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Measurement of two-photon correlation of synchrotron radiation by delay modulation technique

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Introduction

Two-photon correlation (second order coherence) has been measured in order to investigate the photon statistics and spatial coherence of synchrotron radiation. However, the signal corresponding to the two photon correlation was extremely small due to the short coherent time compared with the response time of the detector or electric circuit. To overcome the difficulty, Tai et al. have developed a new idea to modulate the coherence time and measured the signal with a lockin amplifier. They have succeeded in observing a bunching effect originated from the chaotic nature of the synchrotron radiation [1][2]. In this study, we adopted another technique to modulate the delay time and measured the signal by a lockin amplifier. By this technique, the bunching effect was more clearly observed [3].

Experimental

The experiment was performed at an undulator beamline BL-16B. The monochromatized beam with the photon energy of 60 eV was diffracted by a Fraunhofer slit and the spatial coherence was controlled by the slit. The beam was divided into two pieces and each beam was measured by a photomultiplier tube (PMT). The separation between the time that a photon arrived to a PMT and the time that another photon arrived to the other PMT was measured by a set of modules composed of a constant fraction discriminator (CFD), a time to amplitude converter (TAC) and two solid state switches. There are two paths with different delays between the CFD and the stop input of the TAC, and the solid state switches can control which path the signal goes through. Output of the TAC came into a single channel analyzer (SCA) and the pulse with the selected height was discriminated. The SCA was adjusted so that the signal from the SCA appeared only when two photons were simultaneously detected by each PMT, respectively. The output of the SCA came into a ratemeter and the analog output of the ratemater was measured by a digital lockin amplifier. We switched the paths between the CDF and stop input of the TAC by a function generator with the frequency of 0.49999 Hz, which was also used as a reference input of the lockin amplifier. The x component of the lockin amplifier $-V_x$ has the information on the second order coherence. We accumulated the data for about 4 hours for several width of the Fraunhofer slit D.

Result and discussions

Figure 1 shows the plot of $-V_x$ as a function of the width of the Fraunhofer slit D. As D is smaller, the correlation of the light at the two PMTs becomes stronger. Hence, $-V_x$, which is proportional to the integral of the second order coherence on the Fraunhofer slit, increases. This phenomena is known as the bunching effect of the chaotic light. The experiment clearly shows that the synchrotron radiation of the PF in VUV region has a chaotic component. If the light is chaotic, the first order coherence can be known from the second order coherence. Since the electron-beam emittance can be estimated from the first order coherence, we can estimate the electron-beam emittance from this experiment with the knowledge of the beamsize on the Fraunhofer slit. The beamsize measured with a tungsten wire scanner was 507 µm and the electron-beam emittance was estimated as 135 nmrad, which was much larger than the designed value of 36 nmrad. The reason of the discrepancy may be a rough approximation to derive a theoretical prediction.

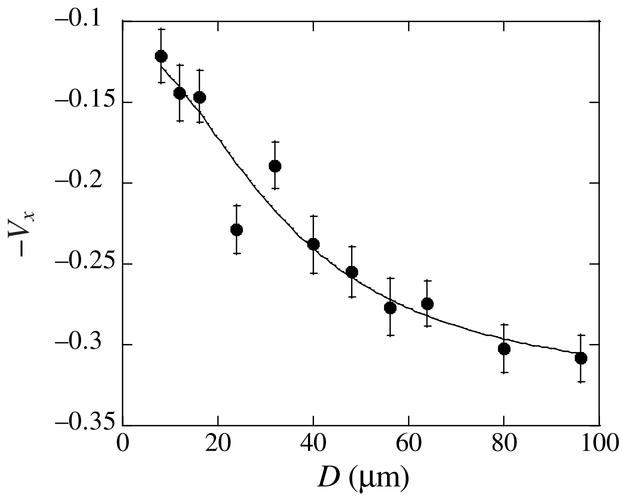

Figure 1: Output of the lockin amplifier as a function of the width of Fraunhofer slit.

References

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