Experimental Study on Single Electron Storage at UVSOR-Ⅲ in 2025

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We have been conducting single-electron storage experiments at UVSOR-III since 2021 with the aim of performing fundamental studies of electromagnetic radiation [1]. At UVSOR-III, single-electron experiments were carried out at beamline BL1U [2, 3] using two identical permanent-magnet APPLE-II undulators, each consisting of 10 periods, and a three-magnet chicane installed between them. These undulators can generate arbitrary elliptical polarization. In this case, for the single-electron measurements they were set to linear horizontal polarization with a central wavelength of 355 nm. The experiments were performed using either a single undulator or both undulators tuned to the same wavelength in an optical-klystron configuration. Undulator radiation in the UV region was extracted into the atmosphere and its intensity was measured using a photomultiplier tube. By applying suitable band-pass filters to suppress background light and a beam scraper to reduce the electron beam intensity, we successfully observed step-function-like intensity changes under few-electron storage conditions with a good signal-to-noise ratio, confirming single-electron storage. Then, we further improved the operational efficiency and automation of the single-electron storage technique and initiated experiments to observe synchrotron radiation from a single electron. As a result, we confirmed that the undulator radiation emitted by a single electron follows a Poisson distribution, where the number of emitted photons per pass is much smaller than unity, in agreement with theoretical predictions based on classical electrodynamics [4].

From this result, it is expected that a single electron passing through the undulator may occasionally emit two photons simultaneously. In recent quantum measurement and sensing technologies, quantum-entangled photon pairs are widely utilized; therefore, the observation of simultaneous two-photon emission events could provide a pathway toward generating entangled photon pairs using synchrotron radiation. To investigate such simultaneous two-photon emission events, experiments were performed using the setup shown in Fig. 1(a), where the coincidence of two photons was examined. In addition, to study the wave–particle duality of photons, a double-slit experiment was carried out using the setup in Fig. 1(b). The latest experimental results will be presented at the symposium.

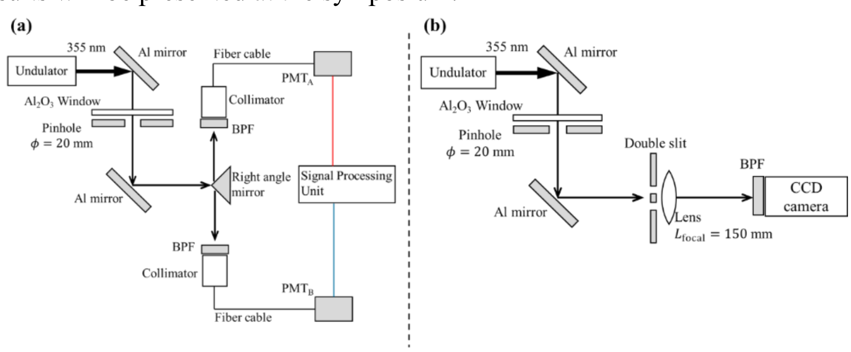

FIGURE 1. The experimental setup.

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