Using the Moiré Effect for Wavefront Sensing

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Summary

This research was motivated by an interest in moiré effects, which can occur when two periodic patterns overlap with an angular offset. We simulated a variety of moiré effects in Mathematica and investigated a simplified method for wavefront sensing using moiré effects and Talbot self-imaging.

The moiré effect

The moiré effect is visual beat effects. They are often observed in nature, such as on overlapping screen windows or chain-link fences.

Linear moiré, moiré created with linear gratings, are the most studied of moiré patterns. The shape of the moiré created with linear gratings can be written as a cosine function

$$
\cos \left( \frac{2 \pi}{\lambda_\text{beat}} \right) \left( \cos \alpha \cos \frac{\lambda_1}{\lambda} y + \sin \alpha \sin \frac{\lambda_1}{\lambda} x \right)
$$

where $\alpha$ is half of the angle between the gratings, $\lambda_1$ and $\lambda_2$ are the grating periods, and $\lambda_\text{beat}$ is the beat period and $\Delta \lambda = \frac{\lambda_1 + \lambda_2}{2}$ is the average period.

Wavefront sensing

An application of moiré patterns is testing the collimation of a laser beam. This is also an excellent example of an application of the Talbot effect. The goal of this research is to model the collimation setup and to quantify the parameters to obtain a systematic scheme for determining beam collimation.

The moiré fringes were recorded for 1.0 mm steps in the collimating lens position. Images shown above correspond to 5 mm steps. As collimation decreases, the wavefront becomes spherical, and the Talbot self image will be either magnified or demagnified in size, depending on the sign of the wavefront curvature. The size difference between the original grating and the self image results in moiré fringes. The tilt of the moiré fringes changes with the period of the self image. When the incident light is collimated, the fringes will be horizontal.

Results

Fringe angle (w.r.t. vertical) versus collimating lens position.

Estimated beam width as a function of collimating lens position.

References / Acknowledgements


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