# Paper Evaluation and Summary

**Name**: Lukas Nies
**Paper**: Odom et al. (New Measurement of Electron Magnetic Moment, 2006)

- What is the main finding of this paper and why is it important?
  Odom et al. measure the electron magnetic moment $g/2 = 1.00115965218085(76)$ with a precision of 76 parts per trillion and is therefore the most precise measurement of a physical constant. This precision is reached by resolving the lowest cyclotron and spin state of a single electron with quantum nondemolition for the very first time.

- Describe at a high level the basic technique used. Try a series of "steps" here if necessary, if there is a sequence to be followed (like a recipe).

  - Single electron is weakly trapped in Penning trap (quadrupole field) and vertical external field.
  - External magnetic field (resonant circuit) is applied along the z-axis.
  - Trap is cooled with dilution refrigerator below 100 mK to avoid excitation of the ground state by black body photons.
  - Measure at night to decrease electric and magnetic noise.
  - Measurement at $\bar{\nu}_c = 146.8$ GHz and $\bar{\nu}_c = 149.0$ GHz:
    1. Prepare spin-up ground state by turning off the SEO (self-exciting oscillator)
    2. Turn on either the $\bar{\nu}_c$ (cyclotron) or $\bar{\nu}_a$ (anomaly) drives for two seconds
    3. Then turn on amplifier and feedback for quantum nondemolition (QND) detection of either one-quantum cyclotron excitation or spin-flip
    4. Avoid saturation effect by keeping the drive strengths low
  - measure between 30 and 70 cycles depending on trap-modified cyclotron frequency

- Choose an interesting technical aspect of the experiment and describe its relation and importance to the measurement.
  Large parts of the apparatus are cooled to sub kelvin temperatures to avoid excitation of the trapped electron induced by blackbody photons. Interesting to me is the fact that the sidebands of the cavity are not operated at such a low temperature, that would increase the precision of the measurement. Note: axial motion was cooled by a resonant circuit for $0.2s$ to sub kelvin temperatures.

- Pick one systematic uncertainty issue that you find interesting and describe its importance and the author's method of addressing it.
  The researchers find an unexplained vibration of SEO and trap probably caused by inhomogeneities of the external trap or the Penning trap itself. To address this, they add an additional "line shape" uncertainty to the data.

- Where did you get lost? Was there anything you did not understand?:
  Most difficult paper so far. Many different frequencies (confusing), not totally sure if I understood the differences between all of them. What exactly is the cavity shift and why is it crucial?