Magnetic Deflections in a Molecular Beam

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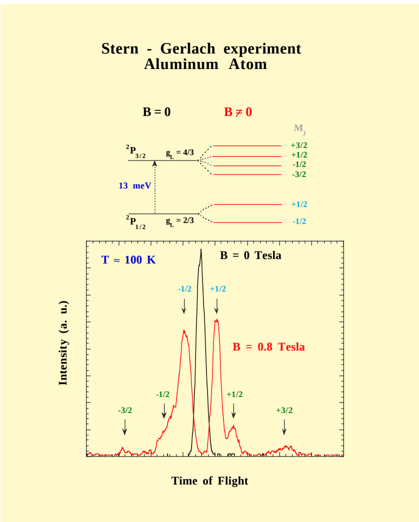
The goal in these experiments is to measure magnetic properties of free clusters. For details of the experimental Setup, please refer to the poster about the Molecular Beam Machine.

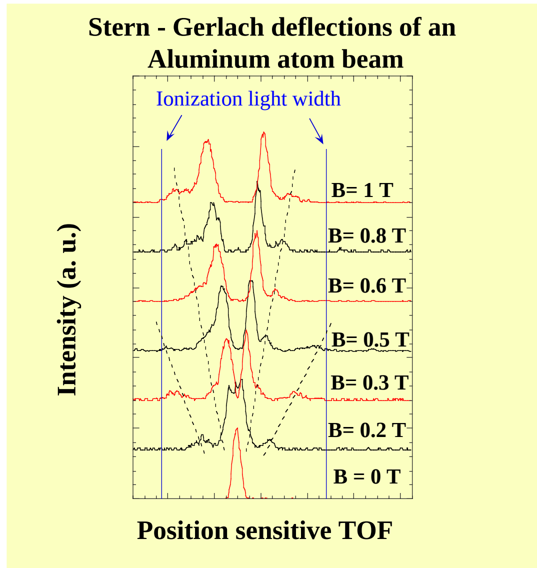
Aluminum



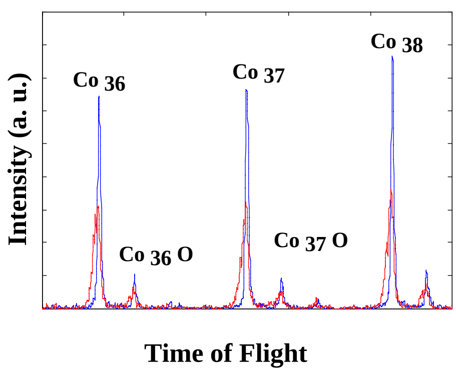
We set up the molecular beam machine to produce aluminum clusters in a laser ablation source. Working in the position sensitive mode we observe both, the mass of the species and the position in the acceleration region. We measure deflections of neutral atoms passing through a Stern-Gerlach magnet.

In its ground state the Aluminum atom has J=1/2 so it is deflected either up or down by the inhomogeneous magnetic field. The first excited state has J=3/2 and so the deflection profile is a quartet in this case. The difference between these two energy levels is 13.9 meV. Using this value and the intensity of the peaks in the profile we can calculate the population distribution according to the Boltzman factors and thus the temperature of the beam.

$$\frac{\text{Peak Intensity } (^2P_{3/2})}{\text{Peak Intensity } (^2P_{1/2})} = e^{-\Delta E/k_B T}$$



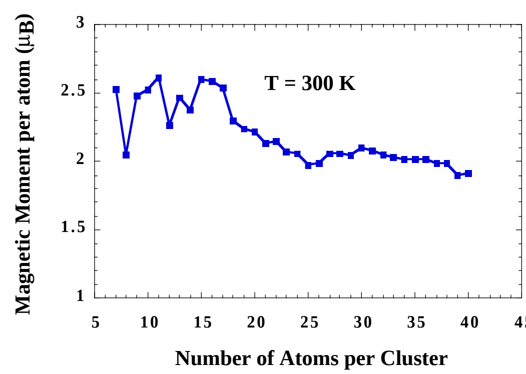
Cobalt



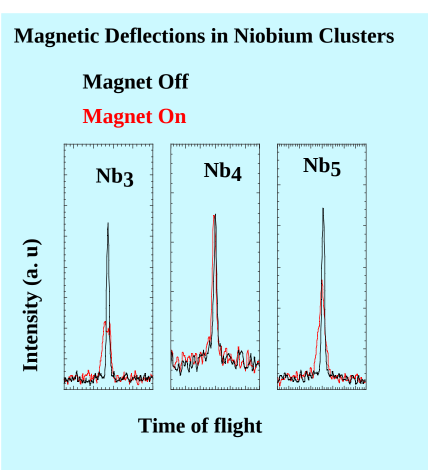
The figure on the left shows part of the spectrum obtained with Cobalt. Deflections are in one direction only, which means that the cluster experiences a spin relaxation process.

Deflections, together with speed of the beam, temperature and field intensity allow us to calculate the magnetic moment per atom.

The figure on the right summarizes these results for clusters with 6 to 40 atoms. Showing an interesting dependence on the size of the cluster.



Niobium



The figure on the left shows some peaks corresponding to clusters of Niobium. The effect of the magnetic field is a broadening of the peaks with very small deflections. This is a qualitatively different effect to the one observed in Cobalt.

What is also remarkable is that clusters with even number of atoms seem to be nonmagnetic, showing neither a deflection nor a broadening, at least for the smaller clusters in the series.

The figure on the right shows how this broadening depends on the size of the cluster. These experimental results where taken with clusters at 77 K.