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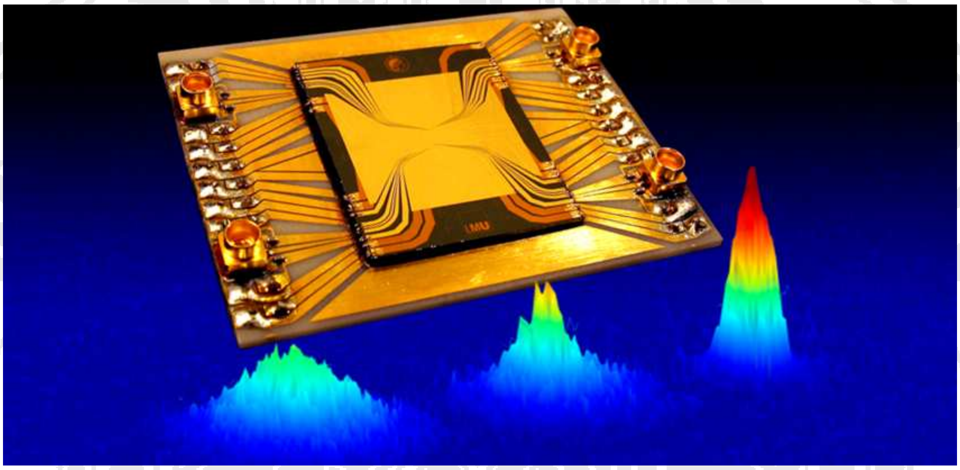
IM GROßEN HÖRSAAL



QUANTUM METROLOGY WITH A SCANNING PROBE ATOM INTERFEROMETER

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Atom interferometers are extremely precise measurement devices for quantities such as time, inertial forces, and electromagnetic fields. When operated with an ensemble of uncorrelated (non-entangled) particles, interferometers are fundamentally limited by shot noise, giving rise to the standard quantum limit (SQL) of interferometric measurement. State-of-the-art devices operate at this limit. Recent proof-of-principle experiments have shown that the SQL can be overcome using many-particle entangled states in the interferometer. Such quantum metrology can potentially lead to significant improvements in interferometer sensitivity. At the same time, it provides new insights into the elusive nature of many-particle entanglement.

I will discuss the physics behind the standard quantum limit and how it can be overcome using entangled states. In a recent experiment, we have realized an atom interferometer operating with an uncertainty of 4.0~dB below the SQL. Our interferometer employs entangled atoms in a spin-squeezed Bose-Einstein condensate and maintains performance below the SQL for Ramsey interrogation times up to 20 ms. Quantum-state tomography is used to characterize the interferometer input state, revealing a depth of entanglement of more than 40 particles. Using an atom chip, we spatially scan the atoms over tens of micrometers while maintaining sub-SQL operation. We use this scanning capability to perform a spatially resolved measurement of microwave fields from an integrated circuit. These techniques are promising for high-resolution imaging of electromagnetic fields near solid-state microstructures.

References:

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