Amplyfing Fluorescence Light Through Multiple Scattering

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Fluorescence is extensively studied and applied due to its spectral distribution properties and versatility, particularly in the life sciences. With advancements in fluorescence-based techniques and a variety of fluorescent probes, it has become a crucial tool in chemistry for molecular analysis and in biology for detecting and imaging specific targets. However, while substantial maturity has been reached in chemical optimization and detection techniques (such as detector and camera sensitivity, noise suppression, *etc.*), significant progress is now expected from a largely untapped area: the physical and optical engineering of amplification techniques. Current research focuses on amplification mechanisms like nanoparticle plasmonic resonances to enhance signal levels and overcome intrinsic background noise, including spurious light and autofluorescence.

In this study, we explore a different amplification path through the stimulated emission of fluorescence light. Instead of conventional mirrors used in laser physics [1], we employ random scattering as a feedback mechanism [2]. This approach uses random scattering of dielectric nanoparticles to create a broadband, geometry-independent, and flexible feedback scheme, enabling the amplification of fluorescence signals by partially trapping radiation within the sample volume. We experimentally demonstrate amplification up to a factor of 40 in ultrapure water with dispersed TiO_2 nanoparticles (30 to 50 nm in diameter) and fluorescein dye at a 200 μmol concentration, using 5 ns long, 3 mJ laser pulses at 490 nm. Our measurements also indicate a measurable reduction in linewidth at the emission peak, suggesting that feedback-induced stimulated emission significantly contributes to the observed large gain [3].

References

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