Rapid Single-Cell Physical Phenotyping Based on Acoustic Compression in a Microfluidic Channel and Interferometric Sensing

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The mechanical properties of living cells are closely related to their physiological state, offering potential as label-free markers to distinguish individual cell health within a population. Additionally, the cell refractive index can provide insights into subcellular physio-pathological conditions citePark. These label-free measurements, based on mechanical and optical properties, hold promise for personalized medicine citeHillger by enabling cell-based diagnosis. However, current high-resolution single-cell techniques face challenges due to their low analysis speed, requiring examination of millions of cells within an hour. A promising technique involves forced flow through a hydrodynamic constriction [3], where real-time cell deformation measurements provide sufficient diagnostic information, demonstrating potential for label-free detection of diseases such as COVID-19 [4].

Our technological implementation employs a low-finesse Fabry–Perot resonator, offering very high sensitivity and a speed potentially suitable for high-throughput analysis necessary to manage the variability of single-cell biological diversity. This approach is applied to a variety of samples, including reference polystyrene beads, algae, and yeast [5]. The results demonstrate the capability of the acoustofluidic interferometric device to detect and quantify the optomechanical properties of single cells, achieving a throughput suitable for label-free single-cell clinical analysis.

References

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