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*Abstract*

# Two Orders of Magnitude Improvement in the Detection Limit of Droplet-Based Micro-Magnetofluidics with Planar Hall Effect Sensors †

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**Abstract:** The detection, manipulation, and tracking of magnetic nanoparticles is of major importance in the fields of biology, biotechnology, and biomedical applications as labels as well as in drug delivery, (bio-)detection, and tissue engineering. In this regard, the trend goes towards improvements of existing state-of-the-art methodologies in the spirit of timesaving, high-throughput analysis at ultra-low volumes. Here, microfluidics offers vast advantages to address these requirements, as it deals with the control and manipulation of liquids in confined microchannels. This conjunction of microfluidics and magnetism, namely micro-magnetofluidics, is a dynamic research field, which requires novel sensor solutions to boost the detection limit of tiny quantities of magnetized objects. We present a sensing strategy relying on planar Hall effect (PHE) sensors in droplet-based micro-magnetofluidics for the detection of a multiphase liquid flow, i.e., superparamagnetic aqueous droplets in an oil carrier phase. The high resolution of the sensor allows the detection of nanoliter-sized superparamagnetic droplets with a concentration of 0.58 mg $cm^{-3}$, even when they are only biased in a geomagnetic field. The limit of detection can be boosted another order of magnitude, reaching 0.04 mg $cm^{-3}$ (1.4 million particles in a single 100 nL droplet) when a magnetic field of 5 mT is applied to bias the droplets. With this performance, our sensing platform outperforms the state-of-the-art solutions in droplet-based micro-magnetofluidics by a factor of 100. This allows us to detect ferrofluid droplets in clinically and biologically relevant concentrations, and even in lower concentrations, without the need of externally applied magnetic fields.

**Keywords:** droplet microfluidics; planar hall effect; sensorics; contactless sensing; ferrofluids

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