A sensitive electrometer based on a Rydberg atom in a Schrödinger-cat state

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Reference:
Nature 535, 262–265 (14 July 2016) doi:10.1038/nature18327

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http://www.nature.com/nature/journal/v535/n7611/abs/nature18327.html [2]

Fundamental quantum fluctuations caused by the Heisenberg principle limit measurement precision. If the uncertainty is distributed equally between conjugate variables of the meter system, the measurement precision cannot exceed the standard quantum limit. When the meter is a large angular momentum, going beyond the standard quantum limit requires non-classical states such as squeezed states or Schrödinger-cat-like states. However, the metrological use of the latter has been so far restricted to meters with a relatively small total angular momentum because the experimental preparation of these non-classical states is very challenging. Here we report a measurement of an electric field based on an electrometer consisting of a large angular momentum (quantum number $J \approx 25$) carried by a single atom in a high-energy Rydberg state. We show that the fundamental Heisenberg limit can be approached when the Rydberg atom undergoes a non-classical evolution through Schrödinger-cat states. Using this method, we reach a single-shot sensitivity of 1.2 millivolts per centimetre for a 100-nanosecond interaction time, corresponding to 30 microvolts per centimetre per square root hertz at our 3 kilohertz repetition rate. This highly sensitive, non-invasive space- and time-resolved field measurement extends the realm of electrometric techniques and could have important practical applications: detection of individual electrons in mesoscopic devices at a distance of about 100 micrometres with a megahertz bandwidth is within reach.

- 41.10.+p Quantum enhanced measurements [3]
- RySQ [4]
- Quantum Metrology, Sensing and Imaging [5]
- Result [6]

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