Towards Reconfigurable Wavefront Sensing Using a Spatial Light Modulator

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Measuring the wavefront gives valuable insights into the characteristics of optical instruments. For example, imperfect wavefronts in astronomical instruments, resulting in image degradation, due to misalignment, component tolerances and so forth can be measured.

A common device for wavefront sensing is the Hartmann sensor. It consists of a mask made from a regular grid of holes in an opaque substrate and an imaging sensor, onto which the diffraction patterns of the holes are mapped. Any offset of the image position from the regular grid indicates a local deviation of the inspected wavefront from an ideal plane wavefront. Such systems are already published for Terahertz radiation [1].

This paper demonstrates a 345 GHz setup for reconfigurable Hartmann masks using a terahertz spatial light modulator (THz-SLM). The THz-SLM consists of a disc of Germanium and a projector for near infrared and visible light. The disc of Germanium is transparent for the 345 GHz radiation while it is not illuminated. When light is projected onto the Germanium disc, it becomes less transparent at the illuminated regions. As the spatial filter characteristics depend mainly on the projected pattern, they can be easily and quickly reconfigured.

The experiments aim to investigate the usability and advantages of a THz-SLM in the context of Hartmann wavefront sensing. The number of wavefront samples can be increased by slightly shifting the array of holes and taking further images, leading to super-resolved (compared to static Hartmann masks) wavefront sensing. Furthermore, it is possible to relax the demands towards the imaging sensor. The matrix image sensor may be replaced by a single pixel sensor that is moved to as many positions as wavefront samples are desired. The use of a THz-SLM allows moving the holes in the Hartmann mask, in such a way that they fit directly to a chosen detector position.

An enhancement of the Hartmann sensor is the Shack-Hartmann sensor, in which the mask consists of a grid of lenses instead of holes. The Shack-Hartmann design improves the contrast and results in sharper images of each mask element.

We will discuss the feasibility of Fresnel zone lenses in a Shack-Hartmann mask. Like the holes for a Hartmann mask, these lenses can be implemented using an SLM. The reconfigurability of the THz-SLM can be exploited for a super-resolution approach.

[1] Richter et al., Terahertz wavefront measurement with a Hartmann sensor, Applied Physics Letters, AIP Publishing, 2012, 101, 031103