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Hyperentanglement-assisted dense coding: Beating the channel-capacity "limit" JULIO T. BARREIRO, TZU-CHIEH WEI, PAUL G. KWIAT, University of Illinois at Urbana-Champaign — Dense coding was the very first quantum information protocol to be proposed and experimentally realized more than a decade ago. Today, however, the achieved channel capacity (CC) remains fundamentally limited as conceived for photons using linear optics: Alice can only decode three of four potential messages sent by Bob, due to the impossibility to deterministically resolve all four Bell states using conventional techniques; the maximum CC is thus limited to $\log_2 3 \approx 1.585$ bits. However, when the particles encoding the Bell pair are entangled in an additional degree of freedom, the complete and deterministic discrimination of all Bell states is possible. Via the process of spontanteous parametric down conversion, we produce photon pairs simultaneously entangled in polarization and orbital angular momentum. Using the auxiliary entanglement and a robust intermode coupling scheme, our experiment achieves CC=1.624(7) bits, the first to surpass the CC "limit" for linear photonic superdense coding. Our encoding is suited for quantum communication without alignment and satellite to satellite communication. Additionally, our scheme also enables the remote preparation of single-photon highly-entangled states.

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