Gouy phase-matched angular and radial mode conversion in four-wave mixing

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We investigate the conversion between transverse mode structures in four-wave mixing (FWM) in a heated rubidium vapour. While angular momentum conservation in this nonlinear process dictates the selection rules for the angular quantum number, the role of the radial quantum number is more esoteric. We demonstrate experimentally that a clean Laguerre-Gauss mode $\mathrm{LG}_p^\ell = \mathrm{LG}_1^0$ can be generated by converting LG_0^1 and LG_0^{-1} near-infrared pump beams – but only if the length of the atomic medium exceeds the Rayleigh range. In the same regime we also observe a direct transfer of the total radial quantum number from input to generated light modes [1].

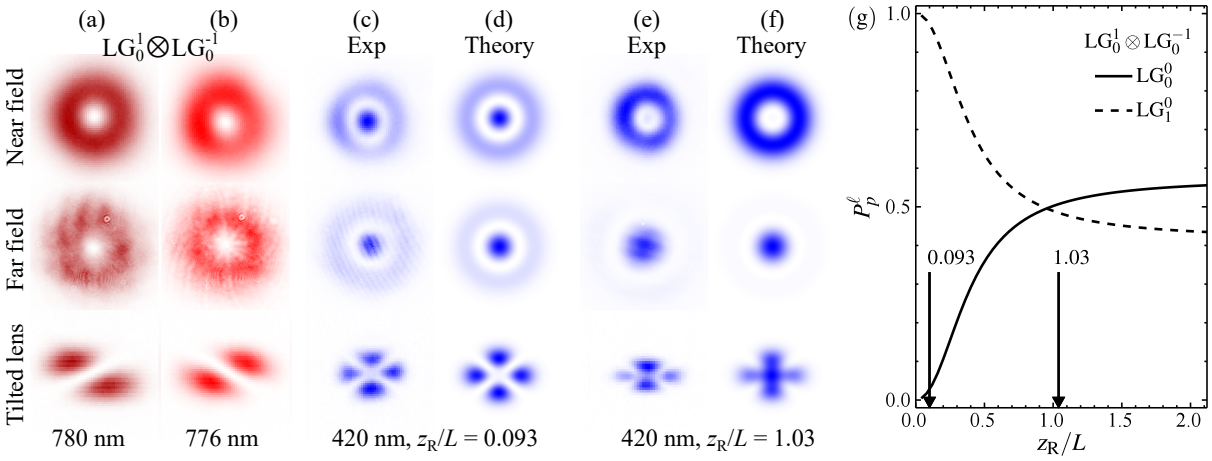

Figure 1: FWM for pump modes with opposite ℓ: LG_0^1 at 780 nm (a) and LG_0^{-1} at 776 nm (b). For a thick medium, we observe 420 nm light in an almost pure LG_1^0 mode (c), in agreement with our model (d). For a thin medium the experimental (e) and predicted (f) light is a coherent superposition of LG_0^0 and LG_1^0. Each image triplet in (a)-(f) corresponds to the near-field (top) far-field (middle) and tilted lens (bottom) beam intensity. In (g) we simulate the impact of the medium thickness on the mode purity of the generated light, with $\mathrm{LG}_0^1 \otimes \mathrm{LG}_1^{-1}$ input.

References

[1] Rachel F. Offer, Andrew Daffurn, Erling Riis, Paul F. Griffin, Aidan S. Arnold, and Sonja Franke-Arnold. *Gouy phase-matched angular and radial mode conversion in four-wave mixing*. 2020. arXiv: `2007.14125 [physics.atom-ph]`.