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Building Laughlin pairs with light

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Can strongly correlated materials be formed from light? Ordinary photons, which freely propagate at the speed of light and do not interact with each other at all, cannot form such materials. However, I will explain how we turn photons into strongly-interacting cavity Rydberg polaritons, quasiparticles which inherit their spatial waveforms from the modes of an optical cavity and gain strong interactions from Rydberg excitations of an atomic gas. These polaritons can indeed form quantum materials. In fact, using this platform we have recently induced the formation of photon pairs in the Laughlin state, the paradigmatic example of a topologically ordered state which underlies the fractional quantum Hall effect in electron gases. We characterize these entangled photon pairs by measuring correlations in both real space and angular momentum space, exemplifying the unique and powerful new perspective that many-body quantum optical systems can provide for understanding quantum matter.