How Magnetically Induced Convection Reshapes DLS Signals

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Dynamic light scattering (DLS) is straightforward to interpret when particle motion is purely diffusive, or when a single linear drift adds the familiar oscillatory signature to the correlation function. Here we show that weak-gradient magnetophoresis can quickly drive the system beyond this simple picture. By combining Particle Image Velocimetry (PIV) with three-dimensional DLS in dilute dispersions of superparamagnetic polystyrene particles, we resolve how magnetically induced flow changes both the particle dynamics and the meaning of the DLS signal. In the early stage after magnet placement, motion near the scattering volume remains sufficiently coherent for DLS oscillations to appear, enabling the extraction of a characteristic drift velocity. As the flow develops into a convective pattern with a narrow jet and recirculating vortices, however, the oscillations vanish even though advective effects remain strong. Particles still cross the scattering volume and contribute to decorrelation, but the local velocity field is no longer described by a single direction or magnitude. Our results identify a clear breakdown of simple drift-based DLS analysis and show that convective transport can strongly bias magnetophoretic measurements under weak field gradients.

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