

Radostin Danev

The University of Tokyo, Graduate School of Medicine
Professor

Fast Synchronous Quantum Wave Modulation for High-Resolution Biological
Observations
(高速量子波面モジュレーション・クライオ電顕)

§ 1. 研究成果の概要

In the past year, there was a significant progress in the project. I continued investigations of the originally proposed electrostatic and magnetic real-time defocus modulator designs. The calculated values for the required voltages and currents were at the limits of what would be practically possible, considering the space restrictions around the objective lens aperture area of the microscope. This posed a research challenge, which seemed difficult to overcome without a redesign of the microscope objective lens. Nevertheless, in the process of trying to find a practical solution for the problem, I came up with a simpler and more elegant design that resolved all restraints related to the micro-lens modulators. Instead of trying to focus the electron beam by using the power of a micro-lens, I decided to exploit a flaw of the microscope objective lens, namely its chromatic aberration. Chromatic aberration is an undesirable but also an unavoidable characteristic of circularly symmetric magnetic lenses. As in light optics, it manifests as varying focusing power of the lens for different wavelengths/energies. To utilize the chromatic aberration in a productive way, I proposed applying a biasing voltage to the objective lens aperture. This changes the energy of the electron beam close to the aperture which combined with the chromatic aberration causes a focus change. We estimated the magnitude of the effect through theoretical and numerical calculations and the results confirmed that the idea will be feasible in practice. Subsequently, we performed proof-of-concept experiments that matched to within 10 % the predictions of the numerical calculations. We published all current results in a paper which was met with substantial interest and excitement by the cryo-EM community. During the writing of the manuscript, I decided to change the name of the technique to FADE (Fast and Accurate Defocus) because it is more memorable.