Magnetostriction is a magnetic property of solid states that causes a change of dimensions or shape when subjected to a magnetic field. The effect was first identified in 1842 by James Joule when observing the effect of magnetic materials without applying a magnetic field. The magnetostrictive phenomena can be classified in two types. On the one hand there is spontaneous magnetostriction which causes a volume change of magnetic materials without applying a magnetic field, on the other hand there is the forced (or linear) magnetostriction, which means a length change applying a magnetic field. The forced magnetostriction is technically used in sensors or actuators. The origin of magnetostriction is either a single (on effect crystal field striction) or due to two ion effects (exchange striction) or even a band structure effect as in 3d-metals.

Measurements in high magnetic fields are required to distinguish crystal field and exchange striction. In principle magnetostriction measurements can be performed by microscopic methods (X-ray diffraction, neutron diffraction) and by macroscopic methods (strain gauges, capacitive dilatometers, extensometers, interferometry). The main advantages of capacitive dilatometers are the high sensitivity (up to 10⁻⁷) and that our set-up is nearly insensitive to magnetic fields. Therefore they can be used in high magnetic fields. We developed a capacitive dilatometer for this purpose. The dilatometer realizes a parallel plate capacitor design with longitudinal geometry [1,2].

The main goal is to analyse new materials, especially compounds containing rare earth elements, in pulsed high magnetic fields. The capacitive dilatometer will be used in the pulsed magnetic field at the AUSTROMAG at the TU Vienna, where magnetic field strengths up to 40 T with a pulse duration between 400 – 1000 ms can be generated [3].

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References:

First Test-measurement in a Static Magnetic Field

The first measurements with the dilatometer were done in a static electromagnet, which can generate a magnetic field strength of 1.5 Tesla. The magnetic field strength was measured by a hall probe. A sample of Ni (Length = 1mm) was measured in a transversal geometry, at a temperature of 298 K and a frequency of 1 kHz.

The calculation of Δl (Fig. 8) was done using the formula for a parallel plate capacitor:

\[
\frac{\Delta l}{l} = \frac{e_0 A}{l} \left( \frac{1}{C_0} - \frac{1}{C} \right)
\]

Future Prospects

- Fast data acquisition: Lock-In Amplifier, frequency: 100kHz
- Measurements in pulsed high magnetic fields: AUSTROMAG: magnetic field strength: 40T, pulse duration: 0.5 sec
- Test-measurement with a sample of MnF₂
- Analysis of materials in high magnetic fields, e.g.
  - Rare earth based systems,
  - Antiferromagnetic compounds with phase transitions in high magnetic field,
  - High spin value compounds (for example Gd-compounds, e.g.: Gd₂Ag₃)}