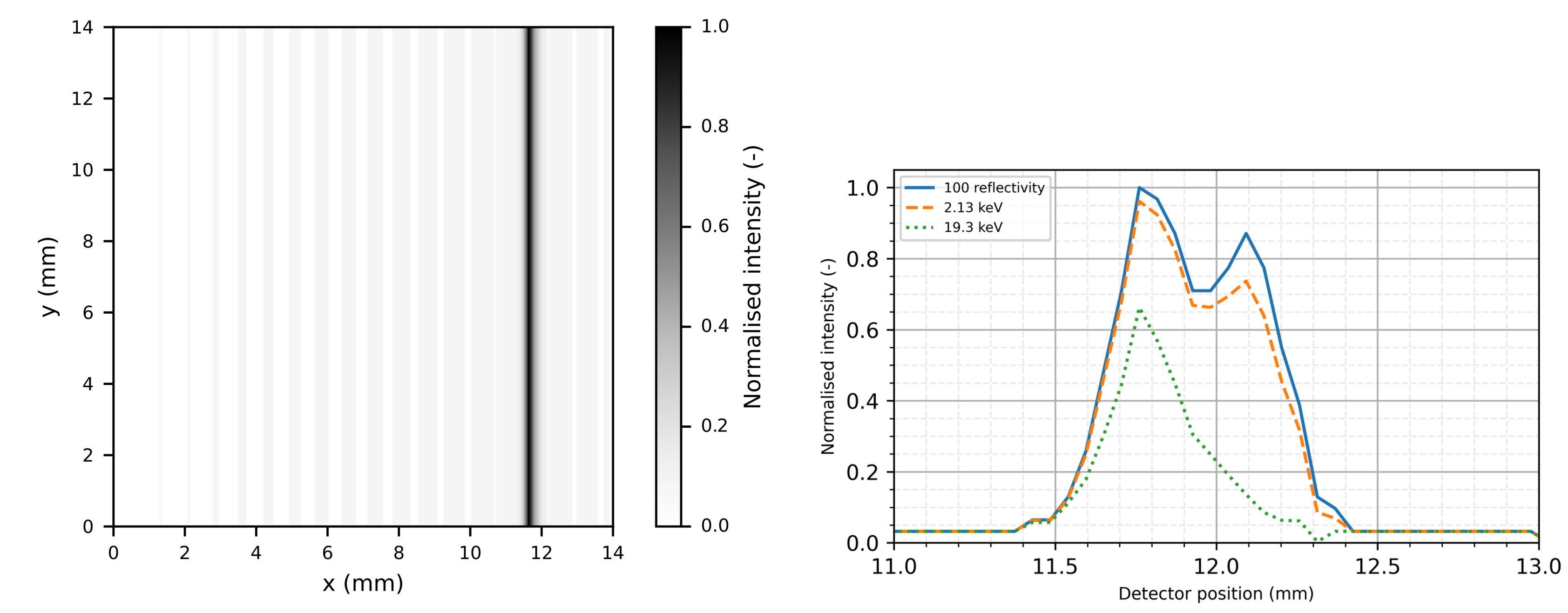

Figure: Cross-section at a row at 7 mm of output pictures with shifted source by 0.2 degrees off-axis; for comparison of an influence of the reflectivity on the angle of incidence. The blue line is for 100% reflectivity, orange is for 2.13 keV, and green is for 19.2 keV.

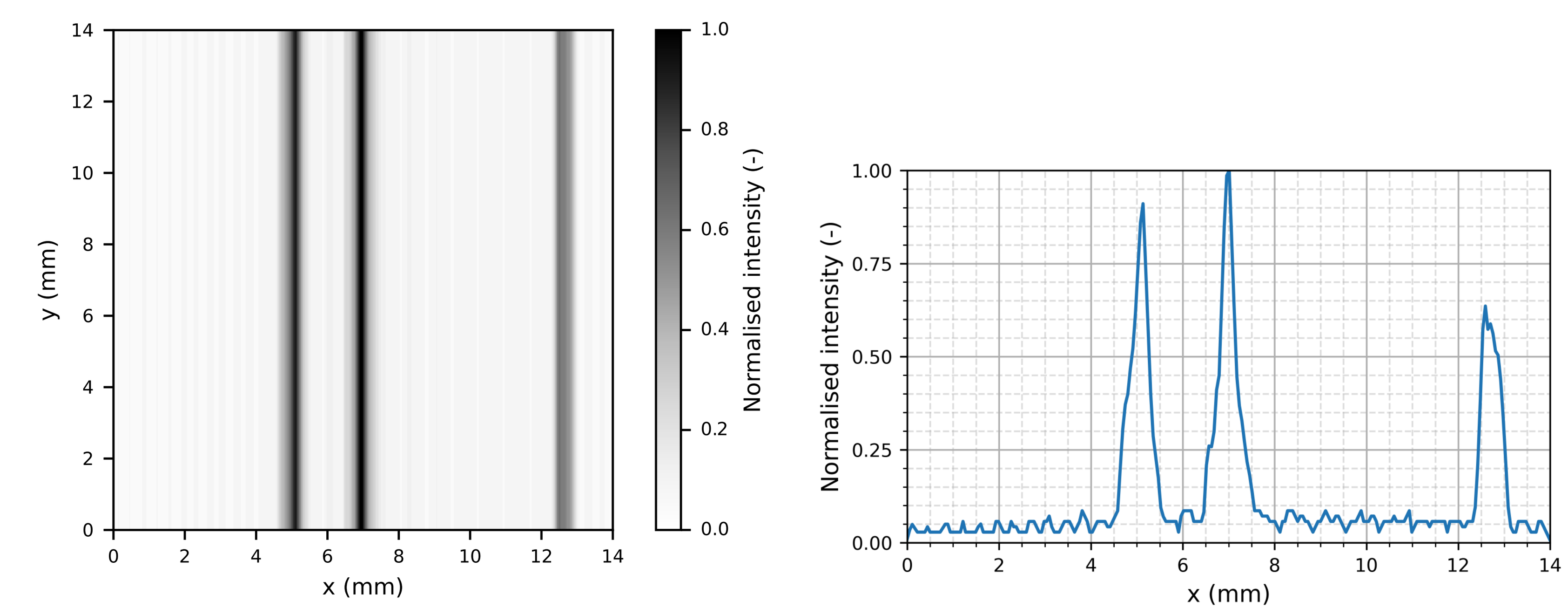

Figure: Example of an image with three point sources. Uniformly generated rays with equal intensity at energy 8 keV are incoming from a central position and deflected for 0.3 and -0.1 degrees from the centre of the x-axis.

Conclusion

The proposed PyXLA simulation software is dedicated to processing X-rays beams in combination with Lobster-Eye optics hitting a detector, e.g. Timepix. In future work, SW can be extended with other optics, such as KB or a Wolter type.

The current state requires developing a graphics interface for usage with broad users, but now it is possible to process the simulation with the included script as an example.

Acknowledgement

We would like to thank colleagues Jozef Dujava, Marek Jaluvka, and Michal Spacek from the Czech Technical University in Prague (course Space Engineering) who participated in the development of the simulation program. The project was supported by the Grant Agency of the Czech Technical University in Prague no. SGS21/120/OHK3/2T/13.

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December 2022
https://gitlab.com/najtvis/pyxla