Short communication

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Perspectives of Orbital Angular Momentum of light in functional diagnosis of water and water organisms

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ABSTRACT. While using the polarization or spin angular momentum (SAM) of light in various biomedical applications has already known for years, the interaction of vector laser beams with Orbital Angular Momentum (OAM) with biotissues and cells has not yet been explored, and has been added to the potential practical toolkit only recently. The results of recent studies clearly show that 'simple' light (i.e. linearly and/or circularly polarized) is able to distinguish the successive grades of cancer and dementia, whereas the laser beams with OAM have a potential to be so specific that it could revolutionize the current practices of tissues characterization, providing sensitivity beyond the standard quantum limitation. Our feasibility studies well agreed with this prediction and suggest that OAM-based diagnostics is able to provide an opportunity to detect constructive disorders in water, cells and water organisms with a breakthrough sensitivity.

Keywords: polarization, vector laser beams, Orbital Angular Momentum, water organisms

Coherence and polarization are the fundamental properties of light that have been attracting great attention due to an extensive use of lasers in various practical applications from space (by NASA) to modern biology and medicine (Wave scattering…, 2003; Mischenko et al., 2006; Tuchin, 2016). Arguably, the polarization is one of light's most salient features, even more so than its spectral or coherence properties (Collett, 2005; Goldstein, 2007). When light interacts with the matter its state of polarization is changed. The state of polarization of 'simple' linearly, elliptically or circularly polarized light has long (since 1800s) been used to characterize material surfaces, thin films and transparent media. In fact, the structure of light can be 'complex' (Molina-Terriza et al., 2007), i.e. in addition to the conventional state of polarizations the light beams can be radially or azimuthally polarized and carry orbital angular momentum. The light with orbital momentum, or twisted light, plays an emerging role in both classical and quantum science, and offers fascinating opportunities for exploring new fundamental ideas, as well as for being used as a tool for practical applications. The angular momentum of light contains a spin contribution, dictated by the polarization of the electromagnetic fields, and an orbital contribution, related to their spatial structure (Molina-Terriza et al., 2007). While the spin angular momentum has been extensively employed in quantum information studies for years, only recently the orbital angular momentum has been added to the practical toolkit (Forbes, 2020). Nevertheless, the potential of twisted light for biological and medical applications is far from being fully explored, in particular as the exact conditions and parameters for reliably recognizing disease onset are yet to be investigated in most cases. In presentation we discuss (i) how the spin-orbit interaction leads to the mutual influence of the polarization and the trajectory of the vector light beams propagated in turbid biological scattering media, and (ii) how sensitive the vector light beams to subtle alterations in the medium morphology. The propagation of complex vector laser beams and twisted light in turbid biological scattering media is considered in comparison to conventional Gaussian beams. We demonstrate that contrast of visibility becomes at least twice higher by applying complex vector laser in comparison to the conventional tissue polarimetry approach utilizing Gaussian beams (Doronin et al., 2019). We also show that when the twisted laser light propagates through normal and abnormal biological tissues the orbital angular momentum is preserved with the noticeably different phase shift. Both experimental and theoretical results suggest that there is a high potential in application of structured light beams in tissue diagnosis. Thus, an overall aim of the presentation is to highlight the potential applicability of vector light beams for current practice of non-invasive diagnosis of water and water organisms.

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