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# Diffraction enhanced X-ray imaging of mammals crystalline lens

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**Abstract**

Crystalline lenses are transparent biological materials where the organization of the lens fibers can also be affected by changes at molecular level, and therefore the structure and morphology of the tissue can be correlated to the loss of transparency of the lens. In this work, internal structure of mammal lenses regarding the long-range ordering of the fibers are investigated by diffraction enhanced X-ray imaging (DEI) radiography. Moreover, DEI and absorption X-ray synchrotron radiographs for healthy and cataractous crystalline lenses are compared. Significant differences in healthy and cataractous crystalline lenses are observed.


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## 1. Introduction

Crystalline lens is an unique tissue where the exact fiber cell organization and distribution of the refractive index are not completely known [1,2]. Several studies have reported that diseases in this soft tissue are associated with some specific causes, such as perturbation in the internal structure of the lenses [3,4]. Since last decade, DEI radiography has been investigated for medical applications such as diagnoses of diseases in biological tissues [5–7]. Here, DEI is exploited for analyzing the tissue of non-cataractous and cataractous crystalline lenses. Borders and contours of the tissues are emphasized by using this imaging technique. The first aim is to inspect the sensitivity of the technique

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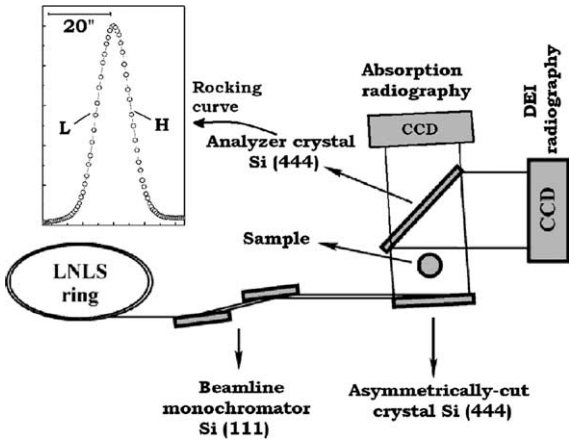


Fig. 1. Experimental set up for diffraction enhanced X-ray imaging (DEI) at the Brazilian synchrotron light laboratory (LNLS). DEI radiographs are acquired after diffraction of the sample-transmitted rays by the analyzer crystal when it is set at the low (L) or high (H) shoulders of its rocking curve (see inset). Absorption radiography is obtained by changing the CCD position and removing the analyzer crystal from the sample-transmitted beam path. X-ray photon energy is 10.7 KeV.

for investigating the ocular tissue, in particular crystalline lens, the etiology of the disease and the changes of the fiber cells organization during cataractogenes. Apparent absorption and refraction contrast images of normal and diseased tissues are therefore obtained.

## 2. Results and discussion

A scheme of the experimental set up used for DEI radiography is shown in Fig. 1. Absorption X-ray synchrotron radiography can also be performed with the same set up as shown. DEI images of horse, rabbit and canine lenses are presented in Figs. 2–4. In Fig. 2, the feasibility to provide some information on the organization of horse lens by DEI is demonstrated in (Fig. 2(a) and (c)), while none information is available by absorption radiography (Fig. 2(b)). The contrast level in the DEI radiographs as a function of the analyzer-crystal rocking curve position is investigated on the rabbit lens (Fig. 3). At the slopes of the diffraction peak, more details are visible in comparison to the images taken at the center, see for instance Fig. 3(a), which is similar to conventional absorption radiography where only the lens shape is

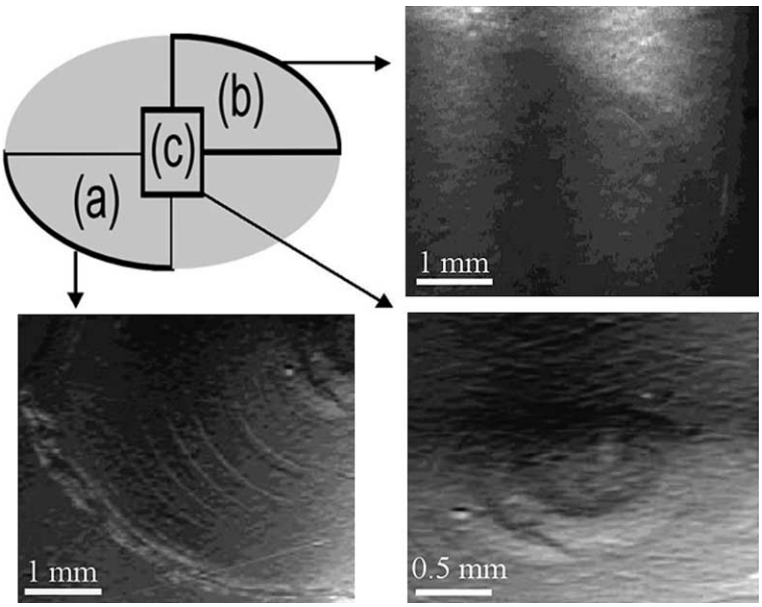


Fig. 2. A horse normal lens in (a) DEI and (b) absorption mode taken from similar regions as indicated in the inset. (c) Details of the central region by DEI. Rocking curve position: L (see inset Fig. 1).

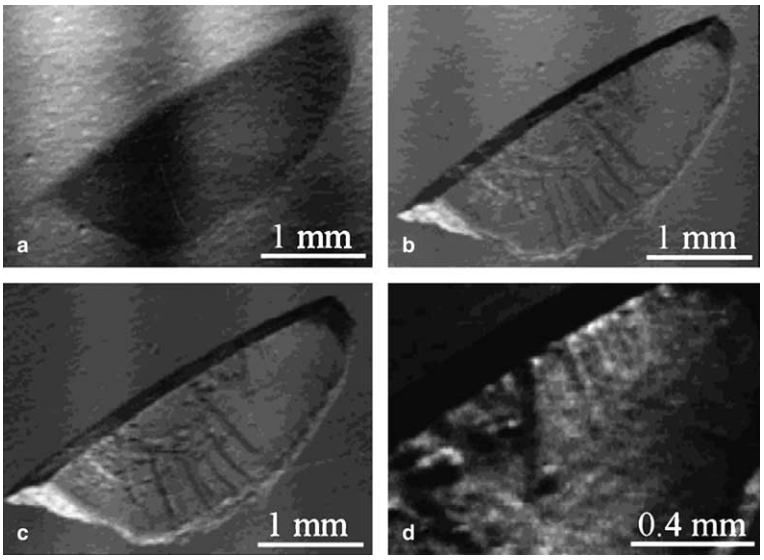


Fig. 3. Images of rabbit healthy lens by (a) absorption mode; (b) structure for slope position (L); (c) apparent absorption contrast image and (d) details of the small region of healthy rabbit lens (apparent absorption) where the fiber cell structure can be visualized.

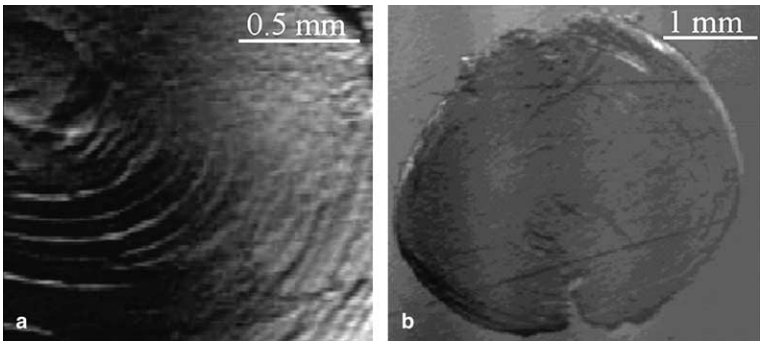


Fig. 4. DEI radiographs of canine crystalline lenses. (a) Normal lens, frontal cross-section, about half of the lens area; the central region is visible at the top-left. (b) Mature cataract, frontal cross-section, entire lens area.

visible. Fig. 3(b) presents details of structures for the slope position of the analyzer crystal (low angle). The apparent absorption contrast image is showed in the Fig. 3(c). In the Fig. 3(d) details of the small region of healthy rabbit lens (apparent absorption [7]) are showed where the fiber cell structures are visualized. Clinical case of mature canine cataract diagnosis is compared with a normal canine lens in Fig. 4.

Patterns of concentric shell-layers are observed in normal lenses of the mammals analysed here by DEI. The absence of similar patterns in the canine cataract lens allows to raise an hypothesis on how the organization of the fiber cells are affected by cataractogeneses. In normal lens the fibers cells seem to be compacted in groups and the X-ray refraction index varies at the contour of such groups, so that they are visible by DEI. On the other hand, in the cataract lens the medium at the contour of the fiber-cell groups seems to have refraction index similar to that of the fiber-shell as if they are all compacted with the same density.

## 3. Conclusion

Diffraction enhanced imaging (DEI) and conventional synchrotron radiography on healthy and diseased crystalline lenses were performed. Our results have indicated that the DEI technique is a potential tool for the investigation of the ocular tissues. The next step is to evaluate the structural changes at selected stages of cataract formation using DEI technique.

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