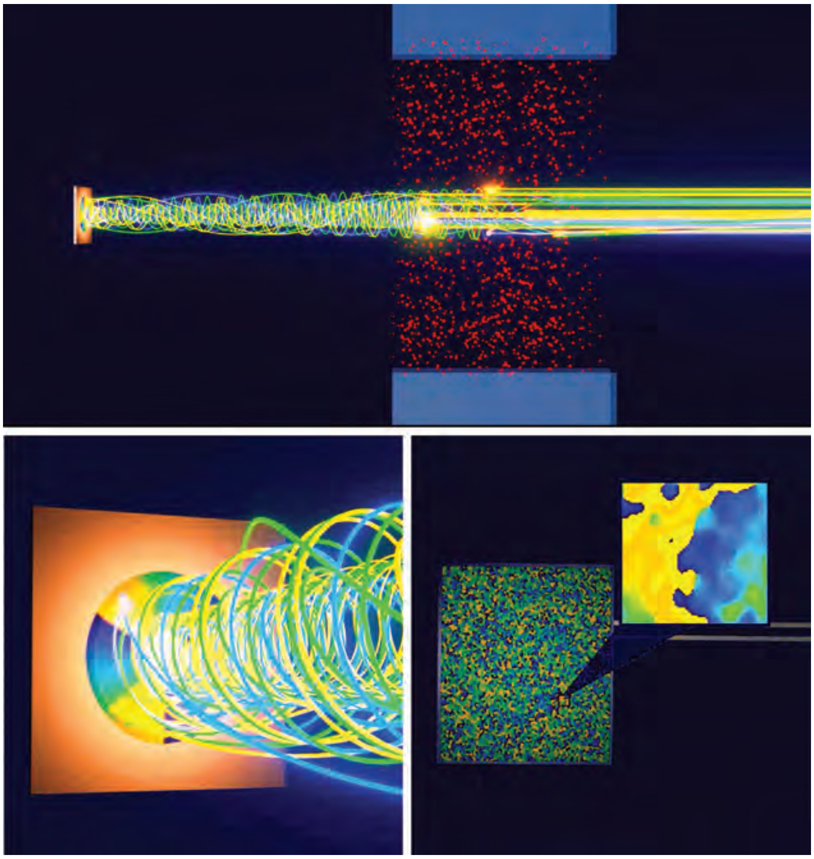
Orbital Angular Momentum of Light in Scattering Medium

Complex sculpted light plays a critical role in advancing the field of photonics, due to its unique ability to carry orbital angular momentum (OAM) and encode information within the phase structure of light.[1] The study of OAM light interactions with various media is crucial, as it potentially enables new possibilities in high-resolution imaging, secure communications and precise sensing technologies. However, conventional sensing and imaging techniques often face challenges when dealing with complex, scattering environments where light's phase and intensity can be significantly distorted. Additionally, existing methods struggle with maintaining optical signal integrity over long distances and accurately detecting subtle changes in heterogeneous media.

In our study, we examined the propagation of OAM light through a medium with a refractive index gradient and observed that the OAM experiences a twist during propagation.[2] This behavior underscores the exceptional sensitivity of OAM light to detecting subtle variations in the refractive index (up to 10^{-6}). Furthermore, we investigated the propagation of OAM light in multiple scattering environments and demonstrated that OAM can preserve its phase integrity even under significant scattering conditions.[2,3] We found that the initial OAM phase is consistently preserved during propagation through highly scattering media, and it can be distinctly observed within the resulting speckle patterns. This finding suggests that, by modulating the initial phase of OAM light, it is possible to transfer information through turbid, scattering media with high efficiency. Through a series of controlled experiments and comprehensive modeling studies, we validated these findings, confirming that OAM-based techniques offer robust and reliable diagnostic capabilities.

We believe that the presented approach holds the potential to revolutionize a range of fields, from secure optical communications systems capable of transmitting data through complex environments, to advanced biomedical imaging and diagnostics, including precise, noninvasive transcutaneous probing of glucose in blood. This research opens up exciting new avenues for both the scientific and medical communities, offering innovative solutions to some of the most challenging problems in optics today. OPN



Schematic illustration of the phase preservation of orbital angular momentum of light within multiple scattering environments.

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REFERENCES

1. Y. Shen et al. Light Sci. Appl. **8**, 90 (2019).
2. I. Meglinski et al. Light Sci. Appl. **13**, 214 (2024).
3. F. Khanom et al. Sci. Rep. **14**, 20662 (2024).