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Optical Cloaking by Aberation Correction

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Optical Cloaking by Aberration Correction

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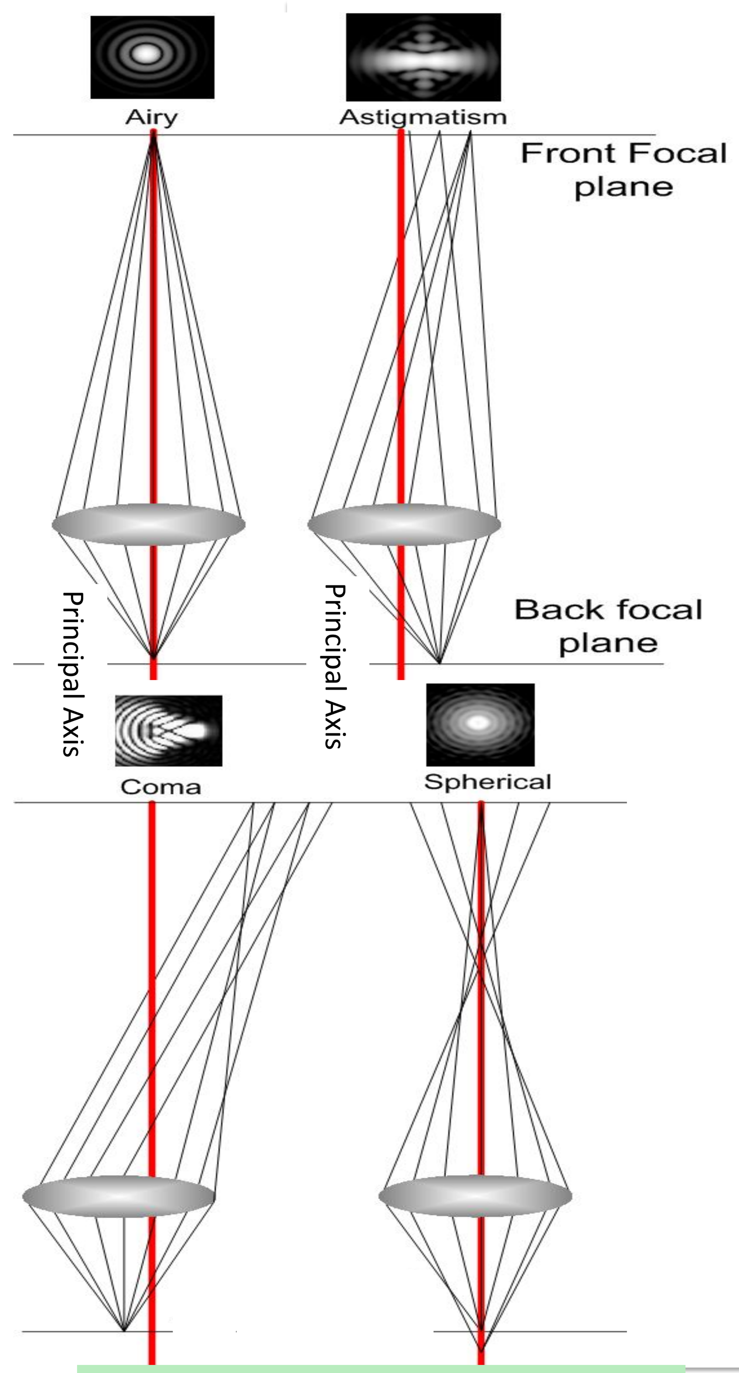
Abstract

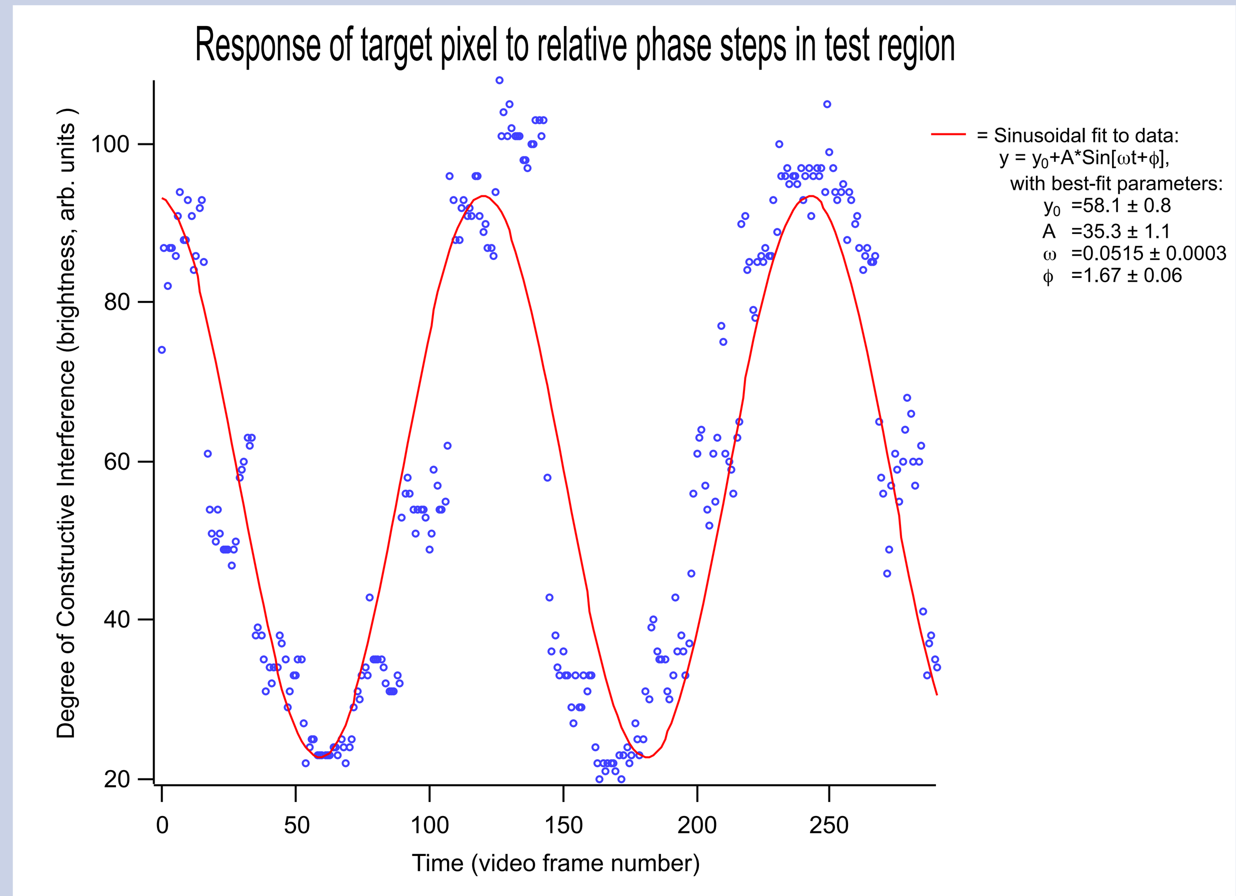
Light incident on a material is scattered and then continues its propagation in seemingly random directions. This scattering of light can be described as aberration of the beam. If one can figure out an "inverse scattering function" to impose upon the light, prior to incidence upon the medium, as a net result one could "see" through the material. **The technique used here is to impose time lags (phase shifts) to local regions of the incident light beam**, so as to allow all transmitted wavefronts of light to interfere, in a constructive manner, at a target location on the transmission side of the material. This is accomplished through the use of a Spatial Light Modulator (SLM). The SLM, essentially a programmable hologram, is a pixelated mirror array coated with liquid crystal molecules, whose orientation is controlled via local electric fields: the optical anisotropy of the liquid crystal molecules allows us to control the local phase shift imposed upon light reflected by the SLM.



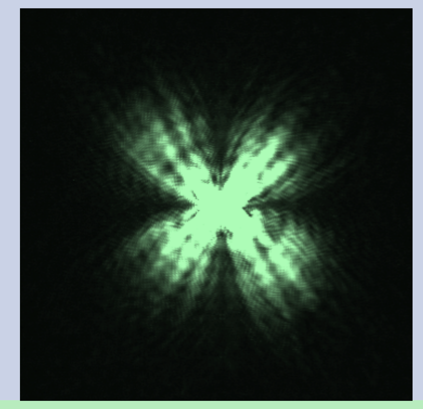
Laser Beam Aberration

Data

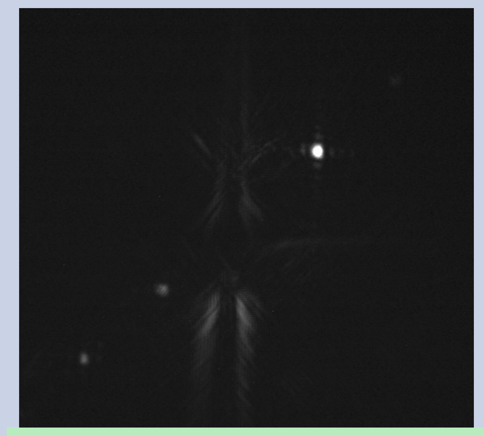
- Adding local phase offsets to a subregion of the beam results in a sinusoidal graph because of destructive and constructive interference with a reference region of the beam.
- Our test data represents cycling through sixteen phase levels within a local area of the beam.



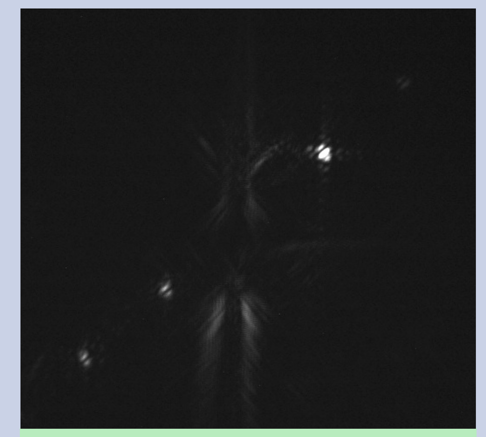
Brightness at Target Transmission Location



Uncorrected Transmission



Reference Diffraction



Interference Pattern

Set-Up

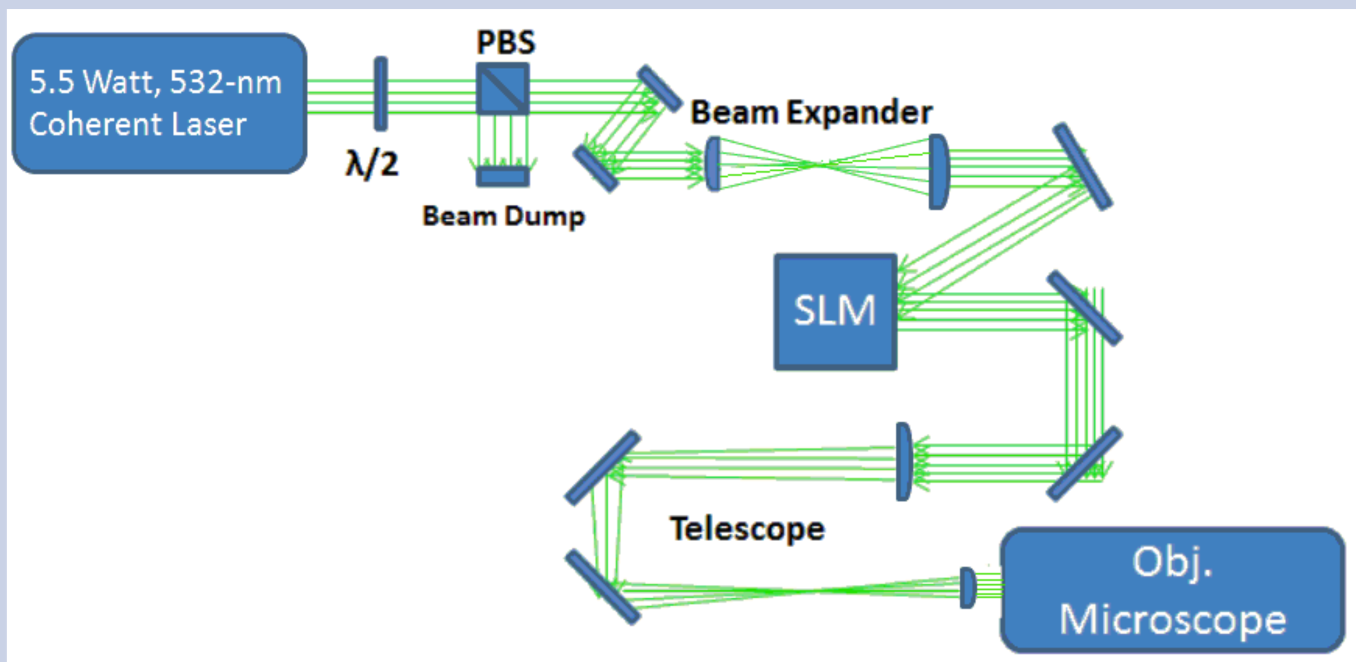
Our setup also consisted of:

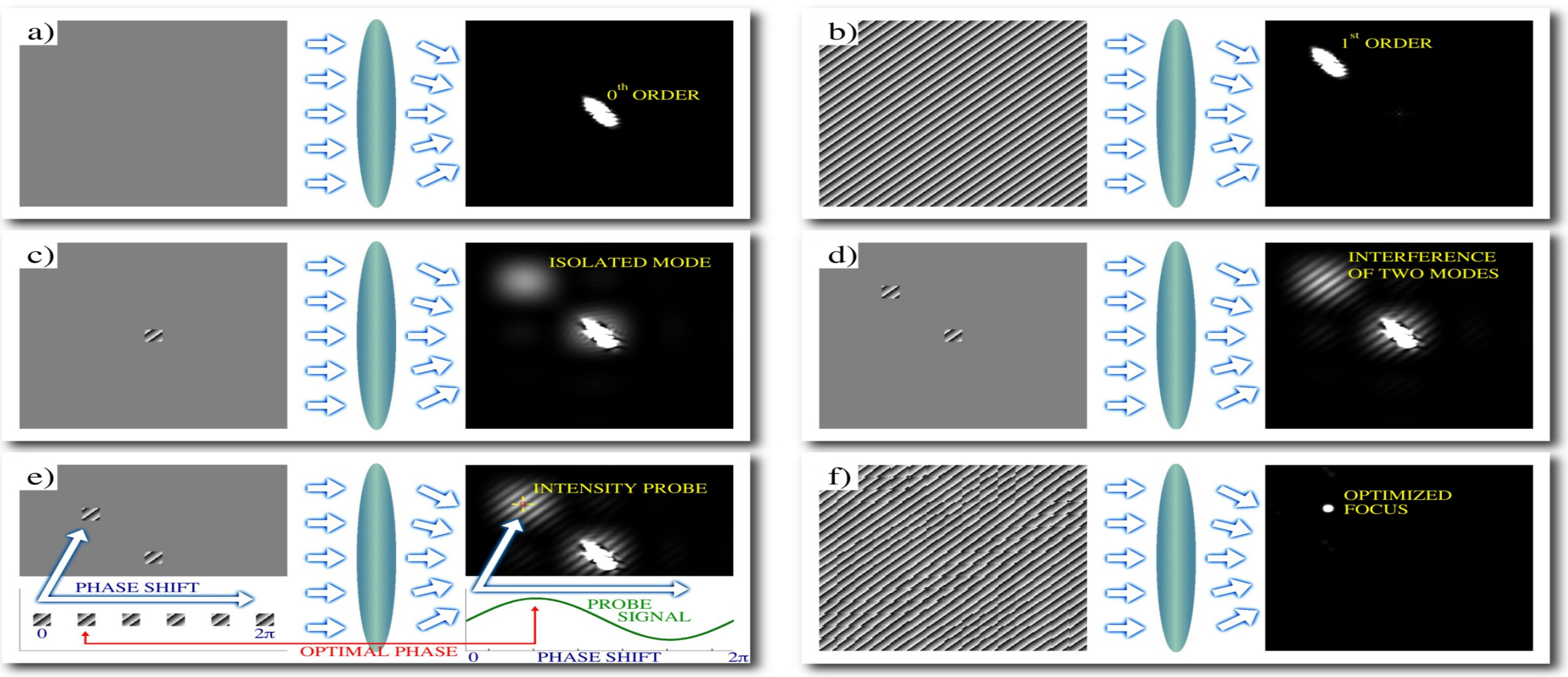
- 1.3-Megapixel firewire CMOS camera (Prosilica Model EC-1280)
- *LabVIEW* programming:

for control of video acquisition

- IDL programming:

for iterative creation of phase profiles, data collection and data analysis





SOPS Method for Laser Aberration Correction by Tomas Cizmar

Conclusion

Improvements:

- Operating the laser at a higher power will yield greater stability than what we found in operating near the lasing threshold, where the laser output is intrinsically unstable (which creates more noise in our data).
- By normalizing our detected intensity through comparison to the tails of the undiffracted beam, we hope to further reduce noise: dividing our raw signal by the normalization signal should give us a differential measurement that is robust against both fluctuations in beam intensity and also "pointing" instabilities (due, *e.g.*, to mechanical vibrations).

Further Research:

- The next step of our research will consist of expanding our test regions to determine optimal phase offsets over the whole SLM to create a fully optimized transmission signal.
- We could also move on to correcting aberration for multiple colors of light or within turbid (time-varying) materials.
- This technology has potential to be used for non-invasive surgeries.
- If a procedure for allowing light to pass through a material is developed, the the procedure constitutes a strong starting point for research into optical cloaking. By expanding the region in which one "sees" through a material to the whole surface area, it is possible to cloak the entire material rather than "see" through a portion of the "cloak". Subsequent research should extend our work on transmitting signals to complementary work on detecting images.

Source:

- Cizmar, T., Mazilu, M., and Dholakia, K. *in situ* wavefront correction and its application to micromanipulation. *Nature Photonics* **4**, 388-394 (2010).