THE Li-LIKE KLL-AUGER SPECTRUM OF FOIL EXCITATION Ne-PROJECTILES

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KLL-Auger transitions of the three electron system in Ne have been recorded in a coincidence experiment free of contaminants from other systems. Energies as well as intensities are compared with calculated values.

From K-Auger electron decay spectra of highly excited and highly ionized atoms information is obtained on projectile or target excitation mechanisms as well as on the electronic structure of the ion. The excited state to be studied can be created either by single ion-atom collisions in gaseous targets [e.g. 1] or by multiple collisions in solid target foils, where the decay of post-foil ions is studied [e.g. 2].

Here, results are reported from foil-excited Ne-projectiles in a typical beam-foil arrangement. Kinematic line broadening and the overlap of electron contributions from various possible populated states make spectral analysis very difficult.

To separate out and distinguish between some of the multitude of overlapping transitions only those Auger electrons were measured from foil-excited (carbon, 8 $\mu g/cm^2$) neon projectiles which were in coincidence with outgoing projectiles having a well defined final charge state q_f [3].

The observed KLL Auger electron spectra of the Li-like system ($q_f = 8$) in neon are shown in fig. 1. A Gaussian shape of the measured transitions was assumed. For the first time both the energy and the intensity of such a Li-like system could be studied experimentally without overlapping contributions from other systems.

The numerical results for transition energies and relative intensities are summarized in table 1. Included in the table are the relative intensities of the lines as

calculated by Chen and Crasemann [4] as well as the transition energies obtained from non-relativistic LS-coupling Hartree-Fock calculations by Matthews et al. [5] and relativistic intermediate coupling multiconfiguration Dirac-Fock calculations [also [2]]. The excellent agreement between the intermediate coupling multiconfiguration Dirac-Fock transition energies [2], indicated by vertical lines in fig. 1 above the spectrum, and the experimental results are clearly seen (table 1). The non-relativistic LS-coupling nomenclature is used for line identification though the evaluations are carried out with relativistic intermediate coupling multiconfiguration Dirac-Fock calculations. To compare with theoretical relative intensities [4, 5] two important assumptions had to be made:

1) Equal probability for creating a 2s or a 2p vacancy and 2) statistical population of the initial configurations ($N = 2J + 1$). Under these assumptions the relative experimental intensities agree very well with the theoretical predictions by Chen and Crasemann [4] and Bhalla [6] based on LS-coupling Hartree-Fock calculations of the transition rates (fig. 1, table 1).

For this comparison the lifetime of the populated states has to be considered. The short-lived (prompt) doublet states (empty bars) with lifetimes less than 10^{-12} s decay completely during the time the electron emitting projectiles are passing through the spectrometer observation region of length l.

The observation time interval corresponding to this length is $\Delta t = l/v_1 \approx 5 \times 10^{-11}$ s, v_1 being the projectile velocity. For the metastable quartet-states (τ_i

Table 1
Li-like KLL-Auger transitions of Ne

Configuration				Ref. [4]	this work			Ref. [3]	
initial		/ final		$E_{\text{theor.}}$ (eV)	$E_{\text{theor.}}$ (eV)	$E_{\text{exp.}}$ (eV)	$I^{\text{rel.}}_{\text{exp.}}$ %	$I^{\text{rel.}}_{\text{theor.}}$ %	
$1s(2s, 2p)^2$	$^2S^e$	$/1s^2$	$^1S^e$	656.3	652.7	652 ± 1	7.1 ± 0.6	6.8	
$1s(2s, 2p)^2$	$^4P^o$	$/1s^2$	$^1S^e$	655.6	656.3	656 ± 1	1.4 ± 0.5	0.9*	
$1s(2s, 2p)^2$	$^2P^o$	$/1s^2$	$^1S^e$	668.6	668.9	669 ± 1	8.4 ± 0.7	10.4	
$1s(2s, 2p)^2$	$^2P^o$	$/1s^2$	$^1S^e$	672.3	673.1	674 ± 1	43.5 ± 1.2	$\begin{array}{c}20.1 \\ +\text{*} \\ 22.3\end{array}$ = 42.4	
$1s(2s, 2p)^2$	$^4P^e$	$/1s^2$	$^1S^e$	672.6	673.5				
$1s(2s, 2p)^2$	$^2D^e$	$/1s^2$	$^1S^e$	681.5	681.8	682 ± 1	32.7 ± 1.0	$\begin{array}{c}32.8 \\ + \\ 0.02\end{array}$ = 32.8	
$1s(2s, 2p)^2$	$^2P^e$	$/1s^2$	$^1S^e$	682.8	683.2				
$1s(2s, 2p)^2$	$^2S^e$	$/1s^2$	$^1S^e$	688.5	693.3	693 ± 1	6.5 ± 0.5	6.3	

* For the metastable states the incomplete decay during the passage of the electron emitting projectiles through the spectrometer focal region is taken into account.

$> 10^{-11}$ s) only a fraction $N_i(\Delta t)/N_i(\text{tot.})$ $= (-\exp(-\Delta t/\tau_i))$ of the ions in the excited state i having a lifetime τ_i decay in the spectrometer observation region. The observable intensities of the two metastable 4p-states (hatched bars) calculated using this formula are shown in the figure too. The spectral intensities are normalized to the total KLL-Auger intensity.

The comparison of our experimental results with calculated energies is good to within 1 eV; comparing the experimental and theoretical relative intensities, one concludes that for beam foil excitation of Li-like Ne-projectiles the population of all states is statistical and 2s and 2p vacancies are created with equal probability. In contrast to this multicollision Ne beam-foil experiment Matthews et al. [1] have recently reported the results from a single collision Cl^{13+}-Ne gas target experiment. There, they report an overpopulation of the $1s2s^2$- and $1s2s2p$ configurations relative to the $1s2p^2$ configurations. It appears that the excitation mechanisms populating the states in question are different in ref. [1] and in this experiment where multiple collisions in the exciter foil are important.
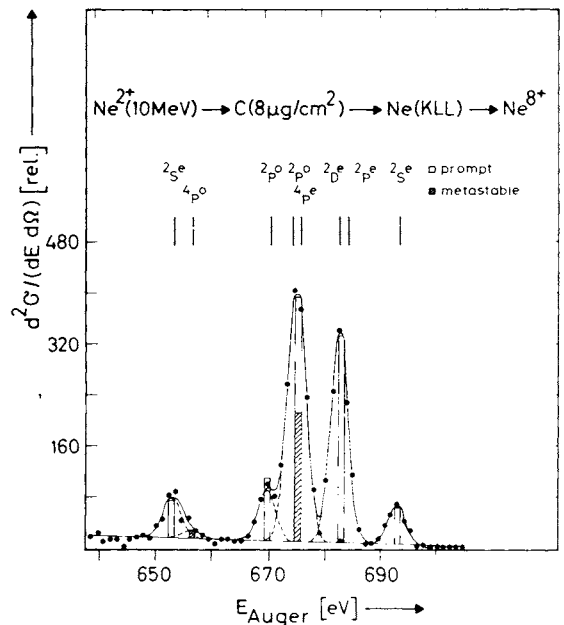
Fig. 1. Li-like KLL-Auger transitions of Ne. The points are the measured data; the dashed lines are least-square fits to the 8 transitions, the sum of which results in the solid line. The vertical bars are the theoretical intensities (hatched when corrected for metastability, see text). The initial configuration is given above the calculated energies (vertical lines).

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