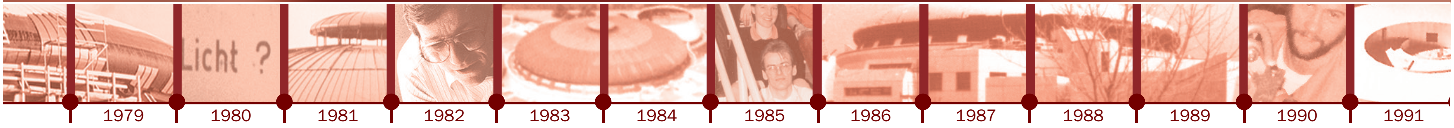

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Stripes are stars! Pt helps Fe to stay magnetised

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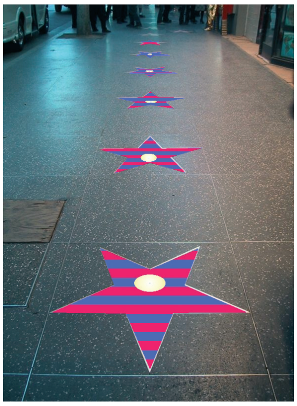

During the last decades we witnessed the miniaturisation of electronic circuits. From pocket calculators with a memory just large enough to store a few floating point values we saw a development towards palmtops with full programming capability and storage capacity for music and images. The fact that the miniaturisation still continues stimulates our interest to study the physics which will be required for their realization in many years from now. An extremely compact computer can still use miniaturised classical magnetic disks, and in addition there will be MRAMs which consist of transistors, whose logic state is controlled by a tiny ferromagnet. Magnets allow a cut of power consumption to zero stopping operations but not erasing data, a property which has since the beginning made magnetic memories very successful and remains attractive for data storage.

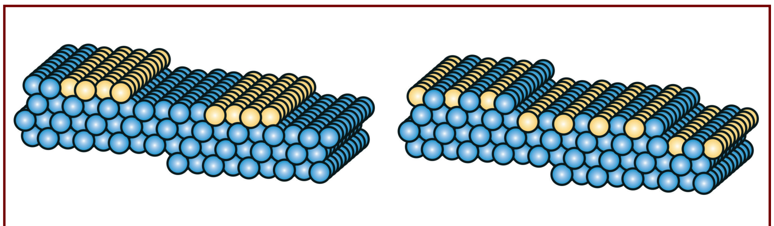

***Fig. 1:* The sphere models illustrate the different arrangement of Fe (yellow) and Pt (blue) atoms on the two samples.**

Since a few years physics has set off to study at which state of miniaturisation the limits of magnetic storage will be reached and how far new materials and structures may eventually lead. We thus become curious what the magnetic properties of clusters with a countable number of atoms would be. Much effort is put into this research and exciting results are emerging. Tiny metal particles are produced in different ways and tested for their magnetic properties. Adsorbate structures are made thinner and smaller. Preparing aggregates from single atoms [1] and using experimental methods which are still sensitive enough to measure their magnetism takes us to the limits. Smallness is, however, not the only goal. Equally important is the stability of the magnetization with respect to heat and other external factors that may lead to erasure of magnetically stored information.

One group of materials studied by industry and applied physics research groups are alloys containing two elements, one ferromagnetic, like Co and Fe and the other non-magnetic, like Pt. In fact, such alloys have favourable properties: In contrast to what one might expect, the non-magnetic Pt stabilises the magnetism of Fe or Co instead of reducing it!

We studied a PtFe alloy close to the described size limit: Depositing small amounts of Fe on a Pt surface we made an alloy layer of about equal amounts of Fe and Pt. Our earlier studies showed that we can easily produce different Fe patterns if we start with a surface in the shape of a staircase in which the height of each step is the height of one atom [2]. Depositing Fe near room temperature allows studying the magnetism of a one atom thick Fe stripe and repeating the preparation at a slightly higher temperature provides a FePt alloy which is as thin as a single atom. Fig. 1 sketches the atomic arrangements in the two cases. We employed X-ray magnetic circular dichroism (XMCD) at the beamline PM-3 to investigate the magnetic moments on the Fe atoms. The difference between Fe absorption spectra taken with reversed magnetic field (blue and black traces in Fig. 2) provides the XMCD spectra displayed at the bottom of Fig. 2.

Measuring Fe spectra for the same amount of Fe in the stripe (left) and in the alloy (right) we find that the observed magnetisation increases significantly (by a factor of 4.5) for the alloy. In the hysteresis curves (red trace in Fig. 3) we find that also the coercive field, i.e. the field required to destroy the stored magnetic information, rises to 0.6 T which is a surprisingly high value. Moreover, the magnetic moments are oriented perpendicularly to the sample surface leading to a large stray field which would facilitate 'reading' its orientation by an external magnetic head. Of course, this sample is not yet a memory for use in our computers. Our data were obtained at a temperature of 10 K and in a vacuum chamber at a pressure below 10^{-10} mbar, which is required to prevent sample contamination.

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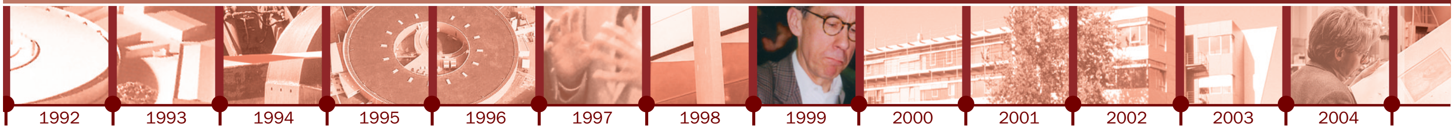

However, the results are exciting since comparable properties are obtained for PtFe alloy particles only at diameters larger than 5 nm [3], which are 'huge' structures with respect to the 0.2 nm thick alloy film.

Although we do not yet understand the detailed mechanism which improves the magnetic properties through the alloying of Fe with Pt, we were able to address the question how the Pt behaves in the alloy. We made use of the element specificity of XMCD and tuned at the PM-3 beamline from the magnetism in Fe to the magnetism in Pt. And, indeed, the Pt carries a magnetic moment proportional to the one on Fe. Comparing our XMCD spectra to published data from a CoPt bulk alloy [4] we find that the observed moments on Pt are aligned with the moments on Fe. Unfortunately, we cannot distinguish between different Pt sites and thus can only speculate that a major contribution may arise from Pt in the alloy layer and an additional part from Pt in the underlying material – probably from little more than the adjacent atomic layer. Earlier theoretical investigations of a Fe layer on Pt support such a picture but details have to wait for calculations of the exact alloy geometry.

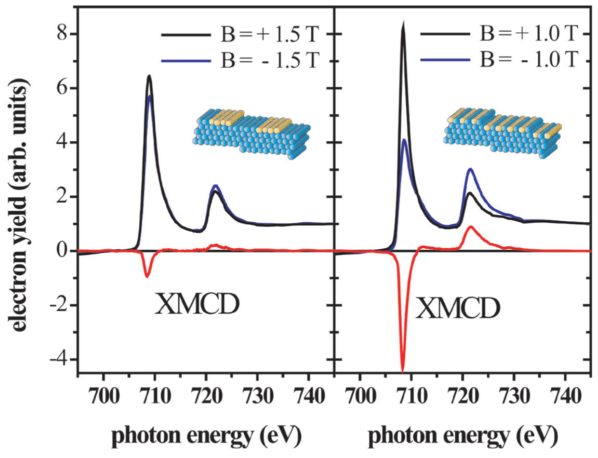

Fig. 2:
X-ray absorption spectra (top) and X-ray magnetic circular dichroic spectra (bottom) for Fe stripes (left) and for a surface alloy (right) with the same amount of Fe.

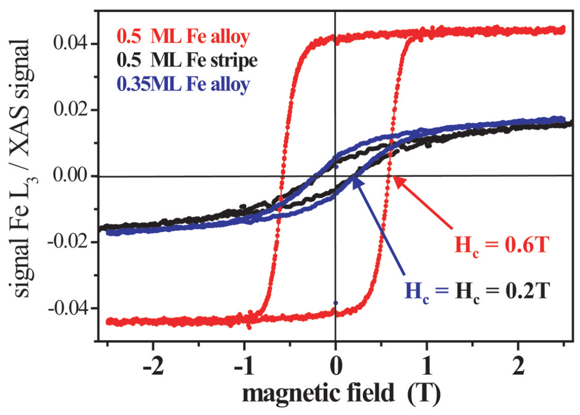

Fig. 3:
Hysteresis curves measured by XMCD on the Fe L_3 absorption edge. The red trace is measured for the alloy, the black curve for a Fe stripe at the same Fe coverage, and the blue trace for an alloy formed with a smaller amount of Fe.

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