# Phase and Amplitude Control Ability using Spatial Light Modulators and Zero Path Length Difference Michelson Interferometer

Michael G. Littman, Michael Carr[⊥], Jim Leighton, Ezekiel Burke, David Spergel[⊥] and Jeremy Kasdin

Department of Mechanical and Aerospace Engineering, Princeton University

[⊥]Department of Astrophysical Sciences, Princeton University

To detect our earth around our sun as viewed from a distance of ~60 lightyears requires the ability to see two objects with an intensity contrast ratio of 10^{-10} and an angular separation of 50 milli-arc-seconds.
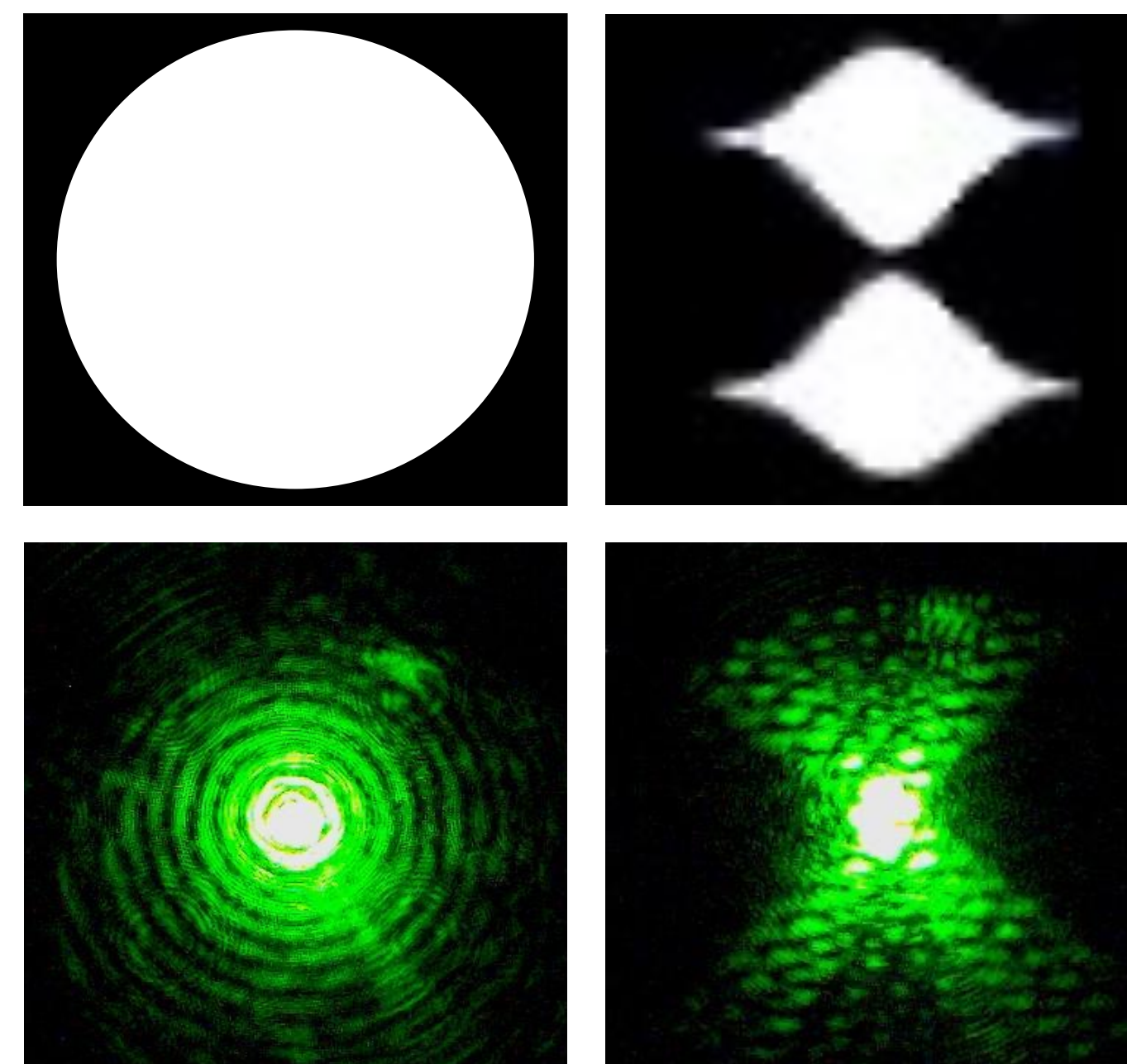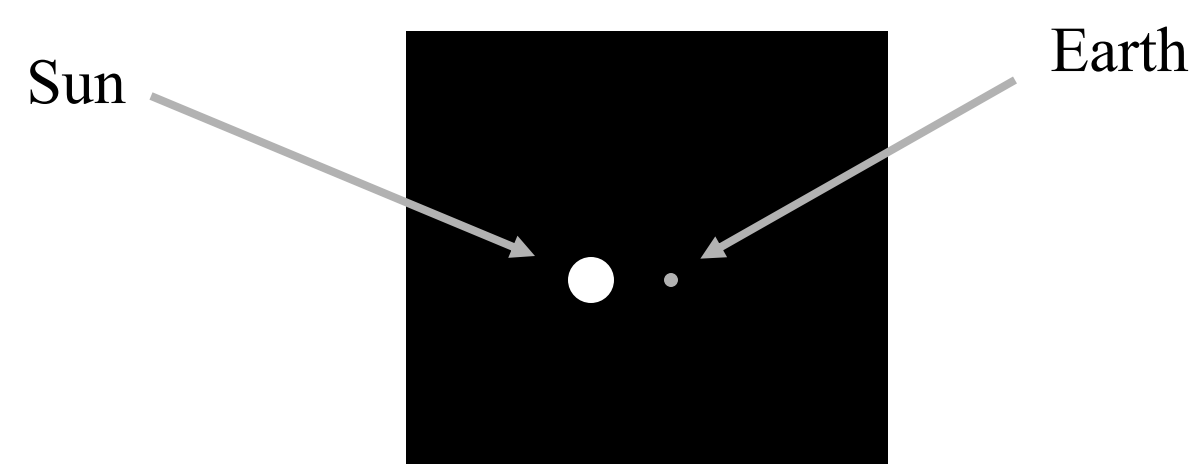
We have studied a new approach to terrestrial planet detection using a pupil–based coronagraph. The focal plane image of the "cats eye" pupil proposed by David Spergel is such that a triangular region to the left and right of the central image of the star is dark. The dark triangular regions are potential discovery spaces for extrasolar planets.
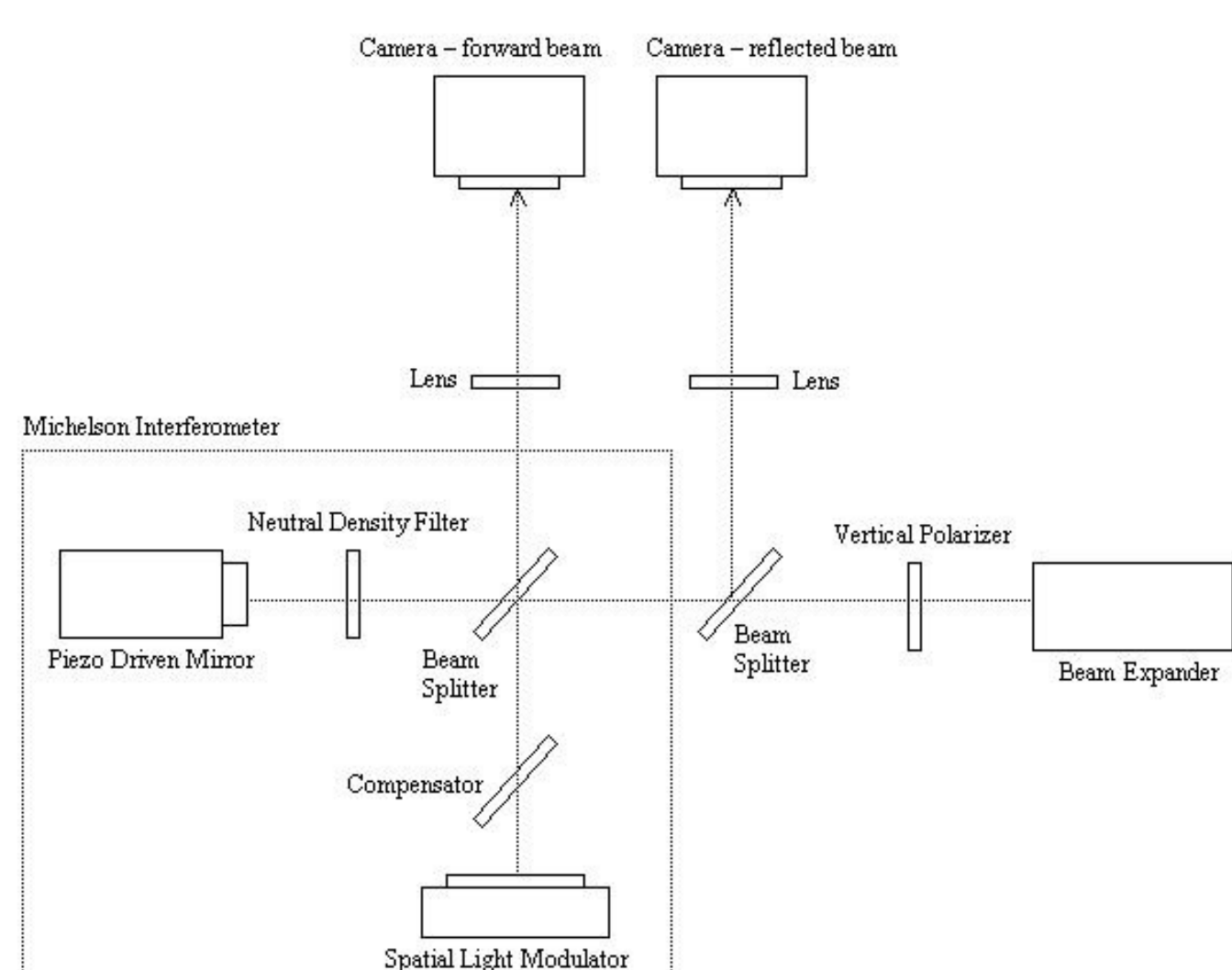

To achieve the required contrast ratio it will be necessary to correct the telescope optics for errors in phase and amplitude. A Zero Path Length Difference Michelson Interferometer using two pixelated optical phase shifters can provide for this control. Tests presented here are based on a Liquid Crystal Spatial Light Modulator (SLM) to demonstrate the concept of amplitude control. The SLM is functionally equivalent to a deformable mirror. The diagram at left and our tests to date have employed only one SLM. Both Laser and broadband sources of light have been used in these tests.
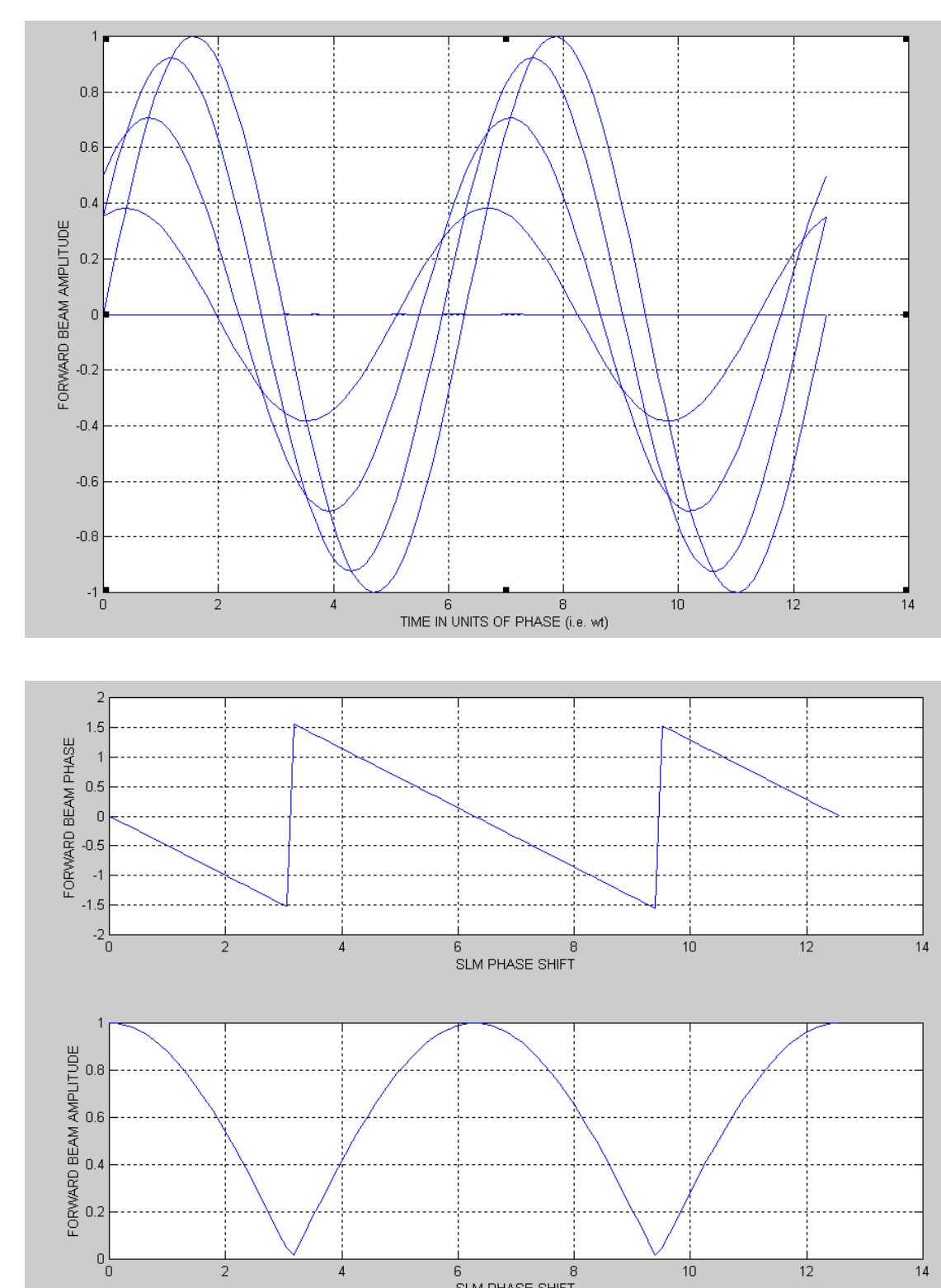
If the interferometer is adjusted for maximum transmission, the forward beam will be made up of two equal amplitude sine waves in phase. As one shifts the phase of one leg of the interferometer using the SLM, the transmitted intensity will drop. Unfortunately, in addition to attenuation there is also a net phase shift. However, if one uses two SLMs (one in each leg of the interferometer) and arranges to advance the phase in one leg while retarding the phase in the other leg, the net phase shift will be zero. This arrangement will allow thus for amplitude control without phase shift. Phase control can then be achieved by allowing for both SLMs to shift in the same direction.

Laser Proof of Amplitude Control Ability: A HeNe laser is used to show that the interferometer can control on a pixel-by-pixel basis whether light is transmitted or reflected. Note that the transmitted pattern (below – left) is the complement of the reflected pattern (below – right). The region in the central box is about 50 x 80 pixels – the SLM is 128 x 128 pixels. The interferometer is deliberately misaligned to show fringes.
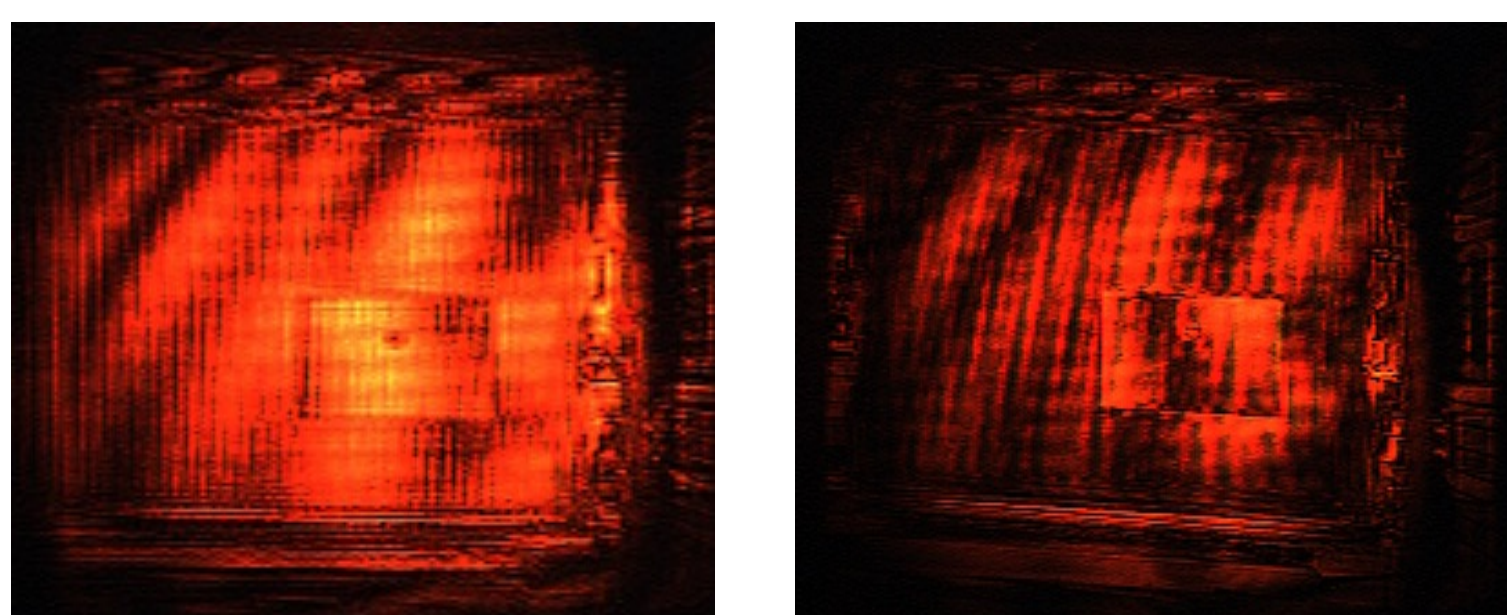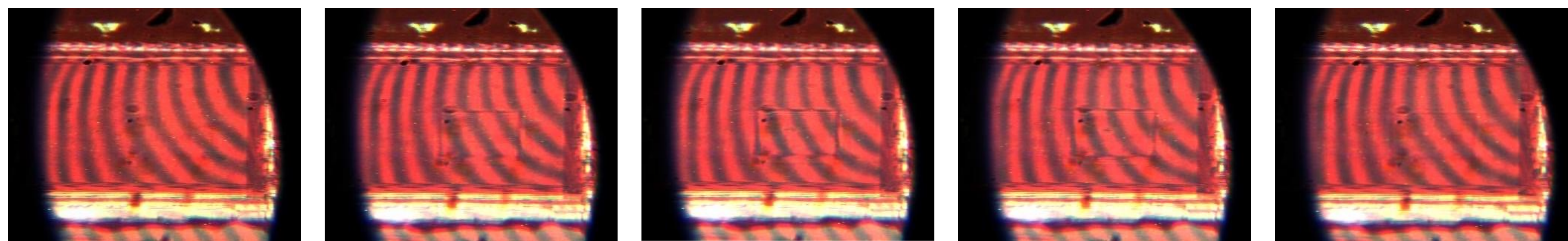
White Light Proof of Amplitude Control Ability: An incandescent light bulb is used as a light source. The interferometer is carefully adjusted so that each leg is equal in length. Under these circumstances white light fringes are visible. The box region in the middle of the figure (about 50 x 80 pixels) is shifted in value from 0 to 2π causing the fringes to shift in the region. This demonstrates that any pixel intensity can be reduced from a maximal to a minimal value, and that this can be done for a wide range of wavelengths in the visible spectrum. The fringes appear orange here because the interferometer dielectric beam-splitter did not reflect in the blue portion of the spectrum.