LEVERAGING ORBITAL ANGULAR MOMENTUM FOR GLUCOSE SENSING IN TISSUE-LIKE SCATTERING MEDIUM

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While the spin angular momentum of light has been extensively utilized for a number of years in material and life sciences for a multitude of fundamental studies and emerging applications [1], the practical use of shaped light carrying Orbital Angular Momentum (OAM) has only recently emerged as a practical technique [2]. This new laser-based technological approach presents exciting possibilities for advanced sensing and imaging, potentially offering a new type of optical contrast. We introduce the application of Laguerre-Gaussian (LG) beams with OAM to non-invasive sensing of glucose in a turbid tissue-like scattering medium. The concept of experimental studies is based on the Mach-Zehnder interferometer. Gaussian beam is converted into LG beam carrying the OAM (l = ±1, ±2, etc.) using a reflection mode optical phase modulator (Holoeye, Germany). The obtained LG beam passes through the glass cuvette (inner thickness of 3.6 mm) with an attached scattering layer of predefined optical depth (*OD*) ranging from 2 to 10. The cuvette is filled with an aqueous glucose solution at a controlled temperature of 21°*C* with a glucose concentration C_{gl} = 50–150 mg/dl which corresponds to the normal physiological range of glucose concentration in humans [3]. The phase twist of the transmitted LG beam is observed with CMOS camera (Thorlabs, USA) as the interference with the expanded Gaussian beam representing a reference plain wave.

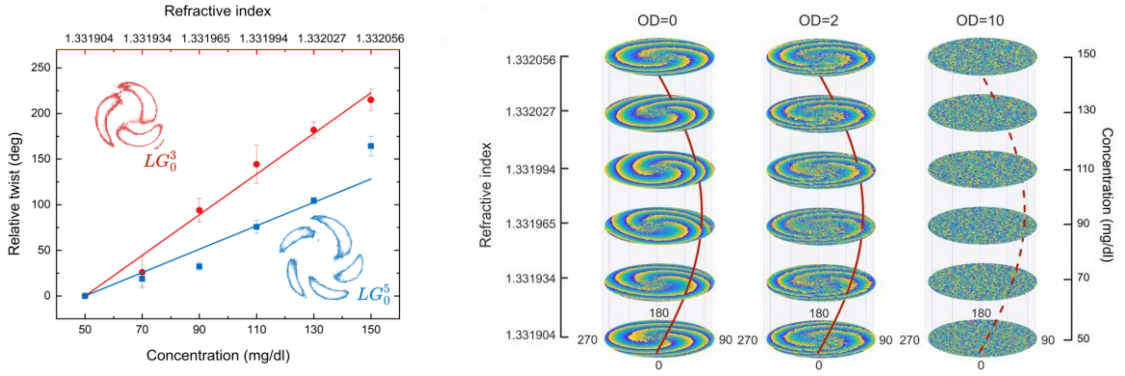

Fig.1. Experimentally recorded relative twist of the OAM-based interference pattern (left) and the OAM phase (right) caused by the consecutive increase of the glucose concentration for different OD of the probed medium.

The experiments clearly show that the light with OAM is highly sensitive to the subtle (up to ~ 10^{-6}) changes in the sample medium refractive index. Notable twist of OAM-based interference pattern, corresponding to the change in the 6th digit of the refractive index of the sample, is observed. OAM twist for LG beams with lower topological charge (l = 3) shows a higher prediction capacity to assess minor changes of the refractive index (see Fig.1, left) compared to the LG beams with higher topological charges (i.e. l = 5 and other). Azimuthal phase twist on OAM due to an increase of glucose concentration can be traced up to multiple scattering (*OD* = 10) when the diffuse regime of light scattering is totally realized. The obtained results demonstrate a high potential for immediate utilization of OAM in the sensing of glucose in biological tissues, surpassing the standard limitations in terms of sensitivity.

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