

Differential Dynamic Microscopy as an Alternative to Dynamic Light Scattering for Turbid Nanoemulsions

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Differential Dynamic Microscopy (DDM) is a powerful method for studying soft-matter dynamics, combining the statistical advantages of scattering techniques with the flexibility of optical microscopy. By analyzing time-resolved bright-field images in Fourier space, DDM provides access to sample dynamics while requiring only a few tenths of a microliter of sample and standard microscopy equipment, thus offering clear practical advantages over conventional Dynamic Light Scattering (DLS) [1]. In addition, because image formation in DDM relies on near-field microscopy rather than the collection of singly scattered light at a well-defined angle, the technique often remains effective under conditions where multiple scattering severely compromises DLS measurements [2]. This makes DDM particularly attractive for concentrated, turbid, or highly scattering samples.

In this work, we compare DDM with DLS to investigate oil-in-water nanoemulsions over a broad range of droplet concentrations. Unlike ideal hard-sphere suspensions, nanoemulsions exhibit more complex interparticle interactions and, at higher concentrations, increasingly pronounced multiple-scattering effects, making them an excellent test case for assessing the general applicability of DDM. Through a systematic comparison of both techniques, we show that DDM reliably captures the dynamic behavior of these soft colloidal systems not only in the dilute regime, where both methods perform similarly, but also at higher concentrations where DLS progressively loses accuracy because of multiple scattering. In contrast, DDM continues to provide robust measurements under these challenging conditions, while also benefiting from smaller sample volumes and the versatility of microscope-based measurements.

These results establish DDM as a robust and broadly applicable tool for characterizing non-ideal colloidal suspensions, particularly in regimes where conventional light scattering becomes difficult or impossible.

Keywords:

Multiple Scattering

Nanoemulsions

Differential Dynamic Microscopy

References:

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