Elastic Electron Scattering by Laser-Excited Ba Atoms; Experimental and Theoretical Results

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Elastic scattering by excited ^{138}Ba (...6s6p $^1P_1$) atoms, prepared by linearly polarized laser light, was studied at 20 eV electron-impact energy (E_0) in the 10° to 20° angular (θ) range as a function of linear polarization angle (with respect to the scattering plane) for laser polar angles of 45° and 900. In addition, scattering intensity measurements were carried out involving the ($^1S_0 \rightarrow {^1P_1}$) inelastic, ($^1P_1 + {^1P_1}$) elastic and ($^1P_1 \rightarrow {^1S_0}$) superelastic channels. These measurements allowed us to subtract, from the overall elastic signal, contributions from background, from elastic scattering by ground state Ba atoms and by metastable ^{138}Ba atoms. It is also possible to normalize the resulting modulation signal, associated with elastic scattering by coherently excited (and aligned) ^{138}Ba ($^1P_1$) atoms, to obtain the modulation equations for the differential cross sections (DCS's). Considering these equations to represent "superelastic" scattering, we extracted the conventional electron-impact coherence parameters (λ, cosε) and the final-magnetic-sublevel-specific DCS's for the inverse ("inelastic") scattering process. The equations were also evaluated in terms of the "forward" process representing the "excited-to-excited" state process. The results of these evaluations were differential elastic scattering cross sections which are specific for initial magnetic sublevels and parameters (p_1 and p2) which allow us to predict the elastic DCS's for any laser geometry and polarization (or equivalently for any coherently excited and *aligned state).*

The theoretical calculations were carried out with the completely converged close-coupling (CCC) method which yielded the complex magnetic-sublevel-specific scattering amplitudes. From these amplitudes all the differential (and integral) cross sections and the various parameters were generated. In Table I selected examples of the experimental and theoretical results are shown.

The present investigation were aimed to test the CCC calculation method against experiemental data and to answer the question, raised in connection with plasma polarization spectroscopy[1] whether elastic scattering can create alignment and to what degree.

Table I. Summary of cross sections (in units of 10^{-16} cm^2) and parameters at E. = 20 eV.

	θ = 10°		θ = 20°	
Parameters	Theory	Exp.*	Theory	Exp.*
λ	0.281	0.28	0.299	0.27
cos ε	-0.192	-0.10	-0.626	-0.46
DCS (M_f = 0)	20.68	24.5	1.88	1.8
DCS (M_f = 1)	26.46	31.9	2.21	2.5
DCS	73.61	88.2	6.30	6.7
PI	0.278	0.29	0.273	0.33
p_2	-0.186	-0.11	-0.566	-0.56
DCS (M_i= O)	61.29	76.4	5.15	6.6
DCS (M_i= 1)	79.76	94.1	6.87	6.8
DCS (M_f = ±1 cob)	94.61	102.2	10.76	10.5

$Q(M_f = 0) = 9.56$
$Q(M_f = 1) = 12.52$
$Q(M_i = 0) = 28.42$
$Q(M_f = 1) = 37.71$
$Q(M_f = \pm 1 coh) = 42.21$
$\bar{Q} = 34.61$
$Q^{[2]}_{CR} = 0.070$

* The experimental error limits are estimated to be ± 30% except for cos ε and p_2 for which it is ±50%.

Comparison of the experimental and theoretical results indicates good agreement (within the combined error limits). A prediction concerning the magnetic-sublevel-specific integral cross sections and the alignment creation cross section can, therefore, be made based on the calculations. It is found that elastic scattering can create alignment with good efficiency.

References

1. T. Fujimoto and S. A. Kazantsev (private communication, 1996).