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Generation and detection of neutron beams with orbital angular momentum DMITRY A. PUSHIN, Institute for Quantum Computing, ROMAN A. BARANKOV, Photonics Center, Boston University, CHARLES W. CLARK, Joint Quantum Institute, MICHAEL G. HUBER, MUHAMMAD ARIF, National Institute of Standards and Technology, DAVID G. CORY, Institute for Quantum Computing — Orbital angular momentum (OAM) states of light, in which photons carry $l\hbar$ units of angular momentum along their direction of propagation, are of interest in a variety of applications.[1] The Schrödinger equation for massive particles also supports OAM solutions, and OAM states have been demonstrated with ultracold atoms and electrons. Here we report the first generation and detection of OAM states of neutrons, with l up to 7. These are made using spiral phase plates (SPP), milled out of 6061 aluminum alloy dowels with a high-resolution computer-controlled milling machine. When a SPP is placed in one arm of a Mach-Zehnder neutron interferometer, the interferogram reveals the characteristic patterns of OAM states. Addition of angular momenta is effected by concatenation of SPPs with different values of l; we have found the experimental result $1 + 2 = 3$, in reasonable agreement with theory. The advent of OAM provides an additional, quantized, degree of freedom to neutron interferometry, enlarging the qubit structure available for tests of quantum information processing and foundations of quantum physics.

[1] *Twisted Photons: Applications of Light with Orbital Angular Momentum*, ed. J. P. Torres and L. Torner (Wiley-VCH, 2011)

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