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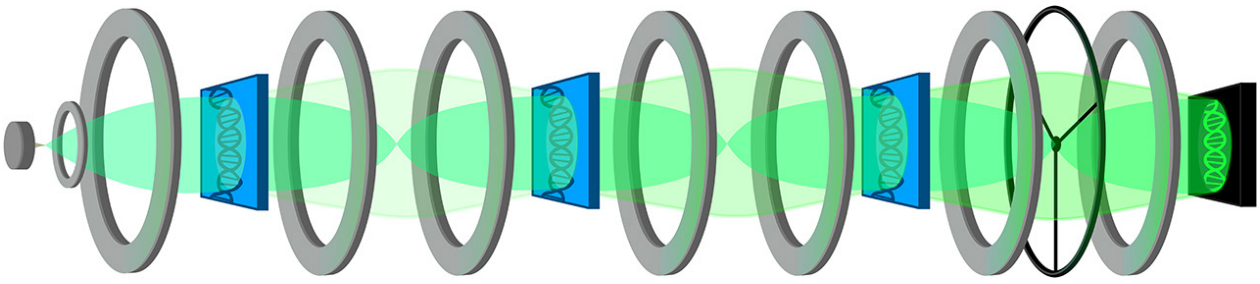
Quantum metrology partners with electron microscopy to increase imaging sensitivity and reduce sample damage.



Transmission electron microscopes (TEMs), while versatile in their ability to offer atomic resolution, possess the fundamental limitation of degrading many samples with their high energy electrons. Biological molecules, polymers, and battery materials are often degraded by the electron beam of TEMs. Adapting the architecture of a TEM to increase the amount of information gathered without increasing the dose of electrons is important to avoid damaging these delicate samples. Using quantum metrology is one possible solution.

Koppell et al. investigated the partnership of electron microscopy with quantum mechanics to achieve ultimate sensitivity and low error.

“Our interpretation of electron microscopy as a quantum metrology protocol allows us to compare various microscope schemes to the ultimate limit for information per dose,” said Koppell.

The researchers concluded that the laws of quantum mechanics enable quantum electron microscopes to gather at least ten times more information per dose than traditional TEMs. Optimal dose-limited electron microscope measurements can be achieved by passing each electron through the sample multiple times—a process called multi-pass microscopy.

A prototype multi-pass TEM is currently being fabricated to operate at lower energies. This instrument will be used to test the performance of new electron-optical components.

“Developing new electron microscopes is far more difficult than developing new optical microscopes,” said Koppell. “As a result, radical adjustments to standard TEM technology need to be very well motivated. Our work helps to identify which new electron optics need to be developed to bring TEM to the quantum limit.”

Source: “Transmission electron microscopy at the quantum limit,” by Stewart A. Koppell, Yonatan Israel, Adam J. Bowman, Brannon B. Klopfer, and M. A. Kasavich, *Applied Physics Letters* (2022). The article can be accessed at https://doi.org/10.1063/5.0086148.