MICROSCALE VISCOSITY IMAGING USING HETERODYNE HOLOGRAPHIC ANALYSIS OF NANORODS ROTATION

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Many processes in microfluidics and biology are driven or affected by local viscosity. Global viscosity measurements, particularly in cells, can be achieved by several methods like AFM, surface measurement of acoustic waves, biomembrane force probe, micropipette aspiration or Dynamic Light Scattering (DLS). Local viscosity measurements inside a cell are conducted via in-cell transducers either in active[1] or passive[2] motion. Contactless optical microscopy-based techniques have clear advantages, but[2] non-fluorescent probes are still mostly within the upper part of the "micro" range.

The relatively large scattering cross-section of metallic or plasmonic nanoparticles offers a way to reduce probe size and increase spatial resolution using 3D superlocalization. Instead of relying on the statistics of lateral motion, which averages properties over the path of the particle, we chose to rely on rotation, which often occurs on shorter space and time scales. Moreover, the short exposure time of ultrafast cameras is not compatible with the detection of weak scatterers unless high power illumination is used, which is impossible in living media. Heterodyning is a powerful alternative: by using a frequency beating at frequency ΔF (up to several MHz), any variation occurring at ΔF in the sample can be imaged after demodulation on a dark background, even with a low frame rate, sensitive camera. Using heterodyne holography[3–5] we imaged a) the Brownian rotation of gold nanorods over a broad frequency range (0-10 MHz) and b) the rotation of magnetic nanorods in an external field. After calibration, a single measurement or a frequency scan can give access to high resolution quantitative viscosity microscopy[6].

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