Maximal Free-Space Concentration of Light

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Abstract: We derive upper bounds to free-space light concentration, mapping out the limits to maximum intensity for any spot size and optical beam-shaping device. For sub-diffraction-limited optical beams, our bounds suggest the possibility for orders-of-magnitude intensity enhancements compared to existing demonstrations, and we use inverse design to discover metasurfaces operating near these new limits. Our bounds require no assumptions about symmetry, scalar waves, or weak scattering, instead relying primarily on the transformation of a quadratic program via orthogonal-projection methods. The bounds and inverse-designed structures presented here can be useful for applications from imaging to 3D printing.