Phonons with correlated directional and orbital angular momentum degrees of freedom

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We present a formalism, based on quantum mechanics principles, that enables the calculation of elastic wave functions supported by parallel arrays of coupled one-dimensional elastic waveguides. These wave functions are expressed as tensor products of a spinor part associated with directional degrees of freedom and an orbital angular momentum (OAM) part associated with the phase of the coupled waveguides. We demonstrate that one can construct wave functions, as a superposition of these elastic waves, which cannot be written as a tensor product of a spinor part and an OAM part. These elastic wave functions are not separable in the tensor product Hilbert space tensor product of the subspaces of directional and OAM subspaces degrees of freedom. We show that the notion of nonseparability of elastic waves functions and the demonstration of the analogy between elastic wave propagation and quantum mechanics open unique opportunities in the emerging field of phononics.