# WAVELENGTHS OF SOFT X-RAY EMISSION LINES IN THE RANGE 13-110Å

R. Crisp

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R.S. CRISP

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

**Resumé** On présente une serie compatible de longueurs d'onde de rayons X, entre 13 et 110Å, qui sont déterminées au moyen d'un réseau concave comportant 2400 traits $mm^{-1}$.

**Abstract** A self-consistent set of X-ray wavelengths between 13 and 110Å, determined using a grating ruled with 2400 grooves $mm^{-1}$, is presented.

## 1. Introductory

If a number of sharp lines of "known" wavelength are recorded in a spectrometer in several orders, the wavelengths of the lines from order to order bear an exact integral relation with one another. If sufficient lines and orders are measured then enough information is available to generate improved values for the line wavelengths and to determine a correction function to the theoretical dispersion curve of the spectrometer. The line wavelengths and the coefficients of the correction function are made the unknowns in a multiparameter least-squares adjustment which is most conveniently effected by iteration. Provided there is sufficient data (i.e. plenty of lines each in several orders) a rapid and well defined convergence occurs. Such a procedure has been used previously by Crisp[1] and Dannhäuser and Wiech[2] (who described one method of applying it in detail) to determine wavelengths for a series of the $M\zeta$ lines.

In the measurements reported here a total of fifty eight data points were used for a least squares determination of thirty one free parameters (twenty eight wavelengths and three coefficients for a parabolic correction curve).

## 2. Experimental

The spectrometer, which operated in a continuous scanning mode, utilised photoelectric detection with on-line control and data collection by an LSI 11/03 minicomputer. The channel width was always set narrow enough that no less than 10 (and usually 20 or more) channels corresponded with the spectrometer line width.

The pure metal samples were clamped to the target holder with good thermal contact and cooled with liquid nitrogen. The target surface was cut clean in situ in the target chamber by means of a tungsten carbide knife scraper which operated in the clean working vacuum of $2x10^{-7}$ torr or less. The spectra were excited by electron bombardment with up to 4.0ma at 3.0kv and this gave detected intensities such that lines could be recorded in first order with 50K or more counts in the peak in times ranging from 0.5 to 2.0 hours. The target surfaces were renewed by scraping several times between scans during the recording of each spectrum.

In the present work a 1m. radius grating, ruled in gold with 2400mm-1 and 1° blaze, was used with 50μm slits at 85.5° angle of incidence which gave a spectrometer Gaussian with FWHM-0.215Å and a resolution of 0.246Å over a usable range from 13-265Å. Second orders with usable intensities at least 5% of that in first order were observed for all the lines down to the short wavelength limit at 13Å (Cu-Lα) and third orders with intensities up to 1% of that of first order were recorded for a number of the lines with wavelengths greater than about 35Å.

Dannhäuser and Wiech[2,3] and Holliday[4,5] have previously illustrated high resolution grating measurements in this region including several of the lines reported here, while the definitive compilation of Cauchois and Senemaud[6] includes a comprehensive collection of references to earlier wavelength determinations.

## 3. Results and Conclusions

The final numerical values with their errors are listed in the Table along with those measured in the earlier work and the values from the tabulation of Cauchois and Senemaud[6].

The present set agrees closely with the previous measurements reported from this laboratrory and this current study extends to shorter wavelengths the group of self consistent "standard" Mζ wavelengths which have earlier been shown to be reproducible with respect to exciting voltage and which are also relatively insensitive to resolution since, notwithstanding their doublet nature, the observed principal component is essentially symmetrical about the maximum. The Lα and Ll lines do not share this property and their observed peak wavelengths are to a degree resolution and excitation dependent, though the effect for Ll is small and can in principle be estimated.

We report here for the first time the wavelength of the Mζ line of 49In (33.80±0.05Å) and confirm the previous finding by Kiessig[7] of two broad peaks of comparable intensity for the Mζ line of 46Pd.

## 4. Acknowledgments

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## 5.References

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## WAVELENGTH TABLE (all in Å)

| LINES | C&S | Crisp | Present |
|---|---|---|---|
| **Lα ($L_3$-V)** | | | |
| 29Cu | 13.330 | - | 13.34±0.03 |
| 28Ni | 14.571 | - | 14.56±0.02 |
| 27Co | 15.970 | - | 15.97±0.02 |
| 26Fe | 17.588 | - | 17.57±0.03 |
| 22Ti | 27.45 | - | 27.41±0.02 |
| 21Sc | 31.33 | - | 31.21±0.04 |
| 20Ca | 36.32 | - | 35.92±0.05 |
| 19K* | 41.6 | - | 42.38±0.04 |
| **Ll($L_3$-$M_1$)** | | | |
| 22Ti | 31.36 | - | 31.35±0.02 |
| 21Sc | 35.60 | - | 35.74±0.06 |
| 20Ca | 40.96 | - | 41.07±0.12 |
| 19K | 47.63 | - | 47.80±0.08 |
| **Mζ($M_5$-$N_3$)** | | | |
| 50Sn | 31.17 | - | 31.19±0.02 |
| 49In | - | | 33.80±0.05 |
| 48Cd | 36.66 | - | 36.64±0.08 |
| 47Ag | 39.83 | - | 39.89±0.06 |
| 46Pd(i) | 43.36 | - | 43.44±0.19 |
| 46Pd(ii) | 43.78 | - | 43.75±0.12 |
| 45Rh | 47.62 | 47.65±0.09 | 47.66±0.08 |
| 42Mo | 64.39 | 64.39±0.07 | 64.40±0.03 |
| 41Nb | 72.22 | 72.26±0.10 | 72.25±0.07 |
| 40Zr | 81.75 | 81.75±0.09 | 81.74±0.03 |
| 39Y | 93.59 | 93.61±0.06 | 93.55±0.03 |
| 38Sr | 108.63 | 108.65±0.18 | 108.69±0.05 |
| **Nζ($N_5$-$O_3$)** | | | |
| 56Ba* | 164.60 | 164.38±0.16 | 164.36±0.07 |
| **OTHERS** | | | |
| 14Si($L_1$-$L_{2,3}$)* | - | - | 241.43±0.08 |
| 49In($M_3$-$M_5$)* | - | - | 56.04±0.05 |
| | | | (Δλ-6.62±0.06) |
| 49In($M_2$-$M_4$)* | - | - | 49.42±0.05 |

**NOTES**
"C&S" refers to Cauchois and Senemaud reference 6
"Crisp" refers to Crisp reference 1
"Present" refers to this paper and Crisp reference 8
Lines asterisked (*) were recorded in first order only and their wavelengths were not adjusted.