SATELLITE LINES IN THE L1η DOUBLETS OF 17Cl, 19K, 20Ca, 21Sc AND 22Ti IN THE RANGE 30-70Å

R. Crisp

JOURNAL DE PHYSIQUE
Colloque C9, supplément au n°12, Tome 48, décembre 1987

SATELLITE LINES IN THE L1η DOUBLETS OF 17Cl,19K,20Ca,21Sc AND 22Ti IN THE RANGE 30-70Å

R.S. CRISP

The University of Western Australia, 6009 Nedlands, Western Australia, Australia

Resumé On a enregistré un satellite des lignes Llη(2p-3s) émises par les metaux 19K-22Ti et par 17Cl et 19K dans KCl. Le satellite, situé entre Ll and Lη, s'identifie comme (2p3x-3s3x) et ne se manifeste pas en cas de K dans KCl et n'est pas résolu dans le cas de 21Sc ou 22Ti.

Abstract A satellite of the lines Llη(2p-3s) has been recorded from the metals 19K through 22Ti and from 17Cl and 19K in KCl. The satellite line, intermediate in energy between Ll and Lη and identified as (2p3x-3s3x), is not observed for K in KCl and is not resolved in Sc or Ti

1. Introductory & Experimental

The intense doublet Ll,η in the L spectrum of the light elements is emitted when initial vacancies in the L_2 or L_3 levels are filled by electrons from the M_1 shell. A host of doubly or triply ionised initial and final states are also possible and give rise to many satellite lines observed in spectra from gaseous targets such as Ar as presented by Nordgren et al[1,2]. Such a profusion of satellite lines is not seen in the spectrum emitted from solid targets and for solids the principal non-diagram structure associated with Ll,η is the "semi-Auger" satellite identified by Cooper and LaVilla[3].

A re-examination of the doublet, using a 1m grating ruled in gold with 2400 grooves mm^{-1} giving a resolution in second order of 0.12Å shows the Ll and Lη components completely separated and reveals a fairly intense, narrow satellite line, whose width is similar to and whose energy is intermediate between Ll and Lη. This feature has been examined for the elemental solid metals 19K, 20Ca, 21Sc and 22Ti and for 17Cl and 19K from KCl. In all cases the target materials were cooled with liquid nitrogen and the spectra were excited with 1.0-4.0mA at 0.5-4.0kV in a vacuum of ~ 10^{-8} torr. The selected spectra illustrated in the figures were all recorded in second order and have been partially corrected for the Gaussian spectrometer function of FWHM 0.12Å and a flat background has been subtracted. The energy resolution is indicated on each figure and while this is adequate to separate Ll, Lη from each other and the satellite, linewidths have not to date been deconvoluted.

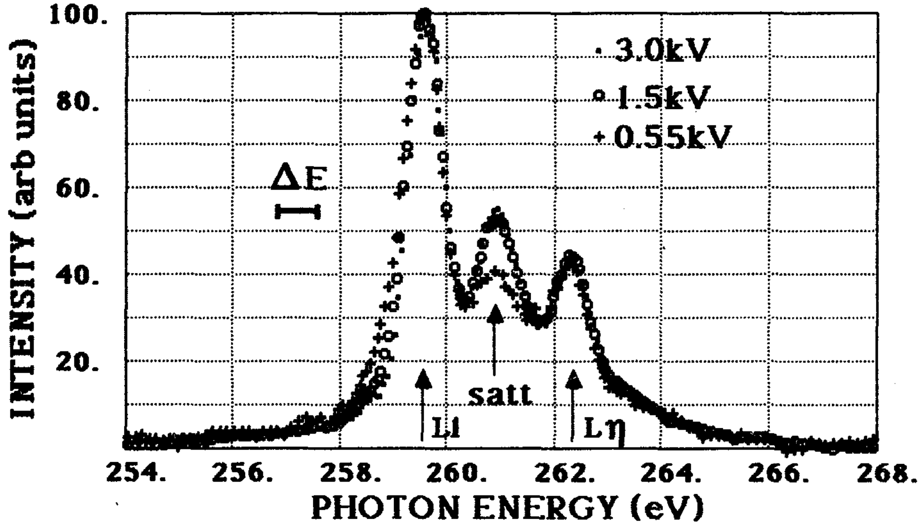

Fig 1. The Llη doublet recorded for K (metal) at 3.0, 1.5 and 0.55kV.

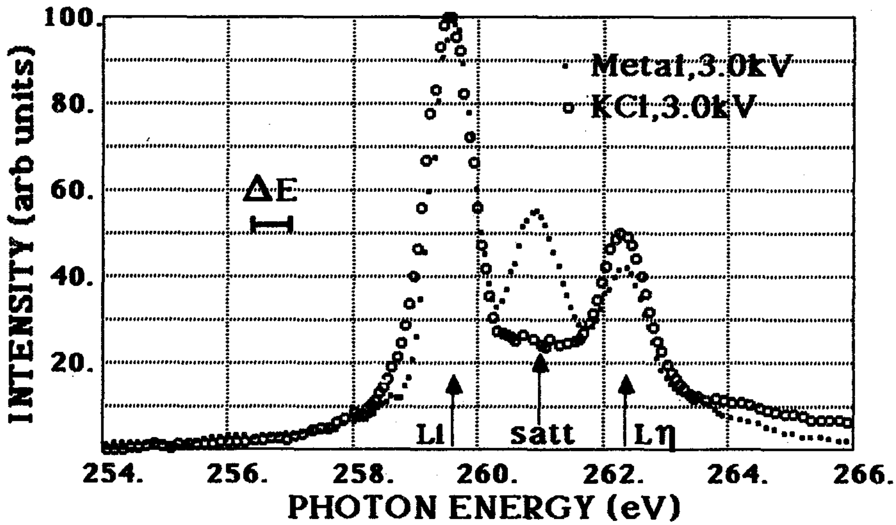

Fig 2. The Llη doublet of K recorded at 3.0kV for K (metal) and K in KCl.

2. Results and Discussion

It is noted that:-

a) The satellite is seen in both first and second order spectra and has been shown definitely not to be an experimental artifact.

b) The satellite intensity in 19K and 20Ca falls with reducing exciting voltage, though its intensity is still significant for exciting voltages of the order of (but not less than) twice the threshold for Llη.

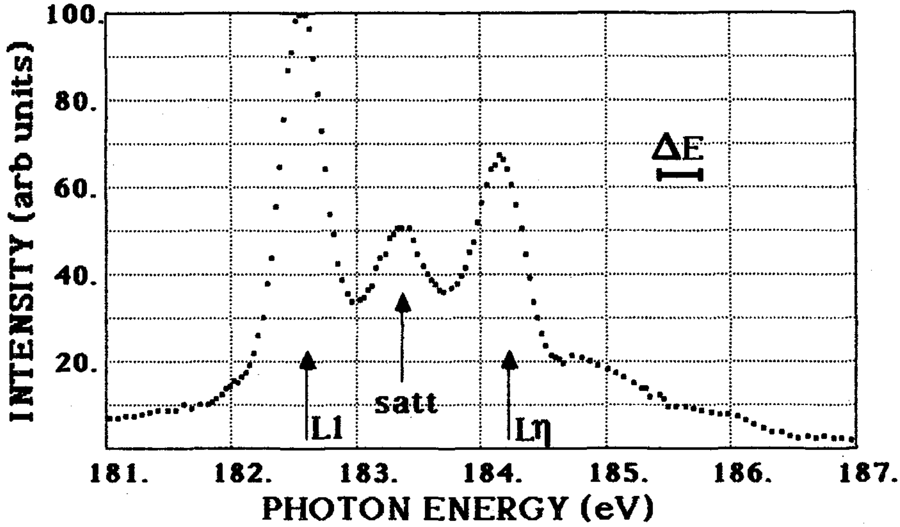

Fig 3. The Llη doublet recorded for Cl in KCl at 3.0kV. The sample was a film of KCl deposited on the copper target from aqueous solution.

c) The satellite is clearly seen for Cl in KCl, K and Ca metals, is completely absent for K in KCl and is not definitely identified in Sc or Ti metal (possibly due to a combination of large line width and diminished instrumental resolution).

It is suggested that:-

a) The satellite is due to a multiply ionised initial state, such as 2p,3p (which has been shown to give a satellite line between l and η in gaseous Ar[1,2]).

b) The many other possible multiple ionisation states are not seen in emission from the solid due to Auger or other competing decay channels which will i) reduce the intensity of radiative transitions and ii) grossly broaden the remnant emission lines

c) It is not clear why only a single such satellite line is seen, given the many multiple ionisation states possible. Alternative explanations involve, for example, a continum resonance state, such as that described by Chamberlain, Burr and Liefeld[4], however, the sharpness of the satellite and its relative insensitivity to excitation voltage make these explanations less plausible.

d) the multiple ionisation state symmetries are strongly sensitive to the crystal field in the solid, as evidenced by the complete disappearance of the satellite for K in KCl.

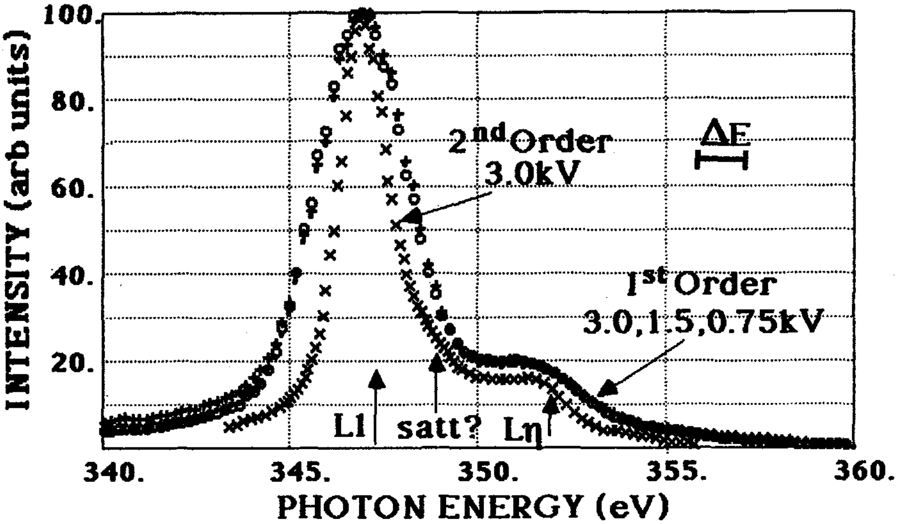

Fig 4. The Lłη doublet recorded from Sc (metal) in first order at 3.0, 1.5 and 0.75 kV and in second order at 3.0kV.

e) For Sc and Ti where the existence of the satellite is not definitely established, a situation rather different from that for Cl, K or Ca pertains:-

i) the 3d shell has been opened, ii) the core levels and the lines are considerably broadened and weakened due to enhanced Auger decay rates and iii) (coincidentally) the instrumental energy resolution falls off at the shorter wavelengths (0.33eV at 68Å, Cl→1.5eV at 31.4Å, Ti).

References

1. Nordgren J, Ågren H, Nordling C and Siegbahn K Int Conf on X-ray Spectra, NBS, Washington 1976
2. Nordgren J, Ågren H, Selander L, Nordling C and Siegbahn K 1977 Physica Scripta 16 70
3. Cooper J W and LaVilla R E 1970 Phys Rev Lett 25 1745
4. Chamberlain M, Burr A F and Liefeld R J 1984 J Vac Sci Technol A2 973

Acknowledgements

The author acknowledges most helpful correspondence with Dr R E LaVilla of NBS, Washington and Dr R J Liefeld of New Mexico State University on the material in this paper. The soft X-ray project receives continuing support from the Australian Research Grants Scheme and The University of Western Australia.