Parallel x-ray microscopy

Probably, all of us have experience with x-ray imaging. If we are injured then we have to take an x-ray picture to diagnose broken bones. In more complicated cases, we need to use X-ray tomography to get a three-dimensional image. When we are at the airport, our luggage is also imaged with X-rays. In both cases, the contrast is created by the different absorption of X-rays in various substances. This is the so-called x-ray absorption contrast. X-rays can also be used for imaging of micro and nano-objects. However, such objects, especially if they are composed of light elements, absorb X-rays too weakly to be imaged (Figure 1). It is necessary to use x-ray phase contrast; when passing through the objects X-rays are also refracted and diffracted.

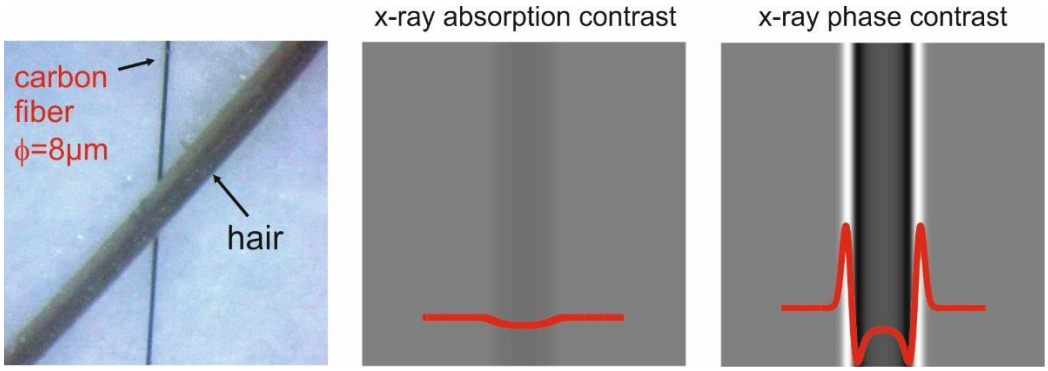

Figure 1. A carbon fiber (~8 times thinner than human hair) x-ray imaged with absorption and phase contrast (computer simulation). In the absorption image (contact geometry), the carbon fiber is hardly visible.

X-ray phase contrast requires coherent X-rays, which are generated either by synchrotrons or by very small laboratory micro-sources that provide low photon flux. In this project, we propose a new concept of parallel x-ray microscopy. By means of tailored capillary optics, the object is imaged simultaneously (or in parallel) by hundreds of micro-beams. Each micro-beam forms a separate X-ray projection of the object (Figure 2). This detection scheme will massively decrease the acquisition time. We believe that parallel x-ray microscopy will enable three-dimensional imaging of cells, bacteria, tissues and complex material at a resolution that is significantly higher than the resolution of optical microscopes. Contrary to electron microscopy, it will provide information about interior of the examined samples.

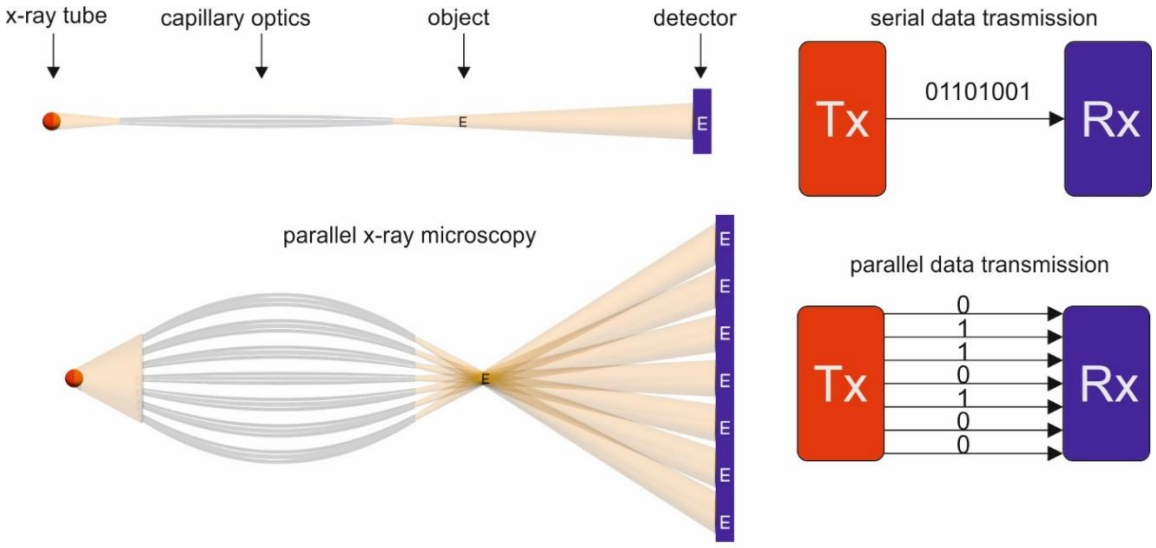

Figure 2. Analogy between parallel x-ray microscopy and parallel data transmission. In parallel x-ray microscopy the object is simultaneously imaged by multiple x-ray microbeams that are generated by tiny capillaries. Next, individual images are added numerically by means of computer software. Simultaneous detection of multiplexed x-ray images will result in much more efficient and faster x-ray laboratory based microscopy. In a similar way one increases speed of digital data transmission.