A Fiber-Optic Laser Interferometer for Vision Research

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Adaptive optics allows retinal image resolution at the spatial scale of single cells, which is valuable for studying normal and diseased retinas. Even with adaptive optics, diffraction by the eye's fully dilated pupil poses a limit on the finest features that can be resolved in the retinal image. Structured illumination is a technique in microscopy that could potentially extend the resolution limit by nearly twice the normal diffraction limit. It involves illuminating the object, in this case the retina, with a high-spatial frequency, sinusoidal grating. The minute features in the retina beat with the high-contrast grating to produce coarse features that can be resolved through the diffraction-limited optics of the eye. My project goal is to produce interference fringes on the retina at sufficiently high spatial frequencies to produce a Moiré patterns with the cone mosaic. I am aiding in the design, using ZEMAX simulation software, and building of a laser interferometer to produce the structured irradiation required to exceed the diffraction limit. Temporal frequency, contrast and phase, will be controlled by two coupled acousto-optic modulators that lie in one in each arm of the interferometer. The light emanating from the two fibers is relayed to the plane of the eye's pupil, forming a fringe image on the retinal plane. Eventually, this instrument will be combined with the Rochester adaptive optics ophthalmoscope to obtain images of the retina suitable for structural illumination analysis.