Spin entanglement in elastic electron scattering from quasi-one electron atoms

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Synopsis We present results for the differential cross section and the spin exchange asymmetry in elastic electron collisions with atomic hydrogen and light alkali atoms. Such systems were recently suggested as candidates for continuously varying the degree of entanglement between the elastically scattered projectile and the valence electron. The feasibility of an experimental realization in light of the expected signals is discussed.

We extended our work on e-Li collisions [1] to investigate low-energy elastic electron collisions with atomic hydrogen and other alkali targets (Na, K, Rb). Measured in Bielefeld [2] and at NIST [3] years ago, these systems were only recently suggested for the possibility of continuously varying the degree of entanglement between the elastically scattered projectile and the valence electron [4, 5]. In order to estimate how well such a scheme may work in practice, we carried out overview calculations for energies between 0 and 10 eV and the full range of scattering angles $0^\circ - 180^\circ$.

The relative exchange asymmetry parameter is defined as

$$A_{\rm ex} = -P = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} = \frac{\sigma^s - \sigma^t}{\sigma^s + 3\,\sigma^t}, \qquad (1)$$

where $\sigma^{\uparrow\uparrow}\,(\sigma^{\uparrow\downarrow})$ and $\sigma^s\,(\sigma^t)$ denote the angle-differential cross sections (DCSs) for parallel (antiparallel) spin orientations of the projectile and target spins or singlet (triplet) scattering. The DCS for unpolarized projectile and target beams is given by

$$\sigma_u = \frac{1}{4}\sigma^s + \frac{3}{4}\sigma^t, \qquad (2)$$

and hence the limiting values for P are $+1/3$ for pure triplet and -1 for pure singlet scattering. The latter extreme case corresponds to the well-known situation of two spins forming a combined spin-0 system.

In addition to P, which characterizes the entanglement, we present the differential cross section in order to estimate whether the count rates in the most interesting energy-angle regimes are sufficient to make such experiments feasible in practice.

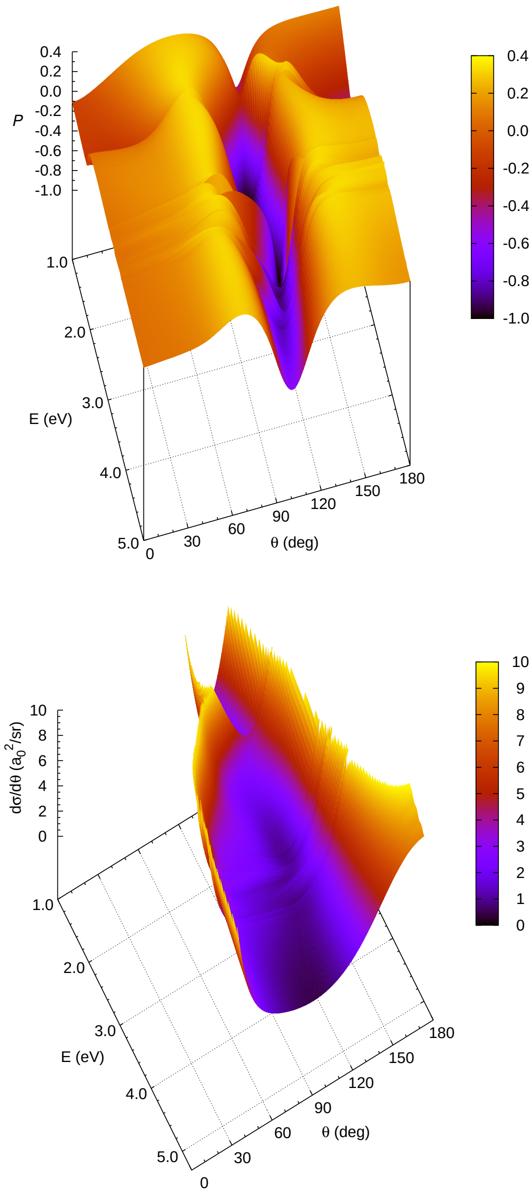

Figure 1. Spin asymmetry parameter $P = -A_{\rm ex}$ (top) and differential cross section (bottom) for elastic electron scattering from lithium atoms.

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References

[1] K. Bartschat and S. Fonseca dos Santos, arXiv:1611.06180 (2016)
[2] G. Baum *et al.*, *Phys. Rev. Lett.* **57** (1986) 1855
[3] J. J. McClelland *et al.*, *Phys. Rev. A* **46** (1992) 6079
[4] K. Blum and B. Lohmann, *Phys. Rev. Lett.* **116** (2016) 033201
[5] B. Lohmann, K. Blum, and B. Langer, *Phys. Rev. A* **94** (2016) 032331

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