Measurement of the Integrated Stokes Parameters for Zn 468 nm Florescence Excited by Polarized-Electron Impact

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Synopsis These measurements resolve a standing inconsistency between experiment and state-of-the-art theory for Zn atom excitation by spin-polarized electrons. Our results are consistent with theory but not previous experiments.

We have measured the integrated Stokes parameters P_1, P_2, and P_3 (shown schematically in Fig. 1) of Zn ($4^3P_0 - 5^3S_1$) 468 nm florescence resulting from transversely-spin-polarized electron impact excitation of the Zn $(4s5s)5^3S_1$ state. This work was motivated by similar studies reported several years ago by Pravica *et al*.[1], in which they measured non-zero values of the integrated Stokes parameter P_2 between the threshold for the $(4s5s)5^3S_1$ excitation and the first cascading $(4s5p)5^3P_J$ threshold.

In our experiment, the electrons scattered in the excitation process are not measured (hence the designation of the Stokes parameters as "integrated"), and the fluorescence is observed in the direction of the initial electron spin polarization. For this geometry (Fig. 1), Bartschat and Blum [2] have shown that P_2 must be identically zero, based on the symmetry properties of the 9j symbol used in the algebra required to describe the dipole fluorescence, and the assumption that the L and S angular momenta of the total wavefunction (atom plus incident electron) are factorizable throughout the scattering process. This assumption is invalid if (a) the excited state producing the fluorescence is not well LS-coupled or (b) the spin of the continuum electron precesses during the collision under the influence of a motional magnetic field, i.e., the electron undergoes Mott scattering. Since both possibilities are ruled out by state-of-the-art theory [3,4], which predicts P_2 values of order 10^{-4}, the results of reference [1], which are as large as 10^{-1}, are remarkable.

We used a standard GaAs polarized electron source to produce beams of electrons with a polarization of 0.25(1) and an energy width of *ca*. 400 meV. The atomic Zn target was produced by a Zn oven and a heated effusive channel that directed an atomic beam at right angles to both the fluorescence observation direction and the electron beam axis.

We observe optical excitation functions in agreement with those of Kontrosh *et al*. [5]. In the cascade-free range of excitation between 6.7 eV and 7.6 eV, we have measured P_2 at 7.0 eV and 7.3 eV and find its values in this range to be consistent with zero and inconsistent with those measured in [1].

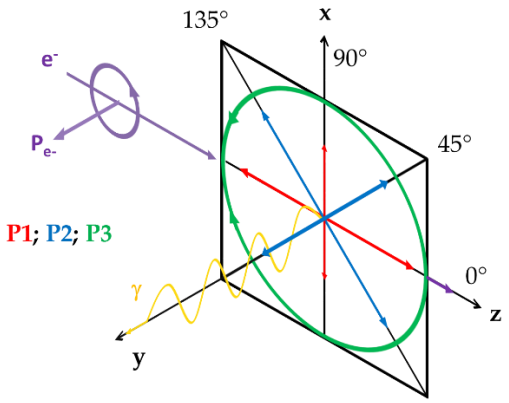

Figure 1. Geometry of integrated Stokes parameter measurements when transversely-polarized electrons, incident along $\hat{\boldsymbol{z}}$, excite atoms, and the subsequent fluorescence is observed in the $\hat{\boldsymbol{y}}$ direction.

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References

[1] L. Pravica *et al* 2011 Phys. Rev. A **83** 040701

[2] K. Bartschat and K. Blum 1982 Z. Phys. A **304** 85

[3] C. J. Bostock *et al* 2013 Comments Phys. Rev. A **87** 016701

[4] K. Bartschat and O. Zatsarinny 2013 Comments Phys. Rev. A **87** 016702

[5] E. É. Kontrosh *et al* 2001 Opt. Spectrosc. **90** 339

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