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“Atomtricity” the world of matter wave circuitry for precision sensing and signal processing

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Matter wave-based sensors have demonstrated exquisite sensitivity and precision, for example, for acceleration and rotation measurements that utilize interferometry. This work takes a new look at matter waves, in particular those associated with alternating currents (AC) of interacting identical neutral particles such as rubidium atoms. The semi-classical mechanics of such waves are governed by a set of matter-wave duals to Maxwell’s equations rather than by Schrödinger’s equation. There is such a faithful analogy between the physics of electron currents and neutral particle currents, that it is meaningful to refer to the latter as the laws of atomtricity as the analog to the laws of electricity. These laws include duals to Ohm’s law, for example, connecting particle current to a “tronic” potential, the dual of voltage in electrical circuits, and Maxwell matter waves as the dual to electromagnetic waves. The analogy is useful when considering how one might design atom-based circuitry to perform measurements and carry out subsequent signal processing. There are, though, surprises lying within the laws of atomtricity, such as a particle speed that has a lower, rather than an upper bound, as is the case with the speed of light. In contrast with the more familiar matter waves of quantum mechanics Maxwell matter waves are associated with two quantum numbers –the total energy, as is the case with vacuum solutions to Schrödinger’s equation, and the oscillation energy, associated with the time-variation of the current. Importantly, the temporal coherence imbedded in Maxwell matter waves gives rise to considerably useful yet different behavior than that of the more familiar Schrödinger, or deBroglie, matter waves. For example, the transmission through potential barriers as a function of particle energy is very different for Maxwell matter waves compared to Schrödinger waves, as will be illustrated.

Author: ANDERSON, Dana

Presenter: ANDERSON, Dana

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