

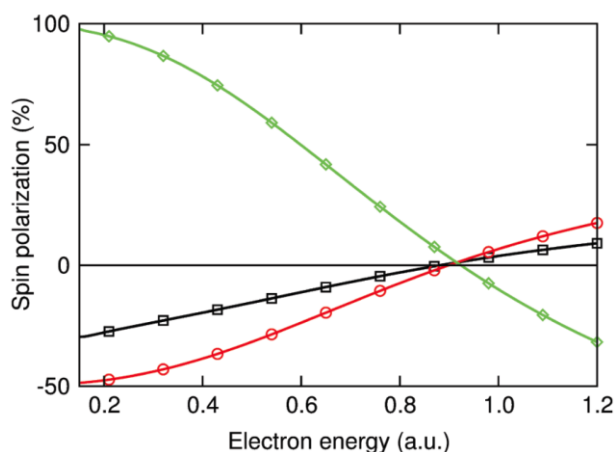
## Measurement of the spin polarization of electrons in a strong laser field

Alexander Hartung<sup>1</sup>, Alina Laucke, Maksim Kunitski and Reinhard Dörner

Institut für Kernphysik, Goethe-Universität Frankfurt am Main, Max-von-Laue-Straße 1, D-60438 Frankfurt am Main

**Synopsis** We present first experimental data on the theoretically predicted effect [1] that photoelectrons created by ionization of noble gas atoms in an intense laser field are spin polarized.

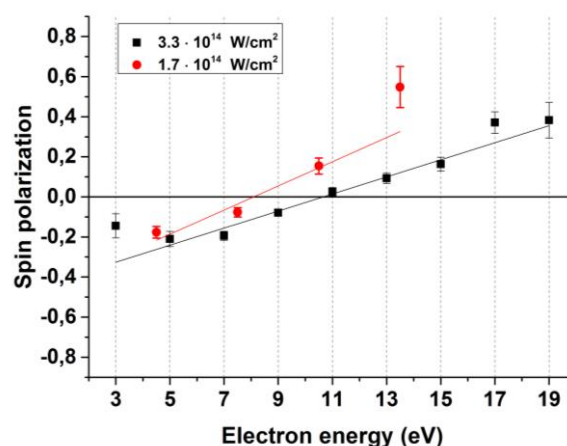
As a fundamental property of the electron the spin plays an important role in the buildup of atoms, matter and its macroscopic properties, e.g. magnetism. Hence studying effects regarding the spin is highly interesting. Even 90 years after the famous Stern-Gerlach experiment was carried out new questions concerning the spin arise consistently. In 2013 I. Barth and O. Smirnova predicted theoretically that electrons, which were created by ionization of noble gas atoms by an intense infrared laser, are spin polarized [1]. They propose two effects to be responsible for the spin polarization. First, the probability for tunnel ionization by circular light depends on the sign of the magnetic quantum number  $m_l$  of the emitted electron [2]. This effect was partly confirmed experimentally by Herath et al. [3]. Second, the tunnel ionization probability is slightly different for different electron spin states. Due to spin-orbit-interaction electrons with spin parallel to  $m$  are less bound than those with spin antiparallel. The resulting spin polarization is presented in Fig 1.



**Figure 1.** Spin polarization of photoelectrons emitted from krypton dependent on their kinetic energy. A circularly polarized 800nm laser with  $I = 1.8 \cdot 10^{14} \text{ W/cm}^2$  was used for the simulation. Green curve with diamonds resolved on the  $^2P_{1/2}$  state of the core; Red curve with circles resolved on  $^2P_{3/2}$ ; Black curve with squares integrated over core states. From [1]

Here we present first experimental data on the effect, shown in Fig. 2. We ionized Xenon with an 800nm, 40fs, circularly polarized laser at  $1.7$  and  $3.3 \cdot 10^{14} \text{ W/cm}^2$ . A Mott detector was used for the measurement of the spins. The results strongly indicate the existence of the theoretically predicted spin polarization. The measured strength of the effect as well as the dependences on the electron energy and laser intensity are in good agreement with theory.

Momentarily, further measurements with different gases and laser intensities are carried out to gain more precise comparison with theory.



**Figure 2.** Measured spin polarization of photoelectrons emitted from Xenon at two intensities.

### References

- [1] I. Barth & O. Smirnova 2013 Phys. Rev. A **88**, 013401
- [2] I. Barth & O. Smirnova 2011 Phys. Rev. A **84**, 063415
- [3] T. Herath et al 2012 Phys. Rev. Lett. **109**, 043004

<sup>1</sup> E-mail: [hartung@atom.uni-frankfurt.de](mailto:hartung@atom.uni-frankfurt.de)