Development of Ghost Imaging Absorption Spectroscopy

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We are developing ghost imaging absorption spectroscopy by integrating computational ghost imaging (CGI) with plasma absorption spectroscopy [1]. Ghost imaging is a method that employs a single-pixel detector such as a photodiode to capture an image of an object. Structured light with a random intensity distribution, $I_{\mathrm{r}}(x, y)$, as depicted in Fig. 1, is absorbed by plasma with a density distribution, $T(x, y)$. A photodiode measures the integrated value, b_r, of the transmitted light. The value of $T(x, y)$ is subsequently computed as follows:

$$T(x,y) = \frac{\langle b_r I_r(x,y)\rangle - \langle I_r(x,y)\rangle\langle b_r\rangle}{|\langle I_r(x,y)\rangle|^2} \quad (1)$$

By switching and averaging tens of thousands of $I_{\mathrm{r}}(x, y)$ patterns, the contrast of the resultant $T(x, y)$ is progressively improved. As this imaging method is predicated on the correlation between b_r and $I_{\mathrm{r}}(x, y)$, it exhibits a noise tolerance analogous to lock-in detection. Moreover, by restricting the area of correlated absorption with $I_{\mathrm{r}}(x, y)$ through the focusing of structured light, as illustrated in Fig. 2, spatial resolution in the line-of-sight can be attained even in absorption spectroscopy. Figure 3 presents an image procured using our ghost imaging system, with the letter "P" printed on an acrylic plate serving as a test target. In this presentation, we will exhibit the outcomes of a proof-of-principle experiment, demonstrating that our imaging technique retains spatial resolution in the line-of-sight direction. We will also detail the application of this method to the measurement of metastable helium atoms in a helicon wave plasma."

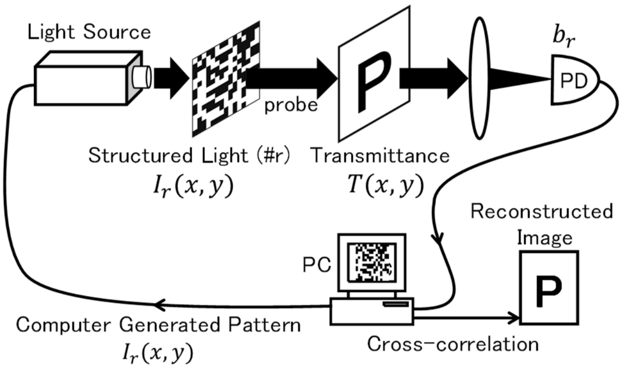

Figure 1. Schematics of ghost imaging absorption spectroscopy system.

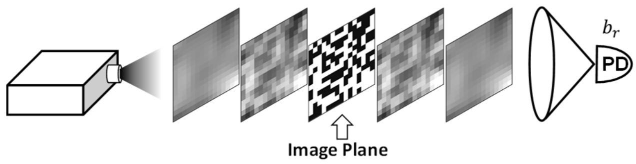

Figure 2. Restriction of the correlated area by foc using of structured light.

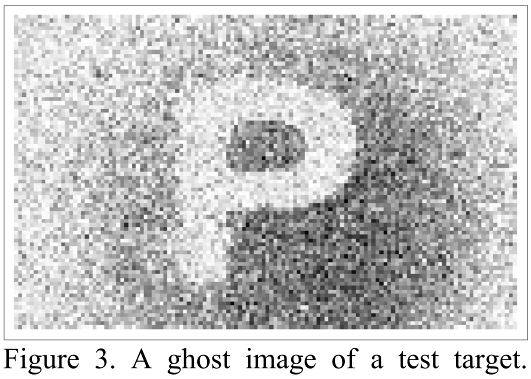

Figure 3. A ghost image of a test target.

[1] J. H. Shapiro, Phys. Rev. A **78**, 061802(R) (2008).

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