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Noninvasive, multichannel nuclear magnetic resonance chemical analysis via OPM arrays in the zero- to ultralow-field regime

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We leverage an array of commercially available OPMs to perform sensitive, high throughput nuclear magnetic resonance (NMR) on multiple chemical samples simultaneously for the first time by leveraging the zero- to ultralow-field (ZULF) regime, with proof-of-principle demonstrations suggesting the feasibility of constructing a 100-OPM-channel device. This regime offers many advantages over conventional NMR methods, such as significantly relaxed magnetic field homogeneity requirements, which significantly mitigates cost. Stable operation for weeks without field drift or need for recalibration has also been achieved, along with the ability to detect analytes non-invasively through various materials, such as metal. We demonstrate significant improvements in sensitivity, namely, the ability to measure “off the shelf” samples without isotopic enrichment, with performance similar to commercial benchtop systems, addressing a critical barrier to real-world application. Lastly, ZULF NMR is a noninvasive chemical fingerprinting tool that can potentially yield precise through-bond coupling values for molecular identification when paired with ab initio calculations.

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