X-RAY SATELLITE INTENSITIES IN THE SUDDEN APPROXIMATION

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The relative intensities of the $K\alpha_1\alpha_2$ satellite group $\alpha'\alpha_3\alpha_4$ are calculated for neon-like ions ($9 \lesssim Z \lesssim 20$), and compared with experimental intensities resulting from both electron and X-ray excitation.

A recent theory of X-ray satellites is based on the sudden approximation [1,2]. In this note we show that it accounts for relative intensities of $K\alpha$ satellites appearing both in electron and in X-ray excitation. The influence of the K Auger width on the relative intensity is considered. Previously it has been assumed that the Auger transition rates of the K single- and multi-hole states are equal.

We treat the most prominent $K\alpha$ satellite group of neon-like ions in LS coupling. The initial states of the satellite lines are identified as KL_I and $KL_{II, III}$ double-hole states in accordance with energy calculations [3,4]. The relative intensity is obtained from

$$\frac{I(\alpha'\alpha_3\alpha_4)}{I(\alpha_1\alpha_2)} = k_{2s}W(2s) + \tfrac{5}{6}k_{2p}W(2p) . \qquad (1)$$

Here $W(nl)$ is the relative sudden approximation probability [1,2] that K-shell ionization is followed by excitation or ionization of an nl electron. The correction factor $k_{nl} = \nu_{nl}^4 M_{nl}^2 \Gamma_0^A / \nu_0^4 M_0^2 \Gamma_{nl}^A$ takes into account that the frequency ν and the

Table 1
Relative integrated intensities (in percent) of the $K\alpha_1\alpha_2$ satellite group $\alpha'\alpha_3\alpha_4$.

| | | Experiment | | | | | Theory |
| | | electron excitation | | | X-ray excitation | | |
Z	Target	Ref.11	Ref.10	Ref.4 *	Ref.13	Ref.12	Eq.(1)
9	NaF	39.5 ± 1.5					42.5
10							26.0
11	NaF	20.3 ± 0.8			21.5 ± 1		18.2
	NaCl		22				
12	Mg	16.1 ± 0.5		12.6	13.8 ± 0.8		13.6
	MgO	15.9 ± 0.5		14.1	15.9 ± 0.4	15 ± 1.5	
13	Al	10.1 ± 0.4		10.7	10.7 ± 0.4		10.5
	Al$_2$O$_3$	11.9 ± 0.4		11.9		9.3 ± 1.5	
14	Si	7.5 ± 0.4	11	9.0	7.7 ± 0.4		8.3
	SiO$_2$	9.3 ± 0.4		10.0	8.9 ± 0.4		
15	P	6.2 ± 0.4					6.8
16	S, Fes	5.6 ± 0.4	4.8				5.7
17							4.8
18							4.1
19	K$_3$PO$_4$		2.6				3.5
20	CaO		2.2				3.1

* Excitation mode not given

dipole matrix element M of the line as well as the Auger width Γ^A of the initial state change when the nl hole is formed besides the K hole. The radiative width Γ^R has been neglected in k_{nl} as $\Gamma^R \ll \Gamma^A$ for atoms with $Z \lesssim 20$ [5].

The probabilities $W(nl)$ were first calculated by using ground-state orbitals [6] with the atomic number $Z + 1$ instead of K-state orbitals with atomic number Z. Only for some ions [2] has it been possible to obtain the probabilities directly by using K-state orbitals [7]. For the remaining ions the final values $W(nl)$ corresponding to K-state orbitals were then found by interpolating the slowly varying reduction factor. The ratio M_{2p}^2/M_0^2 has been calculated in the frozen structure approximation [8]. In the 2s case this ratio has been estimated to be 1.02 times the 2p ratio. Using Archard's relative values [9] of the KLL Auger probabilities $P(nl', nl)$ in LS coupling we have obtained the Auger-width correction from

$$\frac{\Gamma_o^A}{\Gamma_{nl}^A} = \frac{P(2s, 2s) + P(2s, 2p) + P(2p, 2p)}{a_{nl}P(2s, 2s) + b_{nl}P(2s, 2p) + c_{nl}P(2p, 2p)} \quad (2)$$

The constants a_{nl}, b_{nl} and c_{nl} take the nl hole into account ($a_{2s} = 0$, $b_{2s} = \frac{1}{2}$, $c_{2s} = 1$, $a_{2p} = 1$, $b_{2p} = \frac{5}{6}$ and $c_{2p} = \frac{2}{3}$). The ratio (2) which results in a correction of about 30% is rather insensitive to the choice of the relative Auger probabilities and nearly independent of Z.

The experimental relative intensities in table 1 do not reveal any differences between electron and X-ray excitation in accordance with the sudden approximation. The agreement between the measurements and the calculations, resting on the assumption of a free neon core, is good up to $Z = 16$. For heavier atoms exchange effects between the 2p and 3p shell must be taken into account.

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ERRATA

Influence of lattice defects on the hyperfine interaction: Mn^{2+} in NaCl, K. N. Schrivastava, Physics Letters 26A (1968) 251.

The correct name of the author is K. N. Shrivastava.

p.251, col. 1, line 8
   read An interesting variation ... *instead of* An increasing variation...

p.251, col. 2, line 15
   read corresponds to $\rho_{Mn} = 0.910$... *instead of* corresponds to $\rho_{Mn} = -0.910$...

In the caption of table 1
   read NaCl *instead of* CaCl

The correct references 1, 7 and 13 are
1. J. S. Van Wieringen, Diss. Faraday Soc. 19 (1955) 118.
7. E. Clementi, IBM J. Res. Develop. 9 (1965) 2, and supplement; C. Fraose, Proc. Cambridge Phil. Soc. 53 (1957) 206.
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