ESRF	**Experiment title:** **Magnetism in self-organized Fe nanostuctures**	**Experiment number**: HE 558/HE 653
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Report:

In this report we summarize the main results obtained on our project on the **magnetism of self-organized nanostructures**. Until now we have considered only Fe nanostructures through the two systems Fe/Cu(111)-vicinal (HE 558) and Fe/Au(111) (HE 653). The former system forms Fe stripes by step decoration.[1,2] Below the 1D coalescence irregularly distributed islands are formed along the step, but once they coalesce we obtain Fe stripes with widths depending on the coverage. On the other hand the self-organize growth of Fe on the herringbone reconstruction of Au(111) allows the fabrication of regular arrays of Fe clusters[3]. Above ~0.3 ML where the 1D coalescence takes place wires are formed until the 2D percolation occurs (~1.8 ML).

For both systems we have performed a thickness dependent XMCD study. For each thickness the XMCD were taken at different angles in order to extract the orbital moment (m_L) in-the-plane and out-of-plane[4] and the magnetic spin moment (m_S) (without the dipolar contribution). In figure 1 and 2 we plot the variation of m_S and m_L per hole versus the Fe coverage in the case of Fe/Cu(111)-vic and Fe/Au(111) respectively. Common observations can be made for these two systems:

- Above the fcc-bcc transformation both m_S and m_L reach there usual value for the bcc phase.
- m_L shows a large increase going toward very low coverage. This behavior is understood as an increasing contribution from the edge atoms, with more atomic like behavior yielding higher m_L. In the Fe/Au(111) case the island density is bigger, i.e. smaller clusters, leading to a higher (number of edges atoms)/(total number of atoms) ratio. This explains the discrepancy with Fe/Cu(111)-vic, where for similar coverages, m_L is lower.
- Below the 1D coalescence, where the Fe assumes the shape of finite clusters, the m_S per hole is the same: ~0.45 μ_B per hole (~1.4 μ_B assuming a number of holes (N_h) equal to 3.5).

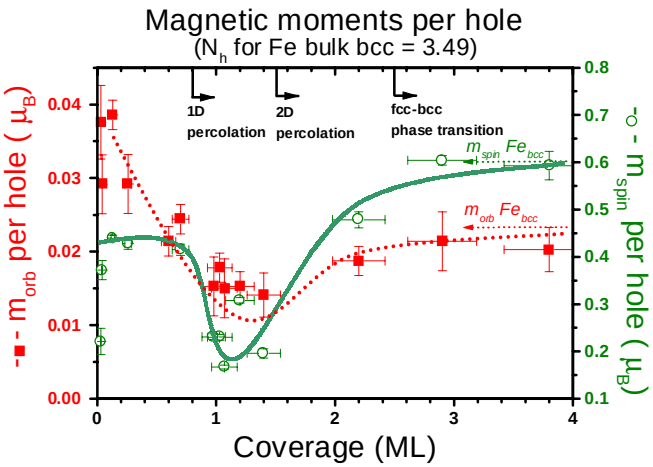

Figure 1. Magnetic spin and orbital moment per hole for **Fe/Cu(111)-vic** (N_h = 3.39 holes for bulk bcc Fe) (the lines are guide to the eye)

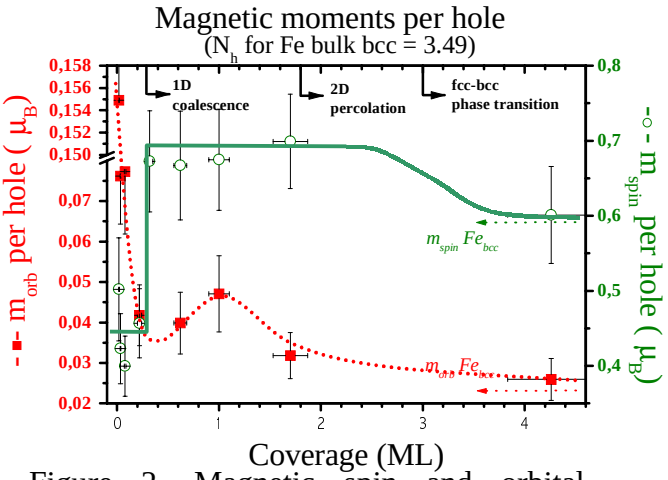

Figure 2. Magnetic spin and orbital moment per hole for **Fe/Au(111)** (N_h = 3.39 holes for bulk bcc Fe) (the lines are guide to the eye)

Actually the behavior of m_S around the 1D percolation is still difficult to understand. It is known that the magnetic properties of fcc Fe show a high sensitivity to the atomic volume.[5] Different magnetic phases are predicted with a general trend to go toward higher spin moments with increasing atomic volume. We also know that the lattice parameter of fcc Fe (a = 3.59 Å) is slightly lower that of both substrates. Consequently, if we assume a pseudomorphic growth at the early stage of the growth we can expect a structural relaxation at the 1D coalescence. This relaxation could lead to a change in the magnetic phase because of the change in the atomic volume. With this simple model we should expect higher spin moments below the 1D coalescence where the atomic volume is bigger. This explanation works for the Fe/Cu(111)-vic, but not for Fe/Au(111) where the opposite behavior is observed giving a huge increase at the coalescence.

To conclude we will say that although we have already extracted interesting information[2] giving a better understanding of the magnetic properties of the Fe nanostructures complementary experiments will be needed. One-way would be to look carefully at the possible structural relaxation in the submonolayer range and in particular at the 1D percolation. Another explanation of this common value for m_S for both systems is perhaps an intrinsic property of supported Fe clusters. In this case similar studies, but looking at Co nanostructures, should help to explain the anomaly.

References:

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