NON-INVASIVE GLUCOSE MONITORING USING ORBITAL ANGULAR MOMENTUM PHASE MEMORY

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This study presents a novel approach for non-invasive glucose monitoring using Laguerre–Gaussian (LG) beams carrying orbital angular momentum (OAM). We demonstrate that OAM beams preserve their helical phase structure even when propagating through turbid tissue-like highly scattering medium [1,2] and *ex vivo* porcine skin. Using off-axis holographic phase retrieval within a Mach–Zehnder interferometer, we detect azimuthal OAM phase shifts corresponding to physiologically relevant low glucose concentrations, including those characteristic of earlier pre-diabetic stages.

A clear linear correlation between glucose concentration and phase twist is observed (Fig.1), even at minimal – pre-diabetic levels, with asymmetric sensitivity for opposite OAM states ($\ell = \pm 3$). The helical phase structure of the LG beam undergoes measurable azimuthal shifts in response to small refractive index changes induced by glucose, and these OAM phase signatures remain robust under strong multiple scattering conditions, such as in water Intralipid solutions and layered biological tissues.

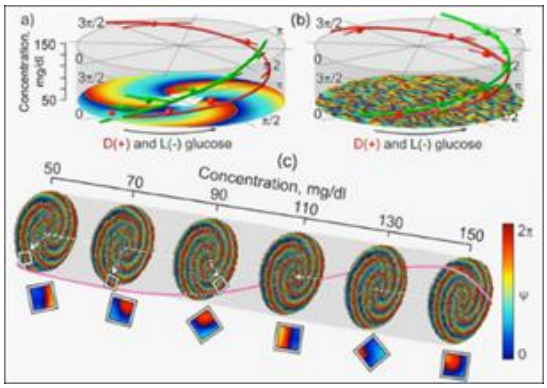

Fig.1: Results showing (a) azimuthal OAM phase twist in solutions of D+ and L- glucose at varying concentrations in a range 50-150 *mg/dl*; (b–c) propagation of OAM light through a turbid, tissue-like scattering medium (porcine skin *ex vivo*) with similar range of glucose concentrations.

The demonstrated sensitivity to refractive index changes, combined with the asymmetric OAM response, enhances diagnostic specificity. This work establishes the feasibility of OAM-based optical systems for real-time, non-contact, label-free glucose sensing and paves the way for broader applications in deep-tissue imaging, optical biopsy, and phase-resolved biosensing in turbid biological environments.

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