【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project： Cell Dynamics Studied by X-Ray Laser Diffraction

Yoshinori Nishino
(Hokkaido University, Research Institute for Electronic Science, Professor)

Research Project Number：15H05737　Researcher Number：40392063
Research Area：　Quantum beam science, X-ray
Keyword：　X-ray free-electron laser, Pulsed coherent X-ray solution scattering, Cell dynamics

【Purpose and Background of the Research】

X-ray free-electron lasers (XFELs) are intense high-quality coherent X-rays with ultra-short femtosecond pulse durations. The excellent properties of XFELs opened up the way for imaging before radiation damage destroys the sample.

Highly coherent XFELs are suitable for coherent diffractive imaging (CDI), microscopy without objective lenses. The principle investigator, Nishino, has been working on CDI and has demonstrated high-contrast nano-imaging of unstained biological samples that are transparent to X-rays.

The project members have also developed pulsed coherent X-ray solution scattering (PCXSS), CDI under controlled environment using XFELs, and succeeded in live cell nano-imaging. In this project we will further extend our study to observe nano-level dynamics of living cells.

【Research Methods】

In XFEL measurement, samples are destroyed with a single-shot, and therefore time series imaging of an identical cell is hindered. This project aims at revealing nano-level dynamics of living cells by imaging different states of synchronized cells with XFELs. For the cell synchronization, flash photolysis of caged compounds and synchronous culture are under consideration. We will utilize fluorescent microscopes, etc. at Hokkaido University for prior studies of cell dynamics.

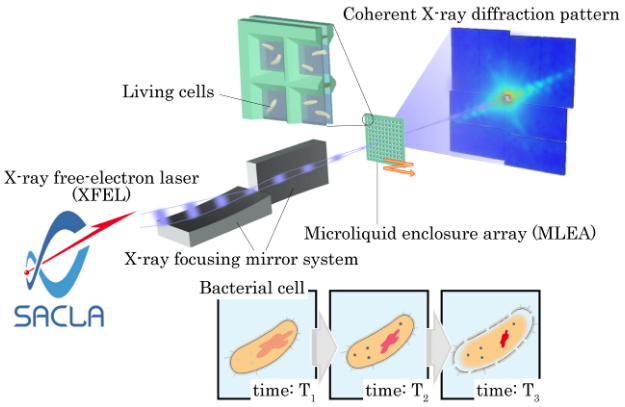

Figure 1: Imaging different states of synchronized cells with XFELs

XFEL imaging by PCXSS will be performed at SACLA (Fig. 1). Cells are kept in micro-liquid enclosure array (MLEA), and placed in a vacuum chamber. We illuminate cells with a single XFEL pulse successively, and record coherent X-ray diffraction (CXD) patterns. The sample images are then reconstructed from the CXD patterns by iterative phase retrieval.

【Expected Research Achievements and Scientific Significance】

PCXSS can image live cells at the nanolevel in contrast to cryo-electron microscopy. The nano-imaging of cell dynamics taking full advantage of XFELs will have enormous potential in cell biology. Studies of extremophiles are also important in industry, *e.g.*, the development of enzyme functioning in extreme conditions. Furthermore, through the observation of sub-micrometer-sized bacterial cells, we tackle the problem how such tiny organisms can maintain life activities.

【Publications Relevant to the Project】

· T. Kimura, Y. Joti, A. Shibuya, C. Song, S. Kim, K. Tono, M. Yabashi, M. Tamakoshi, T. Moriya, T. Oshima, T. Ishikawa, Y. Bessho and Y. Nishino, "Imaging live cell in micro-liquid enclosure by X-ray laser diffraction", Nat. Commun. **5**, 3052 (2014).

· J. Pérez and Y. Nishino, "Advances in X-ray scattering: from solution SAXS to achievements with coherent beams", Curr. Opin. Struct. Biol. **22**, 670-678 (2012).

【Term of Project】 FY2015-2019

【Budget Allocation】 153,900 Thousand Yen

【Homepage Address and Other Contact Information】

http:// cxo-www.es.hokudai.ac.jp/
yoshinori.nishino @ es.hokudai.ac.jp