Contribution ID: **202** Type: **Oral Presentations**

Integrated Platform for Single-Cell Electrical and Optical Characterization via Dielectrophoresis and Optical Tweezers

Thursday 10 July 2025 11:00 (30 minutes)

We present a novel, integrated platform for high-resolution single-cell biophysical characterization that combines dielectrophoresis (DEP) and optical tweezers (OT) within a single, synchronized experimental setup. This dual-modality system enables simultaneous, real-time extraction of both electrical and optical properties from individual, living cells in suspension—without the need for external calibration beads, fluorescent labels, or cell adhesion to surfaces. By integrating DEP and OT, we overcome the limitations of traditional bulk DEP approaches, which average responses across heterogeneous populations and obscure cell-to-cell variability. Our method provides clean, interpretable DEP spectra from single cells, allowing direct and quantitative computation of intrinsic electrical parameters such as membrane conductivity, membrane permittivity, and cytoplasmic conductivity.

The platform is specifically designed to accommodate optically and structurally complex cell types that challenge conventional spherical models used in DEP calibration. It supports repeated measurements on the same cell over time, enabling longitudinal studies of cellular responses to external stimuli, such as drug exposure or environmental changes

The method was validated by comparing DEP spectra obtained through the presented method with DEP spectra obtained on cell populations already validated methods. Moreover, OT stiffness measured by our method was validated by classical drag force measurements. All measurements were done on murine fibroblast cells NIH 3T3.

Importantly, our system is complemented by a suite of custom-built, open-source software tools for automated image-based cell tracking, real-time data acquisition, and finite element modeling of electric fields. It is compatible with a range of electrode geometries, offering flexibility in experimental design and integration with microfluidic platforms. Together, these features make the system broadly adaptable and scalable for diverse research applications.

To our knowledge, this is the first DEP-based technique capable of extracting such dielectric properties from live, non-adherent cells at single-cell resolution. Simultaneously, optical trap stiffness is measured dynamically, offering insight into optical properties (i.e., refractive index of the cell).

Overall, this platform represents a significant advancement in label-free, non-destructive single-cell analysis. By bridging electrical and optical profiling in a single assay, it opens new opportunities for basic research in cell biophysics, high-content screening, and the development of diagnostic and therapeutic technologies.

Primary author: SAVOPOL, Tudor (Biophysics and Cellular Biotechnology Department, Excellence Center for Research in Biophysics and Cellular Biotechnology, Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, 8 Eroii Sanitari Blvd., Bucharest, 050474, Romania)

Co-authors: GHERGHINOIU, Florela (Biophysics and Cellular Biotechnology Department, Excellence Center for Research in Biophysics and Cellular Biotechnology, Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, 8 Eroii Sanitari Blvd., Bucharest, 050474, Romania); TIVIG, Ioan (Biophysics and Cellular Biotechnology Department, Excellence Center for Research in Biophysics and Cellular Biotechnology, Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, 8 Eroii Sanitari Blvd., Bucharest, 050474, Romania); MOISESCU, Mihaela G. (Biophysics and Cellular Biotechnology Department, Excellence Center for Research in Biophysics and Cellular Biotechnology, Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, 8 Eroii Sanitari Blvd., Bucharest, 050474, Romania)

Presenter: SAVOPOL, Tudor (Biophysics and Cellular Biotechnology Department, Excellence Center for Research in Biophysics and Cellular Biotechnology, Faculty of Medicine, University of Medicine and Pharmacy Carol Davila, 8 Eroii Sanitari Blvd., Bucharest, 050474, Romania)

Session Classification: Biophysics, Life Sciences, Medical Physics

Track Classification: S02 –Biophysics, Life Sciences, Medical Physics