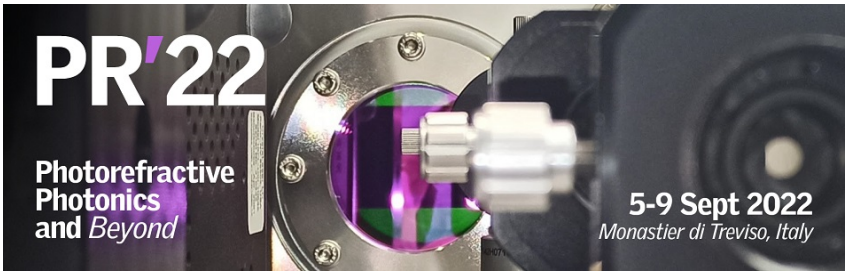

Contribution ID: **27** Type: **Poster**

Real-time manipulation of microparticles in aqueous media by photovoltaic optoelectronic tweezers operating at high light intensities

Thursday, 8 September 2022 16:40 (1h 30m)

Photovoltaic optoelectronic tweezers (PVOT) have emerged as a powerful tool for the manipulation of a wide variety of micro/nano-objects (particles, liquid droplets, bubbles or biological material) based on the electric fields induced by the bulk photovoltaic effect, often using LiNbO3:Fe crystals. Nevertheless, the manipulation of such objects in aqueous media has remained mostly elusive so far, due to the fast screening of electrostatic fields in water. Even in the case of ultrapure Milli-Q water, with a resistivity of 18 MΩ·cm at room temperature, the photovoltaic electric fields are screened in around ~100 μs, thus hindering the proper functioning of PVOT. However, water is ubiquitous in biological environments, where it plays a vital role. Therefore, the successful operation of PVOT in water is of remarkable interest for potential applications in biotechnology or biomedicine, among others. In this work, we show that it is feasible to employ PVOT in distilled water by using simultaneous light excitation with high intensities (around ~1 kW/cm2). At such intensities, the screening time of water is not negligible compared with the photovoltaic buildup time, allowing for the generation of an evanescent electric field. (which persists as long as light excitation is maintained). When light is switched off, the evanescent field rapidly fades away, allowing us to carry out dynamic real-time manipulation, very constrained in nonpolar liquids due to the long lifetime of the electric fields in the dark. Fruitful results with both z-cut and x-cut LiNbO3:Fe crystals have been accomplished, achieving a long-sought milestone for PVOT.

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Session Classification: Poster session - in presence

Track Classification: Novel applications of light-driven charge transport: optofluidics, photovoltaics, photocatalysis