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Hilbert's Hotel paradox Using structured light

This work explores the Hilbert's Hotel paradox, a thought experiment illustrating the counter-intuitive nature of infinity, and its modern optical analogy. Historically, infinity was a vague concept until Georg Cantor provided a mathematical foundation. The paradox describes an infinitely occupied hotel that can always accommodate new guests by shifting existing ones. Recent research has uncovered a direct optical parallel through wavefield singularities. We advance this by experimentally demonstrating Hilbert's Hotel using both phase and polarization singularities in "fractional" order optical vortex beams. Utilizing a multi-ramped spiral-phase-plate and a supercontinuum source, we generate and control these beams to implement Hilbert's Hotel in scalar and vector fields, revealing complex transitions. This generic scheme highlights the power of structured beams in visualizing abstract mathematical concepts and their significance in fundamental and applied optical research.

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