Electron-Impact Ionization of Laser-Aligned Atoms – Contributions from both Natural and Unnatural-Parity States.

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Synopsis. The progress of experimental and theoretical measurements for (e,2e) ionization cross sections from laser-aligned atoms is presented here. It is found that both natural and unnatural parity contributions must be included in the models to emulate the experimental data.

In this work experimental and theoretical results will be presented for (e,2e) ionization measurements from laser-excited and aligned atoms. The experimental data are taken in Manchester, whereas theoretical results are from the groups of Don Madison in Missouri, and James Colgan at Los Alamos Labs in the USA.

The motivation for these studies arises since time-independent distorted wave (DWBA, 3DW) models predict zero flux for atoms aligned orthogonal to the scattering plane (as in fig 1,2), in disagreement with experimental data. By contrast, time-dependent close coupling (TDCC) models predict a *non-zero* cross-section under these conditions, and conclude it is the *unnatural parity* contributions to the cross section that produce this flux [1-4]. An unnatural parity state has parity $(-1)^{L+1}$, compared to a natural parity state that has parity $(-1)^{L}$.

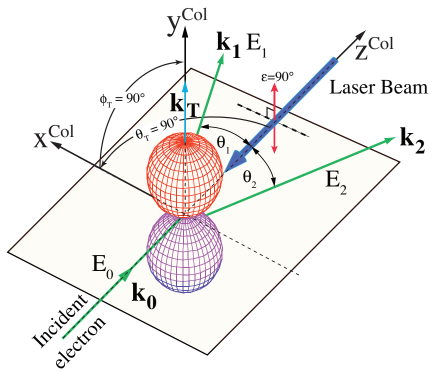

Figure 1. Ionization from atoms aligned orthogonal to the scattering plane using linearly polarized radiation at ε = 90°. DW theories predict the cross section to be identically zero in this configuration, whereas the TDCC model predicts a finite cross section, as found by experiment.

It is important in these studies that the laser-excited P-state is fully aligned (L=1, m_L=0), with minimum contribution from any orientation of the target (L=1, $m_L = \pm1$). For this reason alkali-earth atoms are chosen since they have no hyperfine structure, and so can be aligned to better than 99% accuracy. Mg, Ca and Sr are to be used in these studies, so the effects of mass can also be determined.

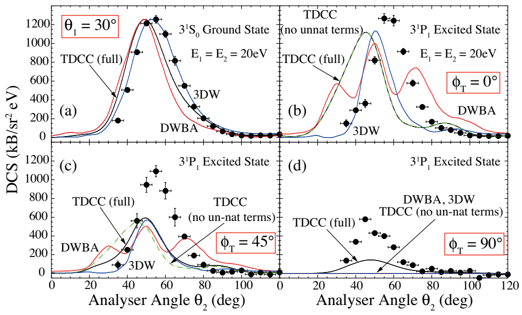

Figure 2. Comparison of experiment and theory for Mg, in the 3^1S_0 ground state and 3^1P_1 excited state at different angles ϕ_T to the plane. The data are normalized to the TDCC calculation for the 3^1S_0 state. The TDCC calculations are shown both with and without unnatural parity contributions.

The atoms are aligned using continuous wave radiation. Cross-sections will be determined for the incident electron in the scattering plane (as in fig. 1), and for out-of-plane geometries. The laser radiation will be injected into the interaction region through angles determined by theory, so that the cross-section sensitivity to different parity contributions can be explored.

The progress of this combined study will be presented here.

References

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[2] KL Nixon *et al.* 2014 *Phys Rev Lett* **112** 023202
[3] S Amami *et al.* 2014 *Phys Rev A* **90** 062707
[4] G Armstrong *et al.* 2015 *Phys Rev A* **92** 032706

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