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Magnetic surface state on pure and iron-doped palladium thin films

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Elemental palladium (Pd) is a well-known paramagnetic transition metal. Doping with iron impurities leads to giant magnetic moment formation and spin glass behavior. Pd surfaces often show different behavior than bulk Pd [1,2], which is particularly relevant in research fields working with Pd nanomaterial, such as for example catalysis and spintronics.
We present depth-dependent transversal field μSR measurements with low-energy muons (1 keV-25 keV) on 100 nm Pd thin films at temperatures of 3.7-200 K and external magnetic fields of 10-330 mT. These measurements reveal a magnetic surface state both on pure elemental Pd and on iron-doped (170 ppm) Pd samples. The surface state is characterized by an increased muon field and increased muon depolarization rate at the sample surface and at the interface with the silicon substrate. The interior of all thin films shows bulk-like Pd properties, in accordance with earlier bulk-μSR measurements [3]. The surface is different from the bulk for all samples, in one case, we even found a strong indication for a paramagnetic to ferromagnetic phase transition at the surface. We argue that orbital moments induced at the surface / interface by localized spins and charges are the most likely origin of the observed surface state [4].
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