Paper Evaluation and Summary

Name: Lukas Nies
Paper: Gundlach et al. (Measurement of G using Torsion Balance with Angular Acceleration Feedback: technical report in 1996 and results in 2000)

- What is the main finding of this paper and why is it important?
  Gundlach et al. measured the gravitational constant G in 2000 with a significant better precision (10^{-5}) than former experiments by using a new torsion balance method which reduces many systematic uncertainties and yields a result of $G = (6.674215 \pm 0.000092) \times 10^{-11} m^3 kg^{-1} s^{-2}$ by transferring the angular momentum induced by attractor masses to a turntable. That is an improvement of three orders of magnitude!

- 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).

  1. Torsion balance is placed on a turntable in a vacuum and shielded against magnetic and electric influences.
  2. Attractor masses are placed on a separate turntable.
  3. Pendulum turntable is slowly rotated such that balance is periodically attracted by attractor masses.
  4. To prevent torque of the pendulum a feedback loop rotates attractor turntable to equal out the gravitational acceleration of the pendulum (transfer of angular acceleration to the outer turntable).
  5. Measure this acceleration for time t while still applying the control loop.

- Choose an interesting technical aspect of the experiment and describe its relation and importance to the measurement.
  The most important aspect, which also makes this experiment that precise compared with the former experiments, is that the torsion fiber which holds the balance only experience negligible torque since the control loop transfers the angular momentum to the attractor turntable. Hence, the anelasticity of the fiber can be ignored and this lowers the systematic error significantly.

- Pick one systematic uncertainty issue that you find interesting and describe its importance and the author's method of addressing it.
  The "rotating temperature gradient coupled acceleration" (funny term) was measured by installing two rotating heaters on the turntable to measure the temperature dependence of the attractor masses. A higher temperature means a volume expansion of the spheres which affects the distance between attractor and mass.

The largest uncertainties are induced by the distance measurements and therefore these measurements were carried out with great care.

- Where did you get lost? Was there anything you did not understand?:
  I don't really understand why this setup is a 2D problem and therefore how the expansion of the angular acceleration in spherical multipole moments works.