Artificial intelligence: a tool for high brilliance sources and X-ray imaging

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The advent of high brilliance X-ray sources, such as diffraction-limited storage rings and X-ray free-electron lasers, has opened new possibilities for the X-ray imaging community. However, these technologies post new scientific and technical challenges that must be addressed to exploit their capabilities efficiently. One obvious challenge, as a result of the increase in coherent flux or brilliance, is the generation of large amounts of data in a shorter time. This problem results in the necessity to develop real-time trigger and online data analysis algorithms to cope with the data generation. For the case of X-ray imaging and precisely coherent imaging techniques, this problem translates into the urge to develop real-time phase-retrieval algorithms, which can retrieve the missing-phase information when acquiring the data. Nowadays, the most popular solutions to the phase problem are iterative approaches. Iterative approaches are overall time-consuming, requiring at least several seconds to converge for a single image. Thus, they are not suitable for performing online reconstructions. Recently, deep-learning-based methods have been explored that process the potential to perform fast image reconstructions.

In this seminar, we will discuss some of the open challenges at high-brilliant sources, which can be potentially addressed with artificial intelligence approaches. Then, we will focus on the phase problem and how it can be addressed with deep-learning approaches. For such purpose, we will discuss state-of-the-art deep-learning phase-retrieval methods and introduce a new deep-learning approach: PhaseGAN. PhaseGAN is an unpaired approach that enhances the phase-retrieval capabilities of analogous approaches by including the physic of image formation.