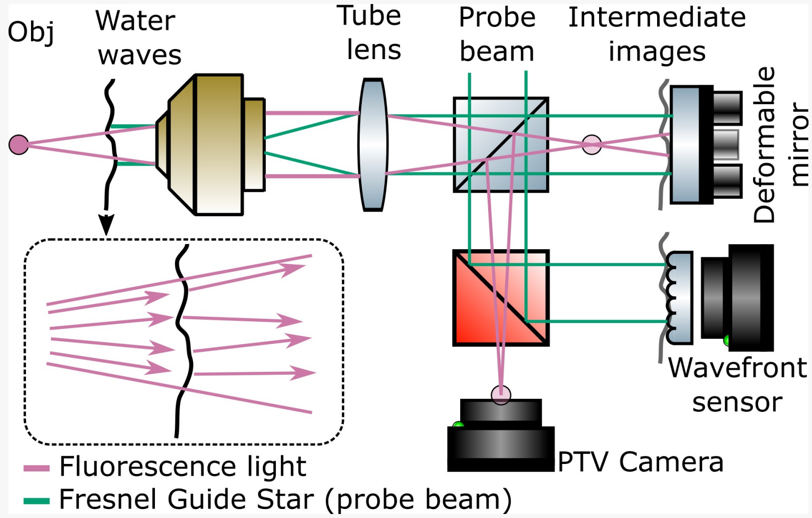
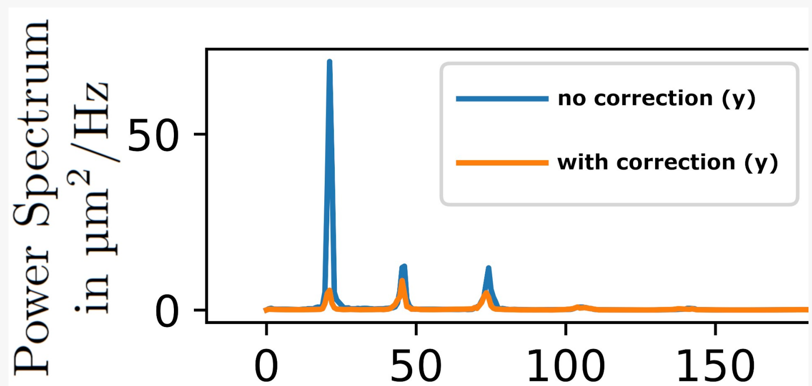
# Adaptive-Optical 3D Microscopy For Microfluidic Multiphase Flows

GA, UNITED STATES, September 9, 2024 /EINPresswire.com/ -- A real-time adaptive optics system was developed, characterised and applied to measure the 3D flow field through an oscillating surface of a water drop on an opaque Gas Diffusion Layer. A case study shows that the system corrects successfully measurement errors of the flow field that are caused by the refraction of light at the time-varying water-air interface.



Simplified overview of the optical setup.



Example power density spectrum of the apparent motion of a particle resting on the substrate.

Imaging and measurements based on optical microscopy can be severely impaired if the access exhibits variations of the refractive index. In the case of flow measurements through fluctuating liquid-gas boundaries, refraction introduces dynamical aberrations that increase the measurement uncertainty. This is prevalent at multiphase flows (e. g. droplets, film flows) that occur in many technical applications as for example in coating or cleaning processes and the water management in fuel cells. In this paper (doi: https://doi.org/10.37188/lam.2024.037), we present a novel approach based on adaptive optics for correcting the dynamical aberrations in real time and thus reducing the measurement uncertainty. The shape of the fluctuating water-air interface is sampled with a reflecting light beam (Fresnel Guide Star) and a Hartmann-Shack wavefront sensor which makes it possible to correct its influence with a deformable mirror in closed-loop operation. Three-dimensional flow measurements are achieved by using a double-helix point spread function. We measure the flow inside a sessile, oscillating 50-μl droplet on an opaque gas diffusion layer for fuel cells and show that the temporally varying refraction at the droplet surface causes a systematic underestimation of the flow field magnitude corresponding to the first droplet eigenmode which plays a major role in their detachment mechanism. We demonstrate that the adaptive optics correction is able to reduce this systematic error. The adaptive optics system can pave the way to a deeper understanding of water droplet formation and detachment which can help to improve the efficiency of fuels cells.

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