BEAM-FOIL LIFETIMES OF CrII

by

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Introduction

In 1962, the first formal proposal for a beam-foil experiment was made by Kay[1]. Beam-foil Spectroscopy (BFS) has since come into wide use. Along with other applications BFS provides a new method for measuring the lifetimes of atomic states from which radiative transition rates may be derived. Previously arc, spark, and absorption spectra were the primary sources for this information. BFS presents problems of its own, of course, but it does not have the problem associated with it of the assumption of thermal equilibrium in the light source. In addition, one need not worry about plasma stratification, which is a difficulty encountered in shock tube experiments.[2]

A BFS lifetime measurement is performed by passing a beam of accelerated ions through a thin foil. As atoms pass through the foil the valence electrons are excited. Downstream of the foil one may observe the number of photons emitted as a function of distance from the foil. The velocity of the beam after the foil is then used to convert the distance scale to a time scale. Thus the final result is a plot of the number of photons emitted versus time. The slope of this plot is the lifetime of the emitting level.

Lifetimes of atomic energy levels may be used with branching ratios to find atomic transition probabilities, which are important to the study of elemental abundances in the solar and stellar atmosphere. Recent calculations of the chromium abundance, based on BFS lifetimes of CrI,[3] make it desirable to calculate a similar abundance based on the lifetimes of CrII. The reason for this is that at solar photospheric temperatures the principle ionic species is CrII. Therefore, a small error in the temperature-pressure stratification might lead to a large error in the fractional abundance of CrI and would produce a significant error in determining the total chromium abundance from CrI. The ratio of CrII to total chromium abundance should be much less sensitive to small errors in the temperature-pressure stratification.

The work presented in this thesis may be conveniently divided into four phases:

1) Some question as to the accuracy of BFS measurements has been raised in connection with the energy loss incured by the beam.[4] The problem has been examined to some extent in this work. The energy loss for 89 keV Ar+ has been measured and agrees surprisingly well with stopping power calculations.

2) In preparation for the lifetime experiments, spectral scans of the BFS spectrum have been taken between 1900 and 4100 A. Lines originating in CrI and CrII exist in this region and have been identified.

3) Lifetimes of five lines representing four levels in CrII have been measured. These measurements were made at two energies to ensure adequate knowledge of the energy loss.

4) A preliminary calculation of the solar abundance of chromium has been made based on our CrII results.

Spectroscopic Background

The following discussion will define common spectroscopic terminology and relate the Einstein coefficient (A) to the oscillator strength (f), and to the atomic radiative lifetime (τ). The following definitions are based on the shell model of the atom and the LS coupling scheme, and will consider only radiative transitions of the valence electrons.[5] In this coupling scheme, a spectroscopic "term" is characterized by the total orbital angular momentum (L) and the total spin (S) of the valence electrons. The conventional notation for a term is ^{2S+1}L, where 2S+1 is called the "multiplicity" of the term. The multiplicity is the number of possible orientations of S relative to L. One may think of the multiplicity as the number of ways L and S can couple to form the total angular momentum, J, but this is only true for $L \geq S$. For example, if $S = \frac{1}{2}$ and $L = 0$ as in the hydrogen atom, the term is ^2S and there are two possible orientations of S, but only one possible coupling to form J ($J = \frac{1}{2}$). A "level" designates one possible value for J, and is written $^{2S+1}L_J$. One specifies the "sublevel" that an atom is in by specifying the orientation of the atom, M. Sublevels are degenerate in energy except in the presence of a magnetic or electric field. A transition between two sublevels produces a "line component". The blend of line components produced by all transitions between two particular levels form a "line". The set of all lines produced by transitions between two terms is called a "multiplet".

The lifetimes of atomic levels are the principal quantities with which this work is concerned. However, the literature often refers to measurements of "gA-values or gf-values" as a measure of electromagnetic transition probabilities. Therefore, it is appropriate to discuss these two quantities as an alternative means of expressing transition probabilities.[6]

Let us express the initial sublevel as $i(\alpha' J' M')$, where α' represents all internal quantum numbers, and the final sublevel as $f(\alpha J M)$. Also let us define $A(\alpha' J' M' \alpha J M)$ to be the transition rate for the transition i->f, that is the transition probability per unit time for i->f. Since, in the absence of an electric or magnetic field the components blend to produce a single line, it is important to know the transition rate for the line. For each level there will be 2J+1 sublevels, corresponding to the 2J+1 possible values of M. To calculate the transition rate for the level ($A(\alpha'J'-\alpha J)$) it is necessary to sum the sublevel transition rate over all M and M'. Thus, $A(\alpha'J'-\alpha J)$ is defined by the equation

$$N(J')\ A(\alpha'J'-\alpha J) = \sum_{M'M} N(J'M')\ A(\alpha'J'M'-\alpha JM),$$

where $N(J')$ is the population of the level and $N(J'M')$ is the population of each of the sublevels $i(\alpha'J'M')$. Since the transition rate of the sublevel is not dependent on the orientation of the atom (M'), it may be factored from the sum over M'. Thus, supressing M' in the transition rate,

$$N(J')\ A(\alpha'J'-\alpha J) = \sum_{M} A(\alpha'J'-\alpha JM) \sum_{M'} N(J'M').$$

Since it is clear that

$$\sum_{M'} N(J'M')/N(J') = 1,$$

we may write

$$A(\alpha'J') = \sum_{M} A(\alpha'J'-\alpha JM).$$

In a thermally excited source the sublevels are assumed to be equally populated. Thus, we may write

$$N(J') = (2J'+1)\ N(J'M') = gN(J'M'),$$

which is the defining equation for the statistical weight g. The observed intensity I is equal to the number of atoms multiplied by the transition rate. The intensities and populations are the quantities normally measured in thermal sources. One may express the intensity as

$$I = N(J')\ A(\alpha'J'-\alpha J) = gA(\alpha'J'-\alpha J)\ N(J'M').$$

The gA-values may be found experimentally by measuring the populations of the sublevel and the intensity of the line.

In BFS the lifetimes of atomic levels are measured directly. Thus a relation must be sought that will provide the total transition rate ($A(\alpha'J')$) from one particular level. This may be done by summing all the transition rates out of the level of interest. Therefore one has

$$A(\alpha'J') = \sum_{J,\alpha} A(\alpha'J'-\alpha J).$$

The lifetime (τ) of a level is defined to be the inverse of the transition rate, and it is the time needed for the population of the level to decrease by 1/e of its original value.

By observing the lifetime of a single line originating in the level of interest, when all transitions from that level are taking place, one is provided with the total lifetime of the level. This is true because the number of transitions per unit time from the level of interest to a particular final level is proportional to the number of atoms ($N(\alpha' J')$) in the level at that time. But N obeys the time dependant equation

$$dN/dt = N/\tau \ ,$$

and will be given by $NA(\alpha' J' - \alpha J)$. Therefore, when all allowed transitions occur each transition out of level ($\alpha' J'$) will be characterized by a decay constant which is the total lifetime of the level. In order to transform the measured lifetime into the corresponding gA-values for a specific transition. More experimental information is needed. This is the branching ratio which is defined as the ratio of the transition rate of $i(J') \geq f(J)$ to the total transition rate.

As has been shown, atomic lifetimes and transition rates are different quantitative measures of the same phenomena. The oscillator strength or f-value is yet another way of describing the rate of an atomic transition.[7] The oscillator strength may be defined by comparing the strength of absorption by a quantum mechanical atom with that which would be incurred by an electron moving in a potential characterized by the resonant absorption frequency (ν). If, for a particular frequency, there are N such classical absorbers per unit volume, and N' atoms per unit volume, then f is defined by N = N'f, and is the number of classical absorbers per atom. In terms of the transition rate the f-value is given by

$$gf = gA\ mc^3/8\pi^2 e^2 \nu^2 = 1.4493 X 10^{-5} m^{-2}\ gA/\nu^2 ,$$

where m is the mass of the electron and e is the charge on the electron in esu. Since the natural lifetime (T) of a classically absorbing electron is

$$T = 3mc^3/8e^2\pi^2\nu^2,$$

the preceeding equation may be written as

$$gf = gA\ T/3.$$

This relationship indicates the intrinsically classical nature of f-values. It is important to realize that the two values of g are not the same and may not be factored from the equation.

The Energy Loss: Procedure

The energy loss suffered by the chromium ions traversing the foil is of great importance in the calculation of the level lifetimes, as it is necessary to express the distance from the foil as a function of time. This distance is related to the time of flight of the ion by

$$t = d\ (m/2(E-\Delta E))^{\frac{1}{2}},$$

where E and m are the energy and mass respectively of the incident ion, d is the perpendicular distance between the foil and the axis of the lens, t is the time it takes for the ion to traverse d, and ΔE is the energy loss.

The problem of calculating the stopping power of a low energy ion traversing matter has been explored by Lindhardt.[8,9] Calculations of energy losses were made using the method of Lindhardt and a program written by Brand, Fox, and Keller.[10] The results for several relevant choices of ion, energy, and thickness of carbon foil are listed in Table I.

Table I

Theoretical energy loss calculations for 89 keV Ar, 85 keV Cr, and 100 deV Cr

Ion	x(gm/cm^2)	E(keV)	E(keV)
Ar	2.4	89	11
Cr	2.0	85	13
Cr	2.0	100	13

In order to investigate the validity of these calculations, the energy loss for an 89 keV Ar ion was measured. Argon was used rather than chromium because the argon beam is easily produced. Since it has an atomic number (Z=17) close to that of chromium (Z=24), the results of the experiment provide a useful comparison to the calculation.

The beam for the energy loss experiment was supplied by a 150 kV linear accelerator, equipped with a Physicon universal ion source. The Physicon source is capable of producing ionized gas from either gaseous or solid materials. The argon beam was produced by aklowing argon gas to enter the source at a rate which produced a partial pressure in the accelerator of approximately $6X10^{-6}$mm of Hg. The gas was ionized in the source and extracted from it by a -10 kV potential on an extractor electrode. The beam was then accelerated to an energy of 89 keV, mass analyzed at the magnet, and directed into the target chamber, as shown

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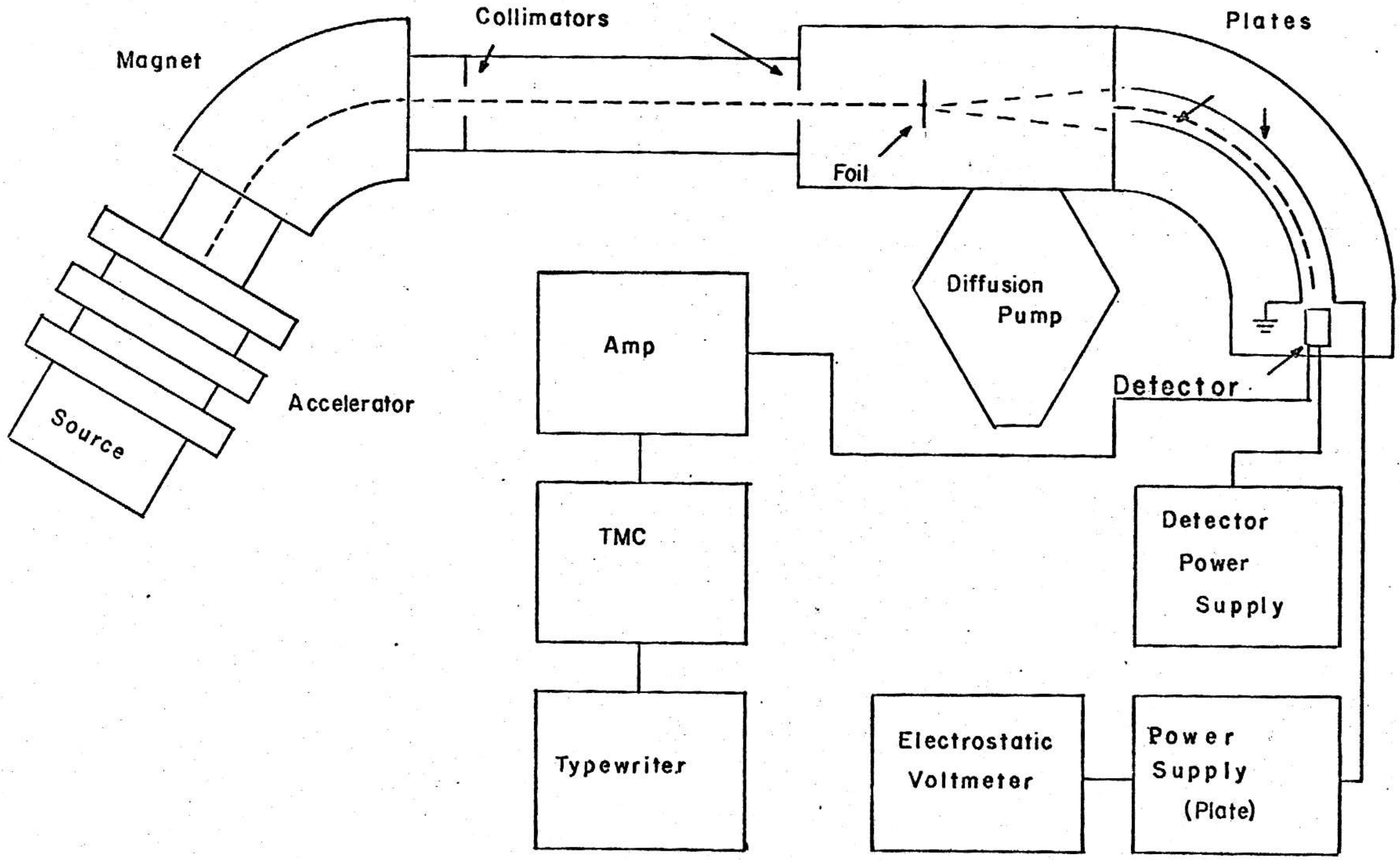

Fig. 1.--The apparatus for the energy loss experiment

in Figure I. The argon beam was identified by maximizing the beam current of the most intense beam at a Faraday cup just downstream of the magnet. The argon leak was then closed; if the beam current dropped dramatically, it was assumed that the argon beam had been identified.

The size of the beam spot was restricted by the use of two $\frac{1}{4}$ in. collimators, and vertical control of the beam was accomplished with the use of electrostatic deflection plates powered by a 400 V variable voltage supply. (The plates and power supply are not shown in Figure I.) A vacuum was maintained in the target chamber by a 4 in. diffusion pump located several inches downstream of the foil.

An electrostatic analyzer, built by Curnutte, was used to measure the energy of the beam before and after passage through the foil, the energy loss being the difference between the two values. The analyzer consisted of two curved parallel plates preceded by a 0.5 mm aperture. Particles were detected by a Bendix Spiraltron electronmultiplier located at the exit aperture of the analyzer.

The signal from the Spiraltron was amplified by a spectroscopic amplifier and recorded on a TMC (Technical Measurements Corporation) multi-channel analyzer, model 404-6. The voltage for the analyzer plates was supplied by a Spellman high voltage power supply, and was calibrated with an electrostatic voltmeter to $\pm$ 0.1 kV (corresponding to approximately $\pm$ 1.06 keV in particle energy). In order to record the energy spectrum on the TMC, the plate voltage was varied manually at a rate of .03 kV/sec, while the TMC address was advanced internally by 1 channel/sec.

The beam was electrostatically analyzed without a foil from which the ratio of the beam energy to the plate voltage of the electrostatic analyzer was determined to be 0.0945 kV/keV of particle energy. Several energy loss measurements were then made on a single foil. It was noted that as time elapsed the energy loss of the beam increased. Therefore energy loss measurements were made using a new foil noting carefully the time elapsed during each run. The foil used for these runs had been damaged in mounting and thus small holes were present in the foil. Under these circumstances, the energy spectrum contained a peak for the beam of particles that passed through the foil and a second peak for the unperturbed particles, which passed through the holes. Three additional runs were made with unused foils to make possible a calculation of the average energy loss.

The foils used throughout the experiments were provided by the Arizona Foil Company. The thicknesses quoted here, ranging from 10 μgm/cm^2 to 2.0 μgm/cm^2, are those measured by the supplier. Thin carbon foils are not durable if self-supporting, and therefore were mounted on 80% transmission electroplated nickel mesh. Several foils could be placed in the chamber simultaneously, and could be moved in and out of the beam while the system was under vacuum.

The Energy Loss: Results

The results of the energy loss experiment may be divided into two parts: first, the thickening of the foils; second, the actual energy loss incured by the beam.

Figure II shows the gradual thickening with time of a carbon foil, which was initially 2.4 μgm/cm^2 in thickness. This time dependence is probably better described as a dependence on the amount of charge

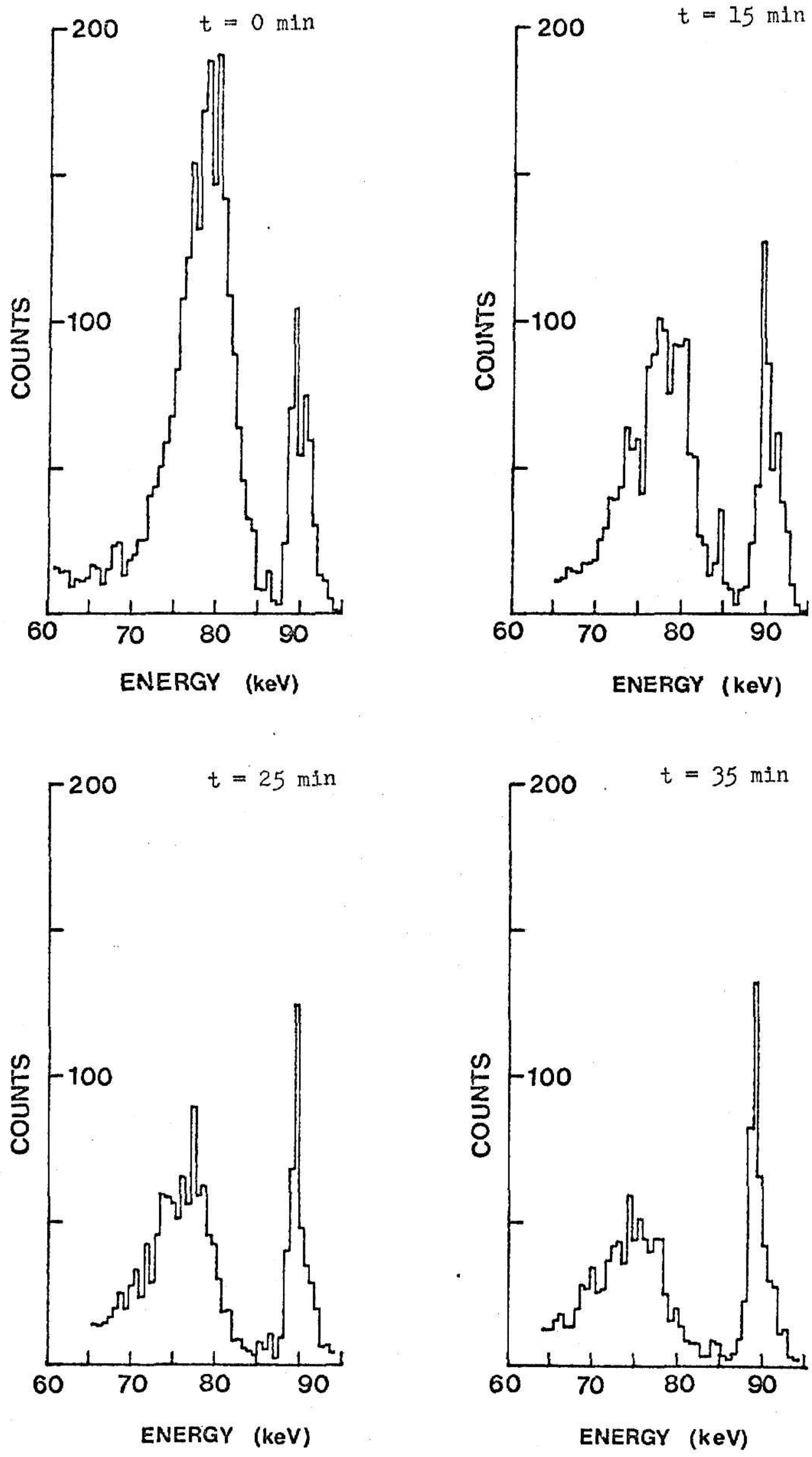

Fig. II.--The energy spectrum of Ar after passage through a carbon foil delivered to the foil. The incident beam was 89 keV Ar^+, and corresponds to the peak of higher energy in each graph. The pressure in the system was 10^{-5}mm of Hg. The time indicated is the time at which each run began, a typical run duration being 3 minutes. The beam current could not be measured directly while the electrostatic analyzer was in use, but it was measured at a forward Faraday cup before the experiment. The percentage of current transmitted to the foil from this cup is normally about 30%, but transmission has been as high as 50%. Therefore from the measurement of 13 μA at the Faraday cup, one may conclude that the foil actually received a current on the order of several microamperes. It was found that the energy loss increased from 10 keV to 14 keV in a period of 35 minutes. This implies that the foil thickened at a rate of 0.015μgm/cm^2-min. This effect is attributed to the presence of hydrocarbons (pump, oil, etc.) in the system. The build up probably occurs when a molecule very close to the foil is hit by an incoming ion. Dissociated, the molecule may form new bonds with the foil or other molecules. It is hypothesized that better vacuum would reduce the size of the effect. Precautions were taken both in subsequent energy loss experiments and in the lifetime experiments to avoid this change in foil thickness. For the energy loss measurements each foil was used only once, while in the lifetime experiments the time each foil was exposed to the beam was kept below 15 minutes.

An average energy loss of 10 keV was measured using 2.4μgm/cm^2 foils. The foils were bombarded for approximately 2 min. The agreement between this measurement and the previous calculation of 11 keV (see Table I) strongly supports the validity of our use of the Lindhardt calculations for the chromium lifetime analyses.

The Spectral Scans: Apparatus

The same acceleration, collimation, and pumping systems were utilized for the spectral scans as for the energy loss experiment (see Figure III). Solid chromous chloride was used in the source to produce the chromium beam. The Cr^+ beam was identified by first producing an Ar^+ beam as in the energy loss experiment. A Hall probe was then used to measure the magnetic field of the deflection magnet. The voltage measured across the Hall probe is proportional to the magnetic field. The magnetic field needed to turn an ion of given energy through a specified radius of curvature is proportional to the square root of the mass of the ion. Thus, for Ar^+ and Cr^+ beams the following formula gives the projected Hall probe voltage (V_2) for the chromium beam,

$$V_2 = 1.14\ V_1,$$

where V_1 is the Hall probe voltage measured when argon was used.

An adjustable LiF lens, with a focal length of 4.5 in. at 4000 A, was placed perpendicular to the beam line and downstream of the foil. The purpose of this lens was to focus the light emitted by the decaying ions on the slits of the monochromator. Survey scans were made using 6 $\mu gm/cm^2$ foils. The position of the foil was such that a maximum amount of light was focused on the slits of the monochromator. The monochromator used was a McPherson model 218 vacuum ultraviolet monochromator. Two gratings were available for use with the monochromator; a 1200 line per mm grating blazed at 3000A which produced a dispersion in the system of 26.5 A/mm of slit width, and a 2400 line per mm grating blazed at 1500 A which produced a dispersion of 13.3 A/mm.

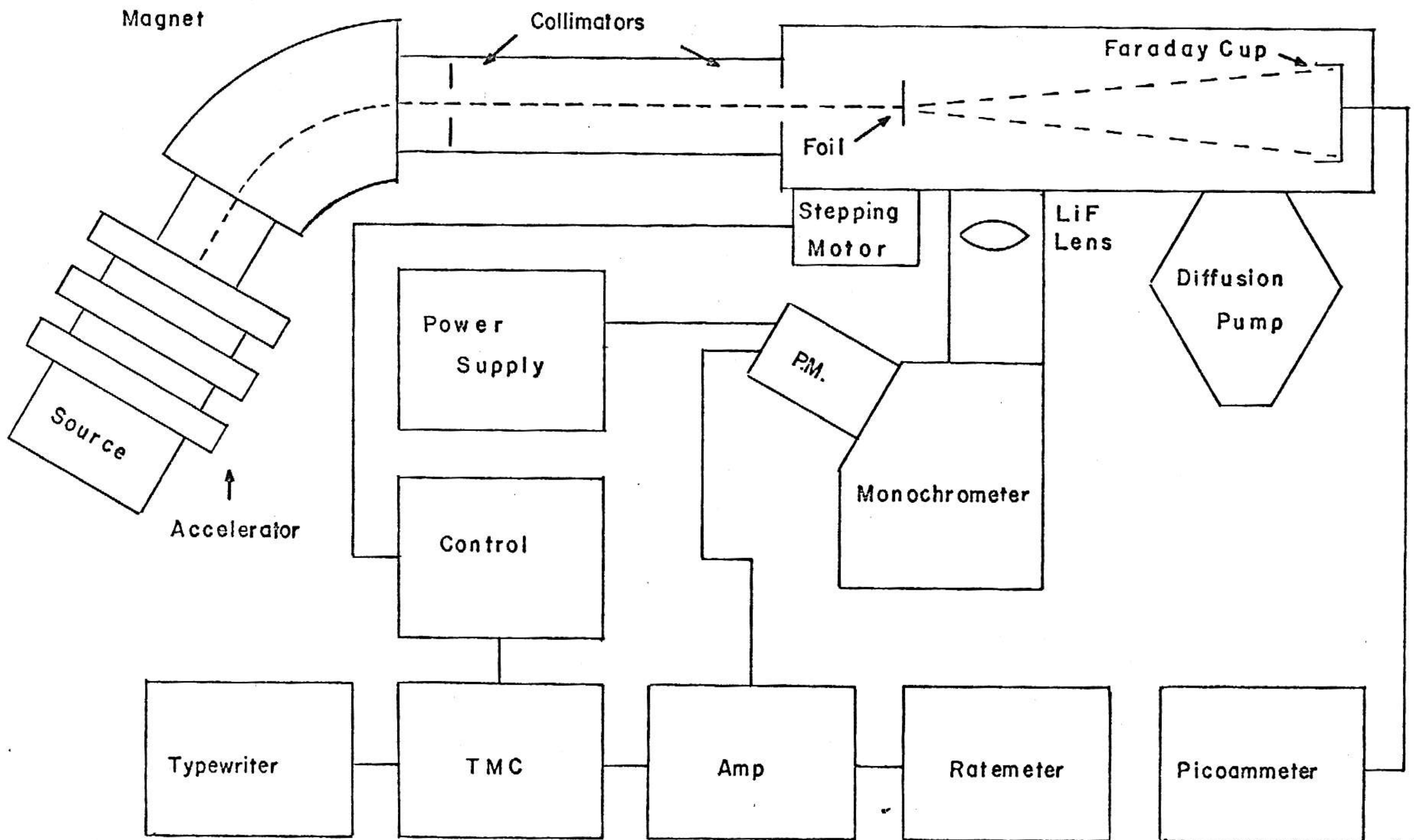

Fig. III.--The apparatus for the spectral scans and for the lifetime experiment

Photons of the proper wavelength were detected with an EMI 6256S photomultiplier tube. The tube was enclosed in a copper case and was cooled by means of a thermoelectric cooling device. A voltage of 1.5 kV was supplied to the tube by a Fluke model 404M power supply. A Nuclear Data Corporation dual channel amplifier and single channel analyzer model ND500, was used to amplify the photomultiplier signal and discriminate against low level noise. This amplifier supplies two output signals, positive pulses which were counted by the TMC, and negative pulses which were monitored on a count rate meter. The electrostatic analyzer had to be removed, and was replaced by a Faraday cup which was used to monitor the beam current.

Two sets of scans were made:

1) Low resolution scans were made using the 2400 line/mm grating. The monochromator slits were set at 250 microns to produce an instrumental resolution of 3 A. The scanning rate was 50 A/min. and the TMC was operated in the internal channel advance mode at one channel per second. Thus the TMC recorded all counts produced within a wavelength range of 5/6 A in a single channel. Seven overlapping scans of 400 channels (330 A) each were taken to cover the wavelengths between 1900 and 4100 A. The results of these scans are presented in Figures IV - IX.

2) High resolution scans of selected regions were taken in a similar manner using the 1200 line/mm grating. Slit widths for these scans were reduced to 150 or 200 microns depending on the resolution needed. The TMC was paced at 1 channel/sec., and the monochromator scan rate was 5 A/min. The length of these scans was approximately 50 A. The resulting spectra are shown in Figures IX - XIII.

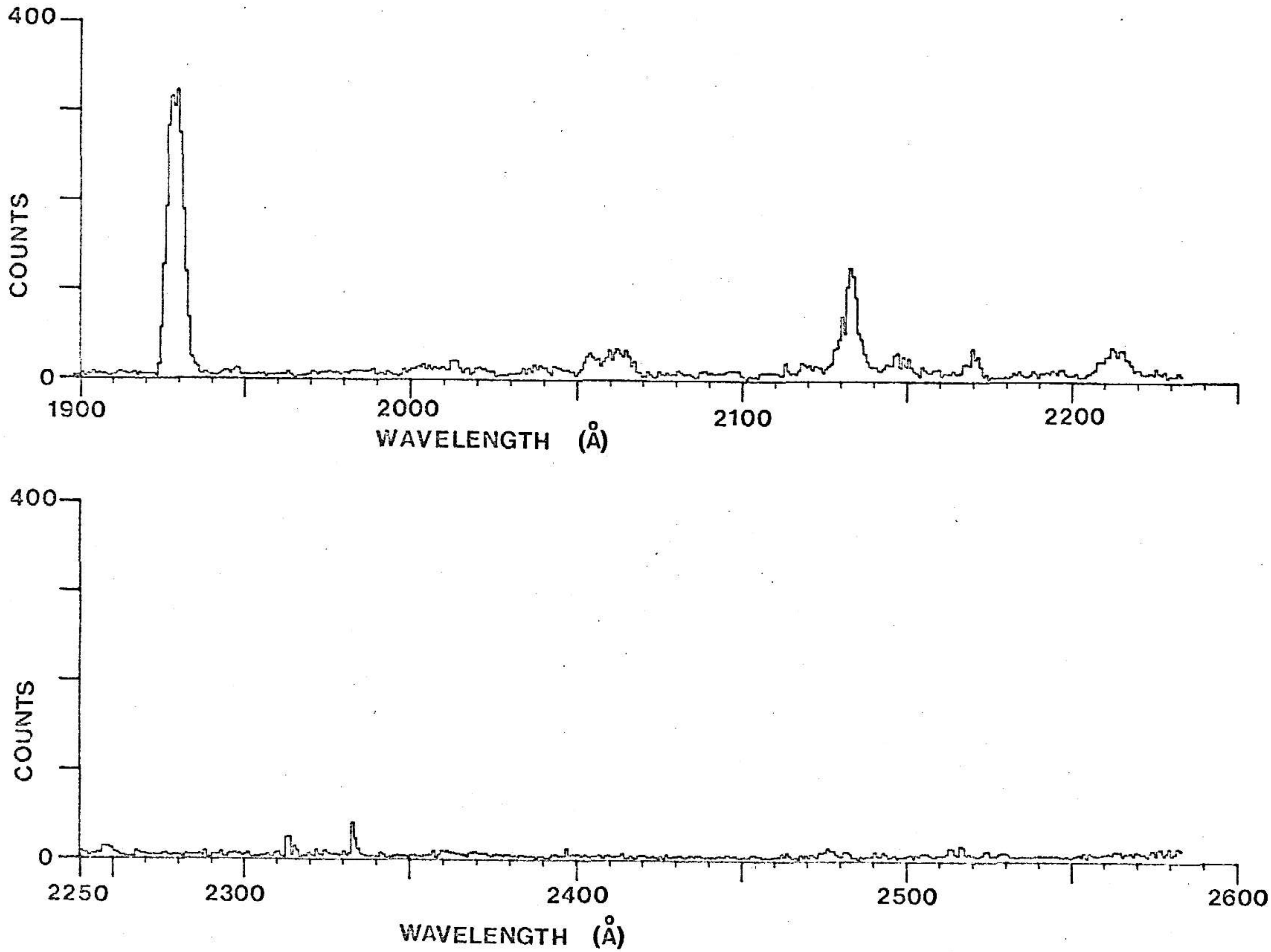

Fig. IV.--The spectrum: 1900 to 2580 A

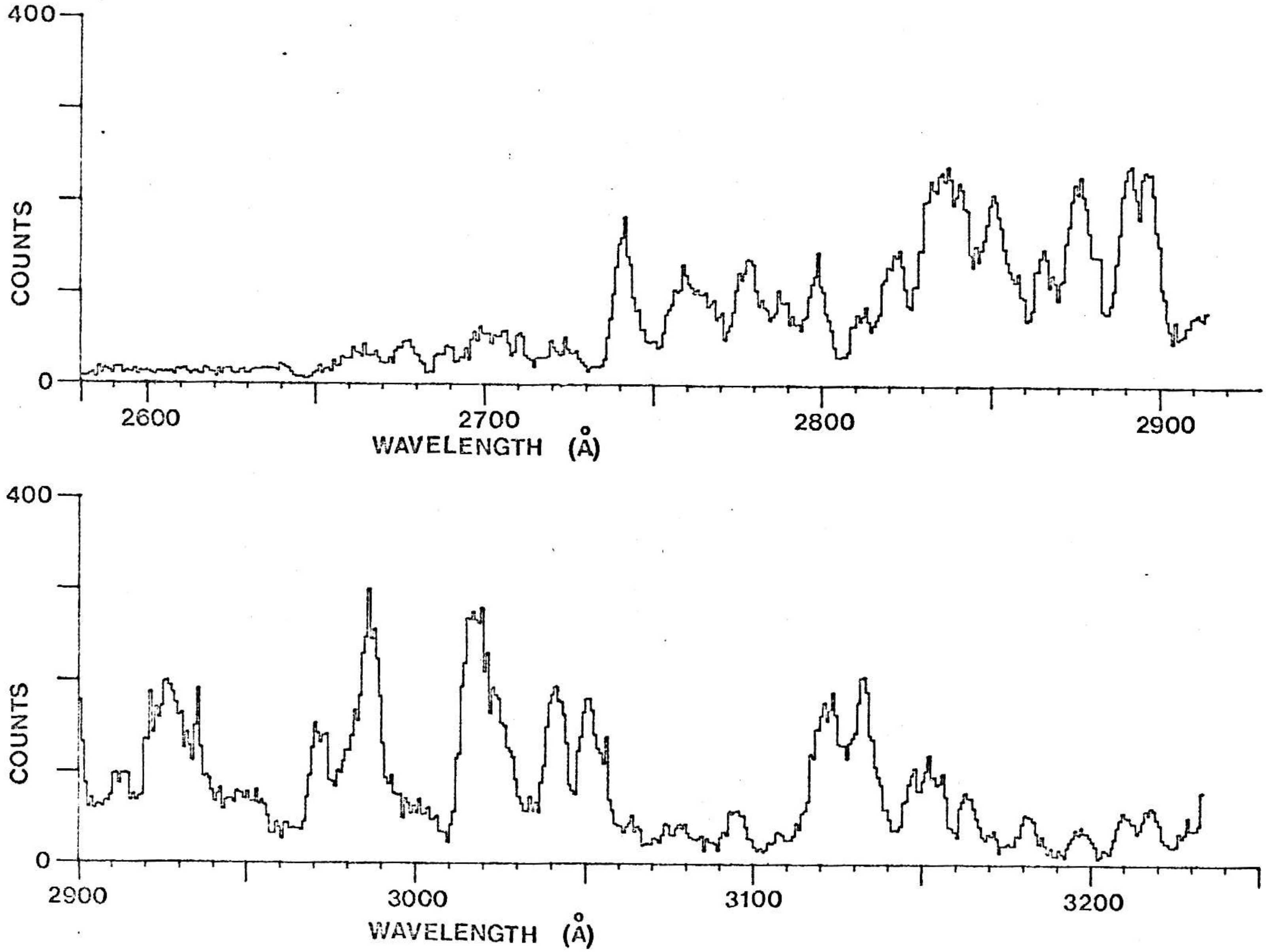

Fig. V.--The spectrum: 2580 to 3230 A

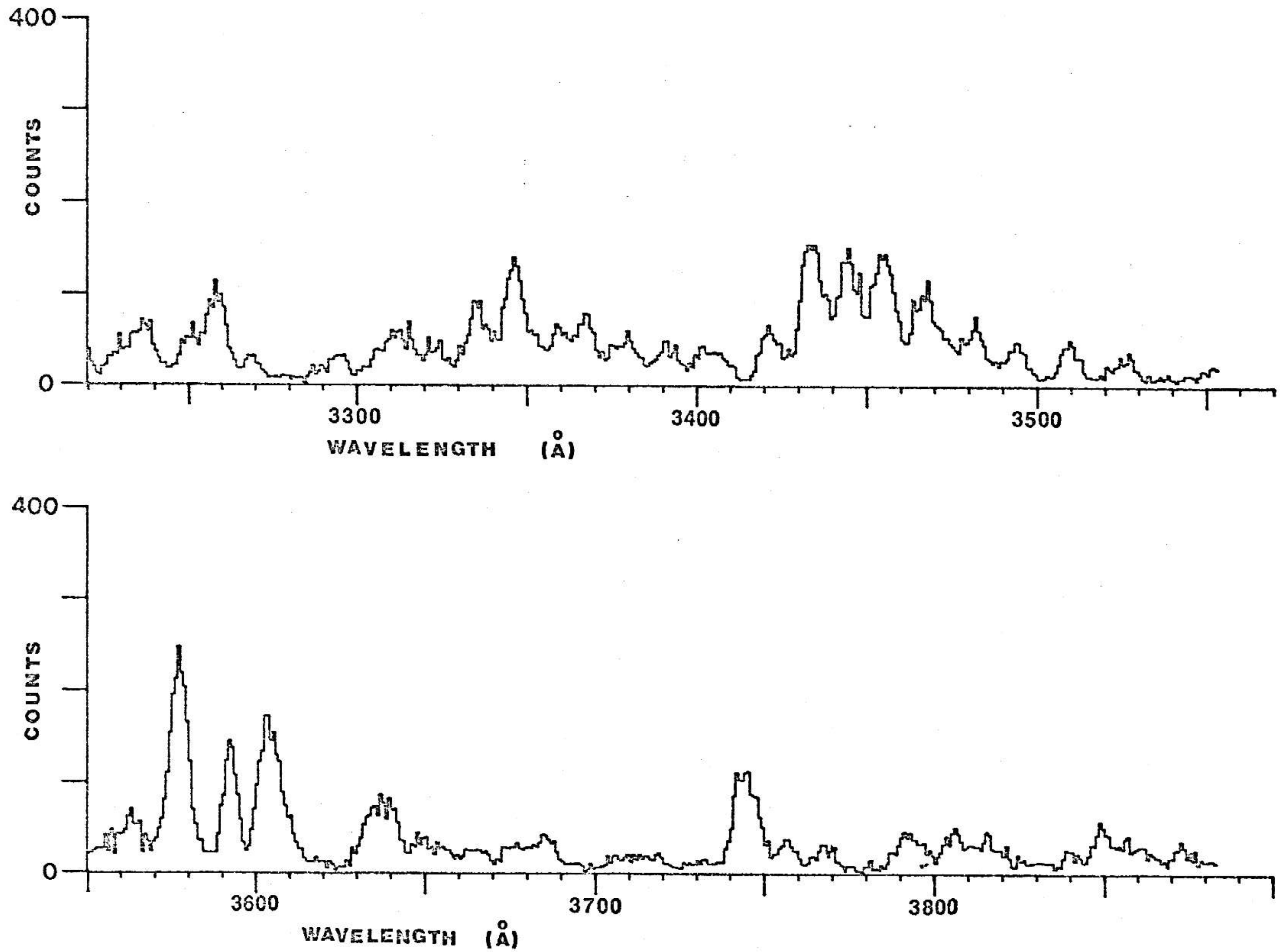

Fig. VI.--The spectrum: 3220 to 3880 A

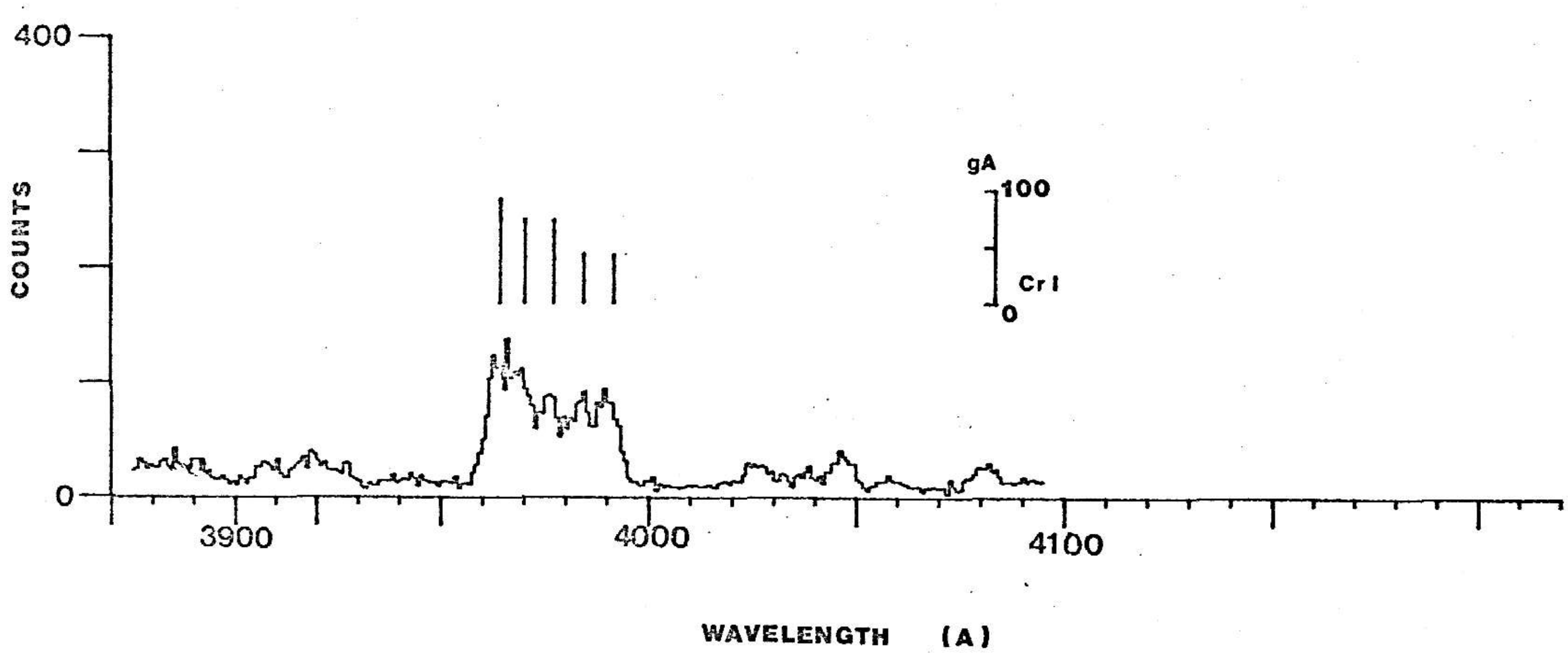

Fig. VII--The spectrum: 3870 to 4100 A

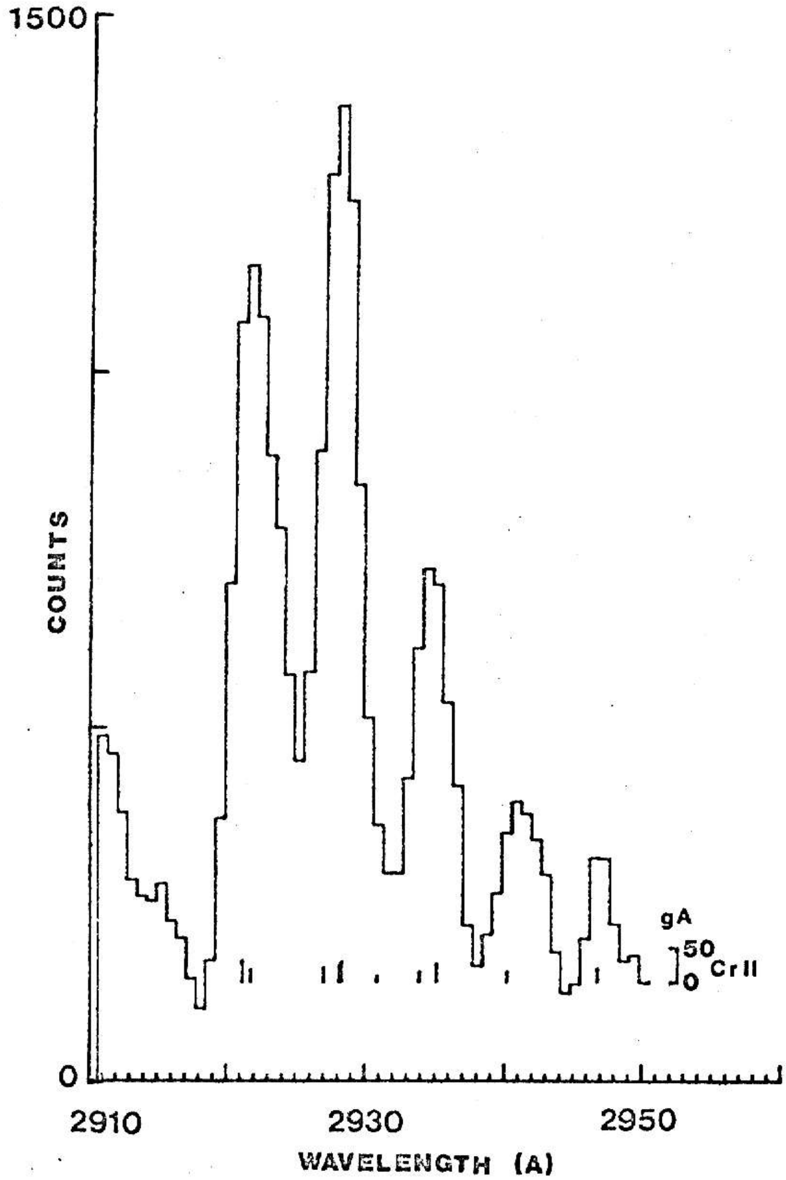

Fig. VIII.--The high resolution spectra of CrI and CrII: 2910 to 2950 A

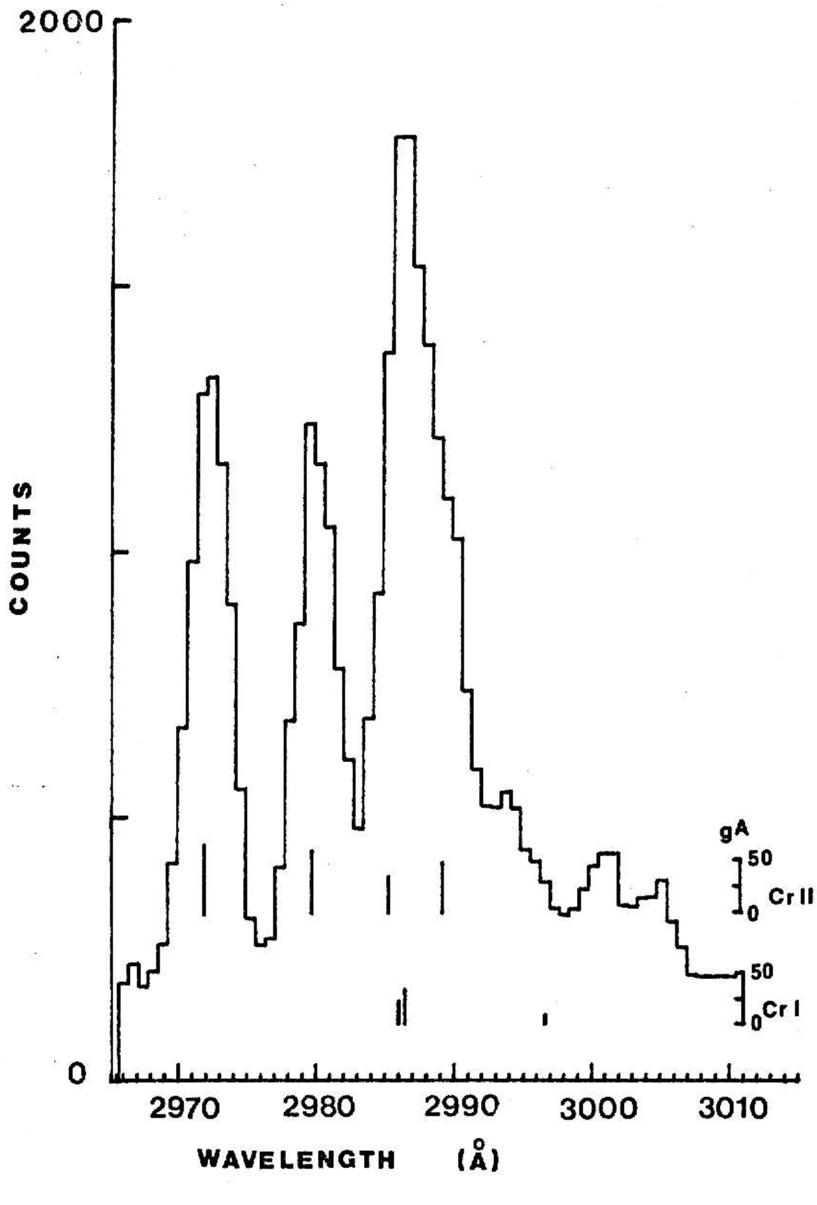

Fig. IX.--The high resolution spectra of CrI and CrII: 2970 to 3010 A

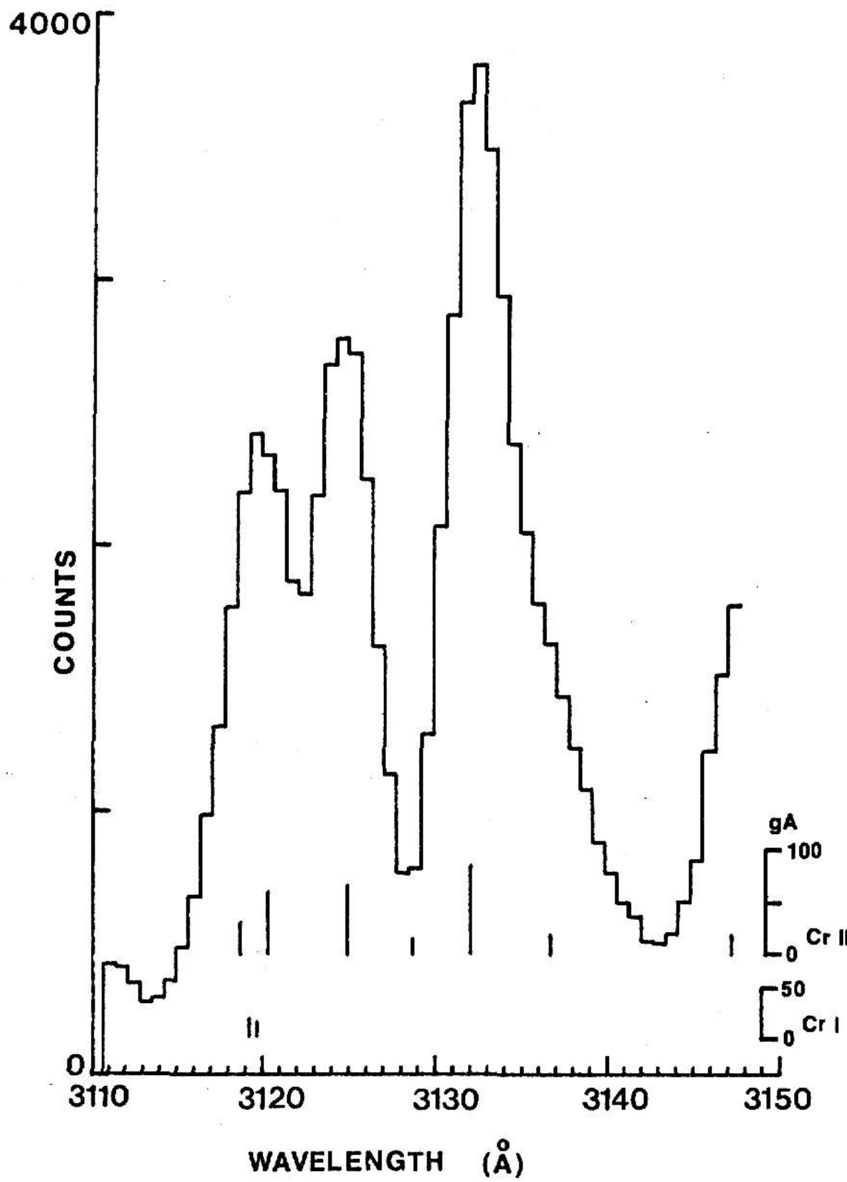

Fig. X.--The high resolution spectra of CrI and CrII: 3110 to 3150 A

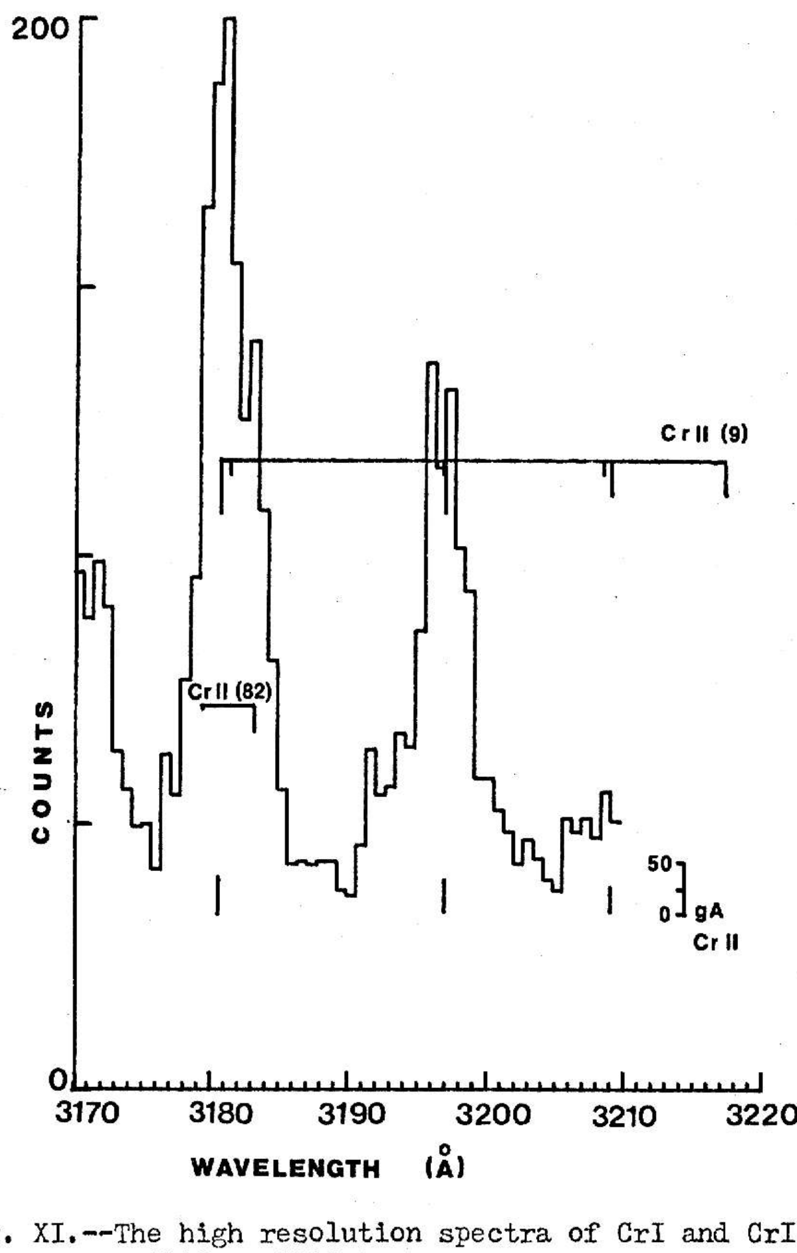

Fig. XI.--The high resolution spectra of CrI and CrII: 3170 to 3220 A

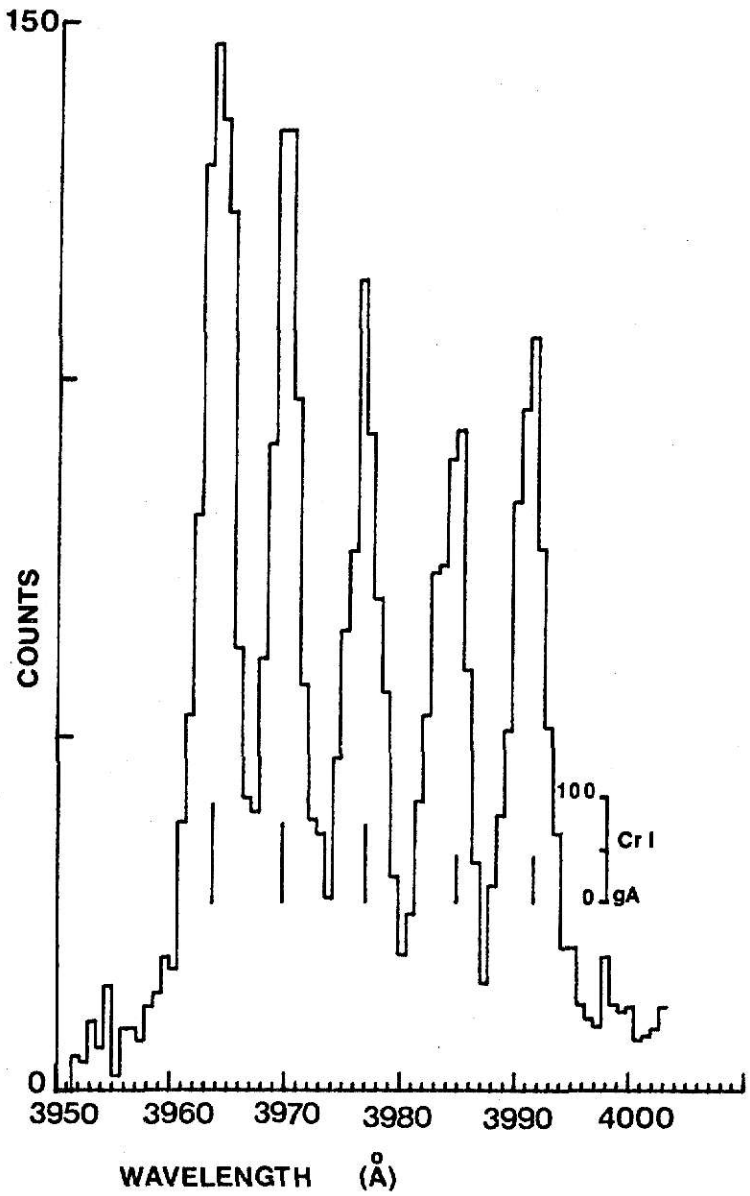

Fig. XII.--The high resolution spectra of CrI and CrII: 3950 to 4000 A

The Spectra: Analysis

The spectral analysis provides the experimenter with the basic information needed to decide which lines are appropriate for lifetime analysis. The procedure used in this analysis consisted of three steps:

1) A graph of the TMC output was made (counts versus channel, and the appropriate wavelength scale was superimposed on the graph. This produced a graph of counts versus wavelength. Selected gA values ($gA > 10^9\ sec^{-1}$) of CrI and CrII, taken from the tables of Corliss and Bozman CB),[10] were then plotted on the same graph.

2) Preliminary line identifications were made on the basis of the correspondence between intensity and gA-value. The multiplets to which these lines belong were then found by consulting Moore's A Multiplets Table of Astrophysical Interest[12] and An Ultraviolet Multiplet Table.[13] If other members of identified multiplets were present with the required intensity, the identification was assumed to be correct. Those CrII multiplets identified in our spectra which seemed to be well resolved and of sufficient intensity for lifetime analysis were noted.

3) High resolution scans were taken in the vicinity of those multiplets chosen to detect any unresolved structure that could influence the lifetime analysis. Table II gives a list of CrI and CrII lines identified.

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Table II

Lines of CrI and CrII identified in this spectrum

Wavelength (A)	gA ($10^8 nsec^{-1}$)	Wavelength (A)	gA ($10^8 nsec^{-1}$)	Wavelength (A)	gA ($10^8 nsec^{-1}$)
	CrI				
2739.38	26.	3639.80	77.	3050.14	44.
2741.07	36.	3743.58	42.	3118.65	32.
2742.17	37.	3743.88	50.	3120.37	60.
2986.00	23.	3757.66	20.	3124.94	66.
2986.47	34.	3768.24	18.	3132.06	85.
3014.92	21.	3804.80	74.	3136.68	20.
3017.57	44.	3963.69	93.	3147.23	20.
3021.56	47.	3969.75	75.	3180.70	35.
3039.78	29.	3976.66	74.	3197.08	32.
3053.88	11.	3983.91	45.	3209.18	25.
3109.34	10.	3991.12	44.	3217.40	20.
3110.86	10.			3295.43	12.
3119.25	18.			3360.30	35.
3119.71	15.			3368.05	46.
3148.44	29.		CrII	3378.34	12.
3155.15	35.	2055.52	9.1	3379.83	21.
3163.76	35.	2061.49	7.3	3421.21	18.
3237.73	20.	2065.42	4.8	3422.74	25.
3251.84	41.	2677.16	132.		
3257.82	41.	2800.77	24.		
3259.98	31.	2812.01	27.		
3346.02	29.	2818.36	21.		
3346.74	28.	2822.01	15.		
3433.60	44.	2822.37	56.		
3436.19	26.	2830.47	55.		
3445.62	28.	2840.02	36.		
3453.33	30.	2851.36	39.		
3455.60	20.	2897.67	19.		
3467.02	11.	2911.68	16.		
3467.72	19.	2921.24	33.		
3469.59	13.	2927.08	23.		
3481.30	14.	2928,15	25.		
3481.54	15.	2930.85	11.		
3494.97	15.	2935.14	28.		
3510.54	21.	2940.22	17.		
3566.16	38.	2946.84	22.		
3578.69	8.3	2971.91	66.		
3593.49	7.0	2979.74	61.		
3605.33	5.2	2985.32	36.		
3636.59	43.	2989.19	49.		

The Lifetimes: Experimental Procedure

In addition to the apparatus used for the spectral scans, the lifetime experiment required the use of a stepping motor and a control box (see Figure III). The stepping motor was used to step the foil up and down stream, the length of one step being 0.258 mm. The control box provided stepping voltage to the motor and a channel advance to the TMC. Since all lines chosen for analysis were in the region of 3000 A, the grating blazed at 3000 A was used for the lifetime runs. The foils used were measured by the Arizona Foil Company to be 2.0 $\mu gm/cm^2$ in thickness.

A lifetime measurement was made at 85 and 100 keV for each of the lines. Spectral lines were located by setting the monochromator for the appropriate wavelength and maximizing the count rate meter in that wavelength region. The slit widths were set at 100 or 150 microns depending upon the resolution required. The foil and the TMC were stepped at the same rate, i.e. 1.04 sec/channel and 1.04 sec/motor step. At this rate one run of 400 channels took approximately six minutes.

One run consisted, in most cases, of stepping the foil upstream a distance of approximately 3 cm and back downstream the same distance. This produced two decay curves for one run. In some cases the counting rate was such that the reversal was unnecessary. During each run the chamber was isolated from the accelerator for several seconds in order to measure the dark count. The dark count was measured to be from four to six counts per channel.

The beam current was monitored continuously in order to note any large fluctuations in the amount of beam delivered to the foil. When changes of more than 15% occured the run was discontinued. During most runs the beam current was quite steady and fluctuated no more than 5%. Because of the hydrocarbon buildup mentioned in the energy loss experiment the foils were not used for more than 15 min. The time elapsed on each foil was noted and is stated in the heading of each computer output (see the Appendix).

Lifetimes: The Results

Lifetime data was taken on five lines originating from four atomic levels in CrII. Figure XIII is a partial Grotrian Diagram showing the transitions whose lifetimes were measured and possible cascades into these levels of interest. A measurement was made on each line at two energies (85 and 100 keV). Each decay curve was analyzed separately, and an average over all of the data for each level was used to obtain the stated lifetimes.

The lifetimes were calculated from the decay curves using a four parameter least-squares fit to the double exponential function

$$F(t) = A \exp(-t/\tau_1) + B \exp(-t/\tau_2) + D,$$

where D is the measured dark count, and A and B are the amplitudes of the decays. The computer program used was written by Brand, Fox, and Keller. The Appendix is composed of photographic reductions of the final computer output.

Brand[14] has indicated that the fitting program will resolve a short component and a longer lived "cascade" component, but that the program will not resolve two short lived components. Therefore it is imperative that one know whether or not strong cascading occurs. Table III provides

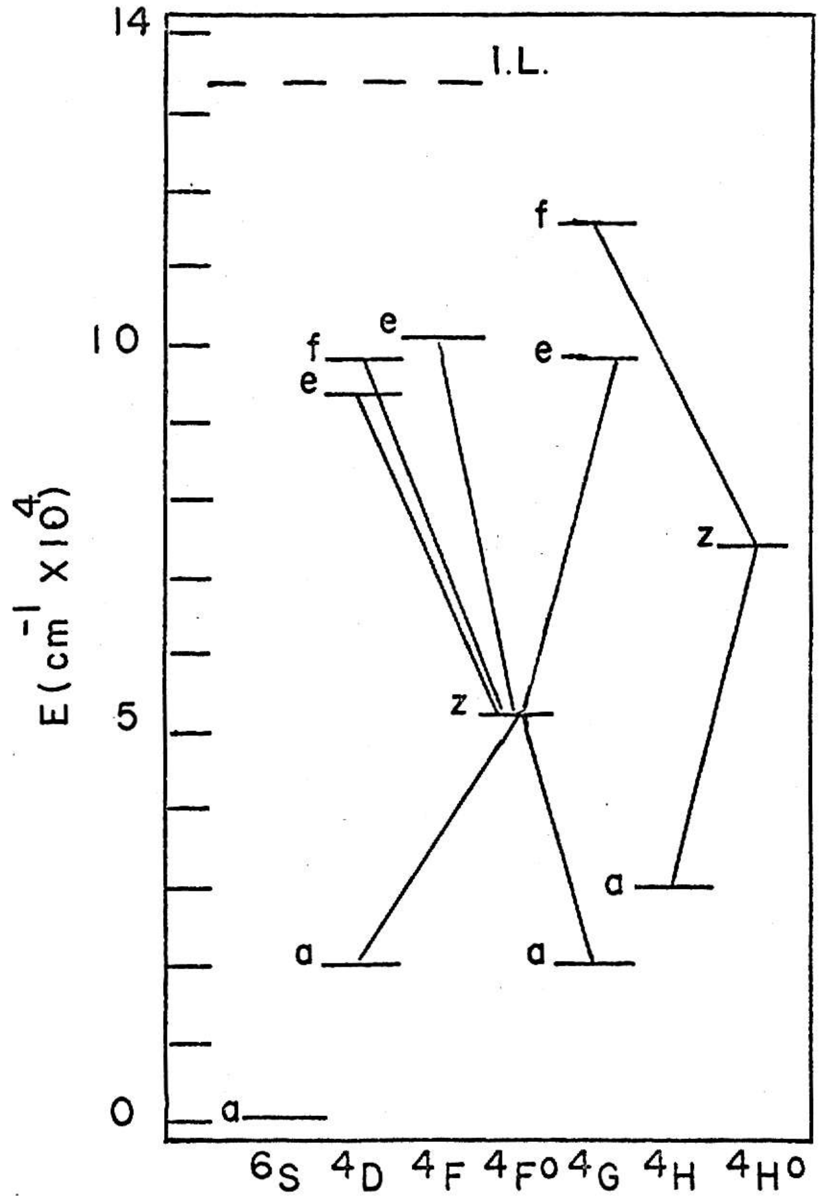

Fig. XIII.--A partial Grotrian Diagram of CrII

Table III

Possible cascades into levels of interest

Wavelength	I	Level	Configuration
Transitions into		$z^4H^o_{6\frac{1}{2}}$	$3d^4(a^3H)4p$
2415.23	5w	$f^4G_{5\frac{1}{2}}$	$3d^4(a^3G)5s$
Transitions into		$z^4H^o_{5\frac{1}{2}}$	$3d^4(a^3H)4p$
2404.72	2w	$f^4G_{5\frac{1}{2}}$	$3d^4(a^3G)5s$
2408.02	3w	$f^4G_{4\frac{1}{2}}$	$3d^4(a^3G)5s$
Transitions into		$z^4F^o_{4\frac{1}{2}}$	$3d^4(a^5D)4p$
3049.49	10w,1	$e^4D_{3\frac{1}{2}}$	$3d^4(a^5D)5s$
2569.40	152,1	$e^4F_{4\frac{1}{2}}$	$3d^4(a^5D)4d$
2577.74	10w	$e^4F_{3\frac{1}{2}}$	$3d^4(a^5D)4d$
2661.22	50w	$e^4G_{5\frac{1}{2}}$	$3d^4(a^5D)4d$
2674.26	7w	$e^4G_{4\frac{1}{2}}$	$3d^4(a^5D)4d$
Transitions into		$z^4F^o_{3\frac{1}{2}}$	$3d^4(a^5D)4p$
3056.66	8w,1	$e^4D_{2\frac{1}{2}}$	$3d^4(a^5D)5s$
2642.60	2w	$f^4D_{3\frac{1}{2}}$	$3d^4(a^5D)4d$
2652.78	3w,1	$f^4D_{2\frac{1}{2}}$	$3d^4(a^5D)4d$
2567.50	5w	$e^4F_{3\frac{1}{2}}$	$3d^4(a^5D)4d$
2576.45	2w	$e^4F_{2\frac{1}{2}}$	$3d^4(a^5D)4d$
2663.28	30w,1	$e^4G_{4\frac{1}{2}}$	$3d^4(a^5D)4d$
2674.07	8w	$e^4G_{3\frac{1}{2}}$	$3d^4(a^5D)4d$

a listing of all transitions into the levels studies given by Keiss.[15] There are no lines listed that occur in the spectral scans with a significant counting rate. The generally low intensities given by Keiss for these lines also suggest that one should not expect short lived cascades. Under these circumstances it was assumed that no strong cascades need be considered.

Table IV provides a summary of the lifetime analyses. The average value for each line are given for 85 and 100 keV, and an average lifetime for each level is stated. Note that there is no systematic relationship between the measured lifetime and the energy at which it was taken. This indicates that if a trend of this kind is present, its magnitude must be within the limits of the experiment. The errors quoted in Table V are based on the standard deviations of the lifetime measurements, and on an estimated possible error in the energy loss of 50%. The standard deviations ran between 0.1 and 0.4 nsec., while the error in energy loss produced an error in the lifetimes of 0.2 nsec.

Table IV.

The lifetimes measured at 85 and 100 keV for five lines

Wavelength (A)	Level	Lifetimes (nsec.) 85 keV	100 keV	Level
2971.9	$z^4H^o 6\frac{1}{2}$	5.3	4.6	5.0 ± 0.6
2979.7	$z^4H^o 5\frac{1}{2}$	4.9	4.7	4.8 ± 0.3
3124.9	$z^4F^o 3\frac{1}{2}$	5.0	4.9	5.0 ± 0.4
3132.1	$z^4F^o 4\frac{1}{2}$	4.9	5.2	4.9 ± 0.4
3180.8	$z^4F^o 4\frac{1}{2}$	4.8	4.7	

Since branching ratio measurements are needed before gf values can be derived for the transitions, the BF data cannot be compared directly to previous measurements of gf-values. To avoid this difficulty, lifetimes were derived from all gA-values given by CB for transitions out of the level of interest. A comparison was then made on the basis of these lifetimes (see Table V). These lifetimes were derived by summing all gA-values for transitions out of the level of interest and dividing by the g of the upper level. This is the total transition rate out of the level and its inverse is the lifetime of the level. The ratio of these lifetimes to BFS lifetimes should be equivalent to a ratio of gf-values. Thus the ratios of gf-values given in Table V compared to the ratio of lifetimes provides a method of inter-comparing our lifetime results with gf-values measured by other authors. Shackleford[14] has measured a gf-value for one line and Byard[15] has measured the gf-values for two lines originating from the $z^4F^o_{4\frac{1}{2}}$ level. It may be seen that these results give gf/gf(CB) in fair agreement with our τ(CB)/τ(BF) for that level.

One should note that the ratio of lifetimes is a factor of two higher for the lines at 2971.9 A and 2979.7 A. The reason for this discrepancy may be that some transitions out of the z^4H^o term were not seen by Corliss and Bozman. If this were true τ(CB) would be reduced, producing a more uniform ratio of lifetimes. In particular, lines at 2297.17 and 2307.19 A were not observed in the present spectrum nor does CB list gA-values for them, but Keiss lists them with substantial intensities (Table VII-VIII). This result may indicate experimental problems in observing this part of the spectrum (2250 to 2650 A) since there seems to be no structure in this region (see

Figure V). Although, the same arguments could be made for the z^4F^o levels, it is believed not to be the case since there is good agreement with gf-values measured by Schackleford and Byard gf-values for those transitions.

Table V.

A comparison of the measured lifetimes to the results of CB, Shackleford, and Byard

Wavelength (A)	τ(BF) (nsec)	τ(CB) (nsec)	τ(CB)/τ(BF)	gf(OSU)/gf(CB)	gf(S)/gf(CB)
2971.9	5.0	1.8	.36		
2979.7	4.8	1.7	.38		
3124.9	5.0	0.8	.16		
3132.1	4.9	0.7	.14	.09	.10
3180.8				.16	

The Solar Photospheric Abundance of Chromium

Two measurements are necessary before the calculation of the chromium abundance is possible. First, the branching ratios for the measured levels must be found, and second, the equivalent widths for the lines out of these levels must be measured in the solar spectrum. The branching ratios can easily be measured with conventional light sources. Problems exist in the measurement of the equivalent width of ultraviolet lines in the solar spectrum. The intensity of the continum in the UV region is low and the number of lines is large. Thus the exact height of the continum is not well known. This is not as much of a problem in the visible region and, as can be seen in Tables VI-IX,

Table VI

Transitions from the $z^4H^o_{5\frac{1}{2}}$ $(3d^4(a^3H)4p)$ level

Wavelength	I	gA	Level	Configuration	Solar Eq. Width
3552.42	2		$b^2H_{5\frac{1}{2}}$	$3d^5$	+
3540.23	2		$b^2H_{4\frac{1}{2}}$	$3d^5$	+
3442.98	1		$a^2H_{5\frac{1}{2}}$	$3d^4(a^3H)4s$	+
3421.62[(a)]	5		$a^2H_{4\frac{1}{2}}$	$3d^4(a^3H)4s$	2.3 min.
3315.28	12		$b^4G_{5\frac{1}{2}}$	$3d^4(a^3G)4s$	blended
3307.02	50	9.2	$b^4G_{4\frac{1}{2}}$	$3d^4(a^3G)4s$	blended
3225.44	8		$b^4F_{4\frac{1}{2}}$	$3d^5$	blended
3063.82	7		$a^4F_{4\frac{1}{2}}$	$3d^4(a^3H)4s$	78 m
2988.04	12		$a^4H_{6\frac{1}{2}}$	$3d^4(a^3H)4s$	blended
2979.73*	80	61	$a^4H_{5\frac{1}{2}}$	$3d^4(a^3H)4s$	?
2972.67	7w		$a^4H_{4\frac{1}{2}}$	$3d^4(a^3H)4s$	?
2307.19	35		$a^4G_{4\frac{1}{2}}$	$3d^5$	+
2306.81	10		$a^4G_{5\frac{1}{2}}$	$3d^5$	+

*Lifetime measured in this experiment.

+Not observed according to MMH.

?Principal contributor to blend.

(a) $a^2H_{5\frac{1}{2}}-z^4H^o_{6\frac{1}{2}}$ may be present.

Table VII

Transitions from the $z^4H^o_{6\frac{1}{2}}$ ($3d^4(a^3H)4p$) level

Wavelength	I	gA	Level	Configuration	Solar Eq. Width
4195.40	4		$b^2I_{6\frac{1}{2}}$	$3d^4(a^1I)rs$	11 m
3529.73	2		$b^2H_{5\frac{1}{2}}$	$3d^5$	+
3421.62[(a)]	5		$a^2H_{5\frac{1}{2}}$	$3d^4(a^3H)4s$	23
3295.42	50	12	$b^4G_{5\frac{1}{2}}$	$3d^4(a^3G)4s$	53
2971.90*	75	66	$a^4H_{6\frac{1}{2}}$	$3d^4(a^3H)4s$	?
2950.69	7		$a^2I_{6\frac{1}{2}}$	$3d^5$	+
2950.10[(b)]	10		$a^2I_{5\frac{1}{2}}$	$3d^5$	+
2297.17	50		$a^4G_{5\frac{1}{2}}$	$3d^5$	+

*Lifetime measured in this experiment.

+Not observed by M.M.H.

?Principal contributor to blend.

(a) $a^2H_{4\frac{1}{2}}-z^4H^o_{5\frac{1}{2}}$ transition may also be present.

(b) $b^4G_{4\frac{1}{2}}-z^2I^o_{5\frac{1}{2}}$ transition may also be present.

Table VIII

Transitions from the $z^4F^o_{3\frac{1}{2}}$ $(3d^4(a^3D)4p)$ level

Wavelength	I	gA	Level	Configuration	Solar Eq. Width
5502.07	40		$b^4G_{4\frac{1}{2}}$	$3d^4(a^3G)4s$	23
5472.60	12		$b^4G_{3\frac{1}{2}}$	$3d^4(a^3G)4s$	+
5280.08	30		$b^4F_{2\frac{1}{2}}$	$3d^5$	blended
5279.88	50		$b^4F_{4\frac{1}{2}}$	$3d^5$	18
5274.99	75		$b^4F_{3\frac{1}{2}}$	$3d^5$	blended
4860.20	20		$a^4F_{4\frac{1}{2}}$	$3d^4(a^3F)4s$	9
4848.24	75		$a^4F_{3\frac{1}{2}}$	$3d^4(a^3F)4s$	52
4836.22	25		$a^4F_{2\frac{1}{2}}$	$3d^4(a^3F)4s$	blended
3738.38	35		$c^4D_{2\frac{1}{2}}$	$3d^4(a^3D)4s$	blended
3736.56	1		$b^4D_{3\frac{1}{2}}$	$3d^5$	+
3336.16	2		$a^4P_{2\frac{1}{2}}$	$3d^5$	+
3197.08	75	32	$a^4G_{4\frac{1}{2}}$	$3d^5$	blended
3196.93	20		$a^4G_{3\frac{1}{2}}$	$3d^5$	blended
3196.35	3		$a^4G_{2\frac{1}{2}}$	$3d^5$	39
3147.22(a)	50	20	$a^4D_{3\frac{1}{2}}$	$3d^4(a^5D)4s$	blended
3124.94*	40	66	$a^4D_{2\frac{1}{2}}$	$3d^4(a^5D)4s$	149
2544.26	15		$a^6D_{4\frac{1}{2}}$	$3d^4(a^5D)4s$	+
2531.84	25		$a^6D_{3\frac{1}{2}}$	$3d^4(a^5D)4s$	+

*Lifetime measured in this experiment.

+Not observed by MMH.

?Principal contributor to blend.

(a) $b^4G_{4\frac{1}{2}}-z^4G^o_{4\frac{1}{2}}$ transition may be present.

Table IX

Transitions from the $z^4F^o_{4\frac{1}{2}}$ $(3d^4(a^3D)4p)$ level

Wavelength	I	gA	Level	Configuration	Solar Eq. Width
7311.60	2		$c^4D_{3\frac{1}{2}}$	$3d^4(a^3D)4s$	5
6478.37	50		$b^4G_{5\frac{1}{2}}$	$3d^4(a^3G)4s$	+
5455.86	8		$b^4G_{4\frac{1}{2}}$	$3d^4(a^3G)4s$	+
5237.35	100		$b^4F_{4\frac{1}{2}}$	$3d^5$	49
5232.54	20		$b^4F_{3\frac{1}{2}}$	$3d^5$	12
4824.12	100		$a^4F_{4\frac{1}{2}}$	$3d^4(a^3F)4s$	94
4812.34	25		$a^4F_{3\frac{1}{2}}$	$3d^4(a^3F)4s$	41
3715.18	25		$b^4D_{3\frac{1}{2}}$	$3d^5$	58
3181.42	20	4.6	$a^4G_{4\frac{1}{2}}$	$3d^5$	blended
3180.70*	75	35	$a^4G_{5\frac{1}{2}}$	$3d^5$	blended
3132.05*	100	85	$a^4D_{3\frac{1}{2}}$	$3d^4(a^5D)4s$	137
2534.33	40	6.4	$a^6D_{4\frac{1}{2}}$	$3d^4(a^5D)4s$	+
2522.01	4		$a^6D_{3\frac{1}{2}}$	$3d^4(a^5D)4s$	+

*Lifetime measured in this experiment.

+Not observed by M.M.H.

?Principal contributor to blend.

which are a compilation from Keiss[14] and Moore, Minnaert, and Houtgast[18], lines from the levels measured do exist in the visible. Thus, a relatively straight forward experiment to measure the branching ratios will produce many gf values for lines which may be useful in the solar abundance problem.

Although, the measured lifetimes alone do not determine the abundance unambigouously, one may derive an approximate abundance by comparison. Warner[19,20] has measured gf values in CrII and has derived an abundance of log $N_{Cr} = 5.47$, where log $N_H = 12$, based on those gf-values. Warner's gf-values may not be compared to the BF lifetimes directly, as there are no lines in common, but a comparison of both measurements to CB will produce a correction to the abundance given by Warner.

Table X compares gf-values taken from CB with those of several authors and with the results of this experiment. The value of 0.82 dex for the CB-BF comparison was arrived at on the assumption that strong transitions out of the z^4H^o levels do exist and were not observed by CB. The correction is thus the log of the average of the two ratios listed in Table VI for the z^4F^o transitions.

The value obtained by Cocke, Stark, and Evans[3] based on BFS lifetimes for neutral chromium is 5.80. The correction of 0.82 dex from the present study would indicate a value of 5.54 for log N_{Cr}. Although the branching ratios must be measured before any firm conclusions are possible, one might seek an explanation for the large disparity in the gf-values of log N_{Cr}, either in the ionization equilibrium for chromium or in the abundance of 5.47 given by Warner.

Table X

A comparison of the measured lifetimes to the gA values of others

log gf(CB-Warner)	0.75 dex
log gf(CB-Byard)	0.89 dex
log gf(CB-Shackleford)	0.95 dex
log gf(CB-Huber and Tobey)	0.94 dex
log gf(CB-Wolnik et al)	0.60 dex
log (BF-CB)	0.82 dex

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FOOTNOTES

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Figure XIV. A. Part one of the 100 keV lifetime fit for the line at 2971.9 A

ILLEGIBLE DOCUMENT

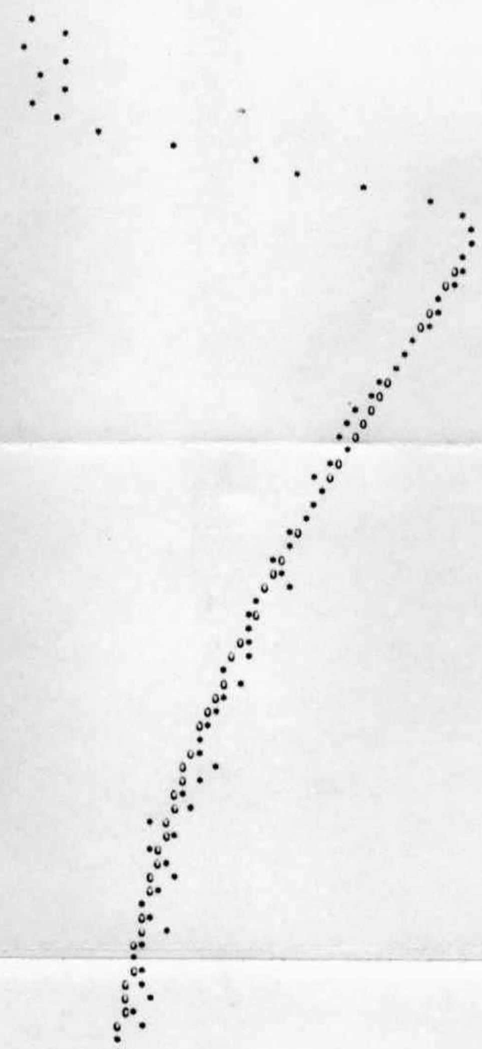
THE FOLLOWING DOCUMENT(S) IS OF POOR LEGIBILITY IN THE ORIGINAL

THIS IS THE BEST COPY AVAILABLE

P-474

2971.9A RUN #2 PART 1 FOIL #1 TIME ON FOIL 9 TO 16 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 17

DIST(NS)	DATA	FIT
0.46	13.000	1.0000
0.91	14.000	1.0000
1.37	9.000	1.0000
1.82	14.000	1.0000
2.28	11.000	1.0000
2.73	15.000	1.0000
3.19	10.000	1.0000
3.65	13.000	1.0000
4.10	20.000	1.0000
4.56	48.000	1.0000
5.01	115.000	1.0000
5.47	188.000	1.0000
5.93	416.000	1.0000
6.38	825.000	1.0000
6.84	1214.000	1.0000
7.29	1291.000	1.0000
7.75	1275.000	1366.227
8.20	1196.000	1237.804
8.66	1198.000	1121.736
9.12	1106.000	1016.831
9.57	951.000	922.013
10.03	910.000	836.309
10.48	815.000	758.841
10.94	719.000	688.813
11.39	622.000	625.509
11.85	560.000	568.280
12.31	497.000	516.540
12.76	425.000	469.760
13.22	379.000	427.463
13.67	341.000	389.216
14.13	295.000	354.628
14.58	318.000	323.347
15.04	266.000	295.054
15.50	238.000	269.461
15.95	250.000	246.309
16.41	221.000	225.361
16.86	208.000	206.406
17.32	166.000	189.252
17.78	171.000	173.725
18.23	141.000	159.665
18.69	153.000	146.942
19.14	166.000	135.415
19.60	123.000	124.975
20.05	114.000	115.515
20.51	111.000	106.943
20.97	109.000	99.172
21.42	113.000	92.125
21.88	82.000	85.733
22.33	96.000	79.934
22.79	85.000	74.669
23.24	79.000	69.889
23.70	72.000	65.545
24.16	66.000	61.598
24.61	61.000	58.007
25.07	73.000	54.741
25.52	62.000	51.766
25.98	53.000	49.057
26.43	58.000	46.586
26.89	36.000	44.332
27.35	47.000	42.274
27.80	37.000	40.393
28.26	42.000	38.672
28.71	47.000	37.096
29.17	39.000	35.652
29.63	34.000	34.327
30.08	37.000	33.109
30.54	44.000	31.989
30.99	34.000	30.957
31.45	30.000	30.005
31.90	34.000	29.126
32.36	32.000	28.313
32.82	35.000	27.555
33.27	29.000	26.859
33.73	33.000	26.209
34.18	26.000	25.603
34.64	25.000	25.037
35.09	22.000	24.505
35.55	19.000	24.014
36.01	30.000	23.549
36.46	34.000	23.112
36.92	30.000	22.700
37.37	15.000	22.311
37.83	21.000	21.944
38.28	22.000	21.595
38.74	26.000	21.264
39.20	19.000	20.949
39.65	20.000	20.648
40.11	21.000	20.361
40.56	24.000	20.086
41.02	33.000	19.823
41.48	13.000	19.569
41.93	18.000	19.326
42.39	20.000	19.091
42.84	27.000	18.864
43.30	12.000	18.645
43.75	18.000	18.433
44.21	14.000	18.227
44.67	23.000	18.027
45.12	18.000	17.833
45.58	22.000	17.644
46.03	22.000	17.460
46.49	16.000	17.280
46.94	24.000	17.105
47.40	8.000	16.934
47.86	23.000	16.766
48.31	10.000	16.602
48.77	18.000	16.441
49.22	24.000	16.284
49.68	17.000	16.129
50.13	18.000	15.978
50.59	14.000	15.829
51.05	21.000	15.683
51.50	13.000	15.539
51.96	22.000	15.397
52.41	19.000	15.258
52.87	12.000	15.121
53.33	13.000	14.986
53.78	15.000	14.854
54.24	14.000	14.723
54.69	13.000	14.594
55.15	11.000	14.467
55.60	13.000	14.342
56.06	23.000	14.218
56.52	9.000	14.097
56.97	9.000	13.977
57.43	18.000	13.858
57.88	15.000	13.741
58.34	8.000	13.626



INTERCEPT-1 IS 7444.8523 SLOPE-1 IS -0.2226 TAU-1 IS 4.4924 NSEC

INTERCEPT-2 IS 43.2345 SLOPE-2 IS -0.0258 TAU-2 IS 38.7698 NSEC
THE PEAK IS AT OR NEAR CHANNEL 17
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 37.4747
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.78742640 00
2 1.77336770 00
3 1.75961560 00
4 1.74668710 00

Figure XIV. B. Part two of the 100 keV lifetime fit for the line at 2971.9 A

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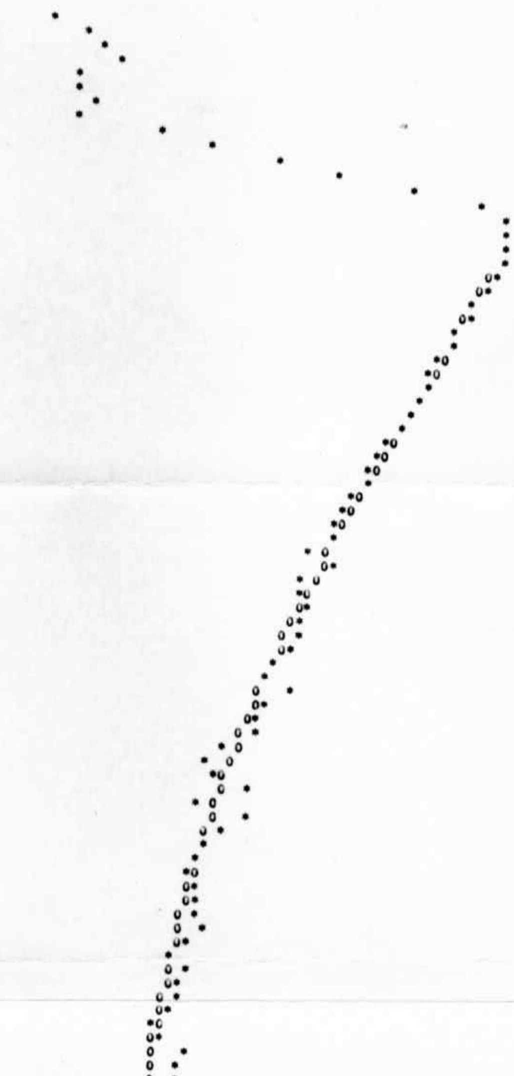
2971.9A   RUN #2   PART 2   FOIL #1    TIME ON FOIL 9 TO 16 MIN      100 KV
MASS=   52.     ENERGY=   87. KEV      1/V=    1.7666 NSEC/MM     DARK COUNTS=    4.
THERE WERE    0.25800    MM/CHANNEL
START FIT IN CHANNEL NO    18
```

DIST(NS)	DATA	FIT
0.46	7.000	1.0000
0.91	10.000	1.0000
1.37	12.000	1.0000
1.82	15.000	1.0000
2.28	9.000	1.0000
2.73	9.000	1.0000
3.19	11.000	1.0000
3.65	9.000	1.0000
4.10	23.000	1.0000
4.56	41.000	1.0000
5.01	87.000	1.0000
5.47	153.000	1.0000
5.93	361.000	1.0000
6.38	729.000	1.0000
6.84	995.000	1.0000
7.29	997.000	1.0000
7.75	981.000	1.0000
8.20	958.000	955.105
8.66	907.000	870.451
9.12	796.000	793.517
9.57	717.000	723.597
10.03	664.000	660.049
10.48	590.000	602.289
10.94	554.000	549.789
11.39	499.000	502.068
11.85	428.000	458.687
12.31	436.000	419.251
12.76	382.000	383.399
13.22	351.000	350.802
13.67	330.000	321.163
14.13	285.000	294.212
14.58	253.000	269.703
15.04	231.000	247.412
15.50	223.000	227.137
15.95	199.000	208.694
16.41	176.000	191.915
16.86	156.000	176.649
17.32	152.000	162.756
17.78	120.000	150.113
18.23	160.000	138.603
18.69	105.000	128.125
19.14	112.000	118.583
19.60	119.000	109.893
20.05	106.000	101.977
20.51	108.000	94.764
20.97	100.000	88.190
21.42	87.000	82.196
21.88	75.000	76.731
22.33	100.000	71.746
22.79	78.000	67.196
23.24	69.000	63.043
23.70	69.000	59.251
24.16	49.000	55.786
24.61	40.000	52.619
25.07	42.000	49.723
25.52	62.000	47.073
25.98	38.000	44.648
26.43	61.000	42.426
26.89	49.000	40.389
27.35	41.000	38.521
27.80	35.000	36.806
28.26	33.000	35.230
28.71	36.000	33.782
29.17	35.000	32.449
29.63	38.000	31.221
30.08	40.000	30.090
30.54	32.000	29.045
30.99	27.000	28.079
31.45	33.000	27.186
31.90	31.000	26.359
32.36	30.000	25.592
32.82	27.000	24.880
33.27	22.000	24.217
33.73	26.000	23.601
34.18	34.000	23.025
34.64	31.000	22.488
35.09	30.000	21.985
35.55	28.000	21.514
36.01	27.000	21.072
36.46	28.000	20.656
36.92	21.000	20.265
37.37	26.000	19.895
37.83	28.000	19.546
38.28	15.000	19.216
38.74	16.000	18.902
39.20	16.000	18.604
39.65	16.000	18.321
40.11	17.000	18.051
40.56	22.000	17.792
41.02	23.000	17.546
41.48	16.000	17.309
41.93	19.000	17.082
42.39	22.000	16.864
42.84	17.000	16.654
43.30	14.000	16.451
43.75	14.000	16.256
44.21	26.000	16.067
44.67	14.000	15.884
45.12	20.000	15.706
45.58	16.000	15.534
46.03	8.000	15.367
46.49	13.000	15.204
46.94	11.000	15.046
47.40	18.000	14.891
47.86	15.000	14.741
48.31	16.000	14.593
48.77	24.000	14.450
49.22	12.000	14.309
49.68	17.000	14.172
50.13	21.000	14.037
50.59	18.000	13.905
51.05	16.000	13.776
51.50	10.000	13.649
51.96	16.000	13.524
52.41	12.000	13.402
52.87	7.000	13.281
53.33	20.000	13.163
53.78	9.000	13.047
54.24	6.000	12.933
54.69	21.000	12.820
55.15	8.000	12.710
55.60	6.000	12.601
56.06	15.000	12.493
56.52	20.000	12.388
56.97	20.000	12.283
57.43	10.000	12.181
57.88	12.000	12.080
58.34	8.000	11.980



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INTERCEPT-1 IS 5183.6820     SLOPE-1 IS   -0.2106     TAU-1 IS    4.7475 NSEC

INTERCEPT-2 IS    37.7253    SLOPE-2 IS   -0.0267     TAU-2 IS   37.4831 NSEC
THE PEAK IS AT OR NEAR CHANNEL    17
THE RATIO OF COEFFICIENTS AT THE FOIL IS:   33.03666
RUN PROCESSED 3 JULY 72.
```

CHISQR

```
1  1.52030650 00
2  1.50613220 00
3  1.49242910 00
4  1.47948860 00
```

Figure XIV. C. Part one of the 85 keV lifetime fit for the line at 2971.9 A

2971.9A RUN #11 PART 1 FOIL #6 TIME ON FOIL 0 TO 4 MIN 85 KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 30

DIST(NS)	DATA	FIT
0.50	3.000	1.0000
1.00	1.000	1.0000
1.50	4.000	1.0000
2.00	2.000	1.0000
2.51	5.000	1.0000
3.01	7.000	1.0000
3.51	8.000	1.0000
4.01	5.000	1.0000
4.51	2.000	1.0000
5.01	7.000	1.0000
5.51	2.000	1.0000
6.01	5.000	1.0000
6.51	7.000	1.0000
7.01	5.000	1.0000
7.52	9.000	1.0000
8.02	7.000	1.0000
8.52	4.000	1.0000
9.02	5.000	1.0000
9.52	3.000	1.0000
10.02	7.000	1.0000
10.52	10.000	1.0000
11.02	6.000	1.0000
11.52	6.000	1.0000
12.02	11.000	1.0000
12.53	24.000	1.0000
13.03	52.000	1.0000
13.53	172.000	1.0000
14.03	315.000	1.0000
14.53	472.000	1.0000
15.03	407.000	444.378
15.53	449.000	404.864
16.03	366.000	368.910
16.53	360.000	336.195
17.03	312.000	306.427
17.54	327.000	279.341
18.04	242.000	254.695
18.54	217.000	232.268
19.04	209.000	211.861
19.54	172.000	193.292
20.04	190.000	176.395
20.54	173.000	161.019
21.04	142.000	147.028
21.54	117.000	134.295
22.04	106.000	122.709
22.55	99.000	112.165
23.05	104.000	102.570
23.55	113.000	93.838
24.05	89.000	85.891
24.55	92.000	78.659
25.05	73.000	72.077
25.55	61.000	66.086
26.05	59.000	60.634
26.55	41.000	55.671
27.05	39.000	51.154
27.56	47.000	47.043
28.06	39.000	43.300
28.56	34.000	39.893
29.06	41.000	36.791
29.56	25.000	33.968
30.06	33.000	31.397
30.56	33.000	29.056
31.06	35.000	26.925
31.56	25.000	24.984
32.06	30.000	23.217
32.57	27.000	21.607
33.07	16.000	20.141
33.57	18.000	18.806
34.07	20.000	17.589
34.57	21.000	16.481
35.07	18.000	15.471
35.57	15.000	14.551
36.07	16.000	13.712
36.57	25.000	12.947
37.07	16.000	12.250
37.58	22.000	11.615
38.08	14.000	11.035
38.58	13.000	10.506
39.08	14.000	10.024
39.58	16.000	9.583
40.08	4.000	9.181
40.58	12.000	8.814
41.08	10.000	8.479
41.58	10.000	8.173
42.08	12.000	7.893
42.59	8.000	7.637
43.09	15.000	7.403
43.59	9.000	7.189
44.09	13.000	6.993
44.59	6.000	6.814
45.09	9.000	6.649
45.59	4.000	6.499
46.09	8.000	6.360
46.59	10.000	6.233
47.09	10.000	6.117
47.60	12.000	6.010
48.10	10.000	5.911
48.60	10.000	5.820
49.10	8.000	5.737
49.60	7.000	5.660
50.10	10.000	5.588
50.60	2.000	5.523
51.10	7.000	5.462
51.60	9.000	5.406
52.10	1.000	5.353
52.61	3.000	5.305
53.11	5.000	5.260
53.61	6.000	5.218
54.11	3.000	5.179
54.61	9.000	5.143
55.11	7.000	5.109
55.61	3.000	5.077
56.11	7.000	5.047
56.61	6.000	5.019
57.11	3.000	4.993
57.62	7.000	4.968
58.12	6.000	4.945
58.62	4.000	4.923
59.12	5.000	4.902
59.62	8.000	4.882
60.12	6.000	4.863
60.62	6.000	4.845
61.12	7.000	4.828
61.62	5.000	4.812
62.12	9.000	4.796
62.63	3.000	4.781
63.13	7.000	4.767
63.63	5.000	4.754
64.13	3.000	4.740

INTERCEPT-1 IS 7455.0473 SLOPE-1 IS -0.1886 TAU-1 IS 5.3024 NSEC

INTERCEPT-2 IS 7.6152 SLOPE-2 IS -0.0256 TAU-2 IS 39.0155 NSEC
THE PEAK IS AT OR NEAR CHANNEL 29
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 209.64253
RUN PROCESSED 3 MAY 72.

CHISQR

1 2.56829290 00
2 1.63371670 00
3 1.62911750 00
4 1.62670860 00

Figure XIV. D. Part two of the 85 keV lifetime fit for the line at 2971.9 A

```
2971.9A   RUN #11   PART 2   FOIL #6   TIME ON FOIL 0 TO 4 MIN        85 KV
MASS=   52.      ENERGY=   72. KEV      1/V=    1.9419 NSEC/MM      DARK COUNTS=    4.
THERE WERE   0.25900   MM/CHANNEL
START FIT IN CHANNEL NO   19
```

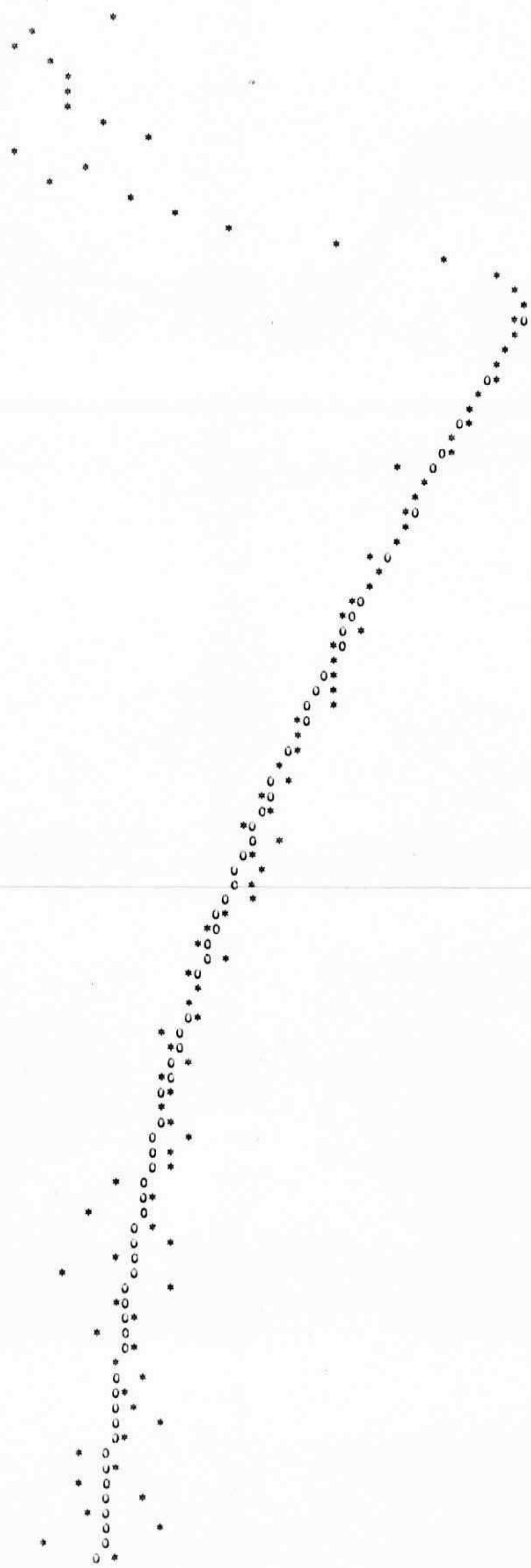
DIST(NS)	DATA	FIT
0.50	1.000	1.0000
1.00	1.000	1.0000
1.50	1.000	1.0000
2.00	1.000	1.0000
2.51	1.000	1.0000
3.01	2.000	1.0000
3.51	2.000	1.0000
4.01	1.000	1.0000
4.51	1.000	1.0000
5.01	1.000	1.0000
5.51	9.000	1.0000
6.01	4.000	1.0000
6.51	11.000	1.0000
7.01	44.000	1.0000
7.52	159.000	1.0000
8.02	325.000	1.0000
8.52	427.000	1.0000
9.02	504.000	1.0000
9.52	491.000	450.371
10.02	424.000	410.981
10.52	379.000	375.099
11.02	341.000	342.414
11.52	323.000	312.640
12.02	274.000	285.516
12.53	270.000	260.808
13.03	231.000	238.299
13.53	202.000	217.793
14.03	194.000	199.112
14.53	166.000	182.093
15.03	166.000	166.588
15.53	163.000	152.462
16.03	139.000	139.591
16.53	126.000	127.865
17.03	137.000	117.180
17.54	103.000	107.445
18.04	101.000	98.574
18.54	93.000	90.490
19.04	62.000	83.124
19.54	74.000	76.411
20.04	70.000	70.292
20.54	57.000	64.716
21.04	70.000	59.634
21.54	49.000	55.001
22.04	58.000	50.778
22.55	51.000	46.928
23.05	43.000	43.418
23.55	63.000	40.217
24.05	43.000	37.299
24.55	39.000	34.637
25.05	47.000	32.210
25.55	37.000	29.996
26.05	26.000	27.976
26.55	32.000	26.132
27.05	30.000	24.450
27.56	35.000	22.915
28.06	25.000	21.514
28.56	26.000	20.235
29.06	25.000	19.066
29.56	22.000	17.999
30.06	21.000	17.024
30.56	11.000	16.133
31.06	16.000	15.319
31.56	14.000	14.574
32.06	16.000	13.893
32.57	9.000	13.269
33.07	11.000	12.699
33.57	13.000	12.176
34.07	14.000	11.698
34.57	12.000	11.259
35.07	11.000	10.857
35.57	10.000	10.498
36.07	18.000	10.149
36.57	4.000	9.838
37.07	6.000	9.552
37.58	11.000	9.289
38.08	12.000	9.047
38.58	7.000	8.824
39.09	8.000	8.619
39.58	9.000	8.429
40.08	6.000	8.254
40.58	10.000	8.092
41.08	9.000	7.942
41.59	14.000	7.804
42.08	6.000	7.675
42.59	4.000	7.555
43.09	7.000	7.444
43.59	7.000	7.341
44.09	13.000	7.244
44.59	15.000	7.154
45.09	7.000	7.070
45.59	6.000	6.991
46.09	10.000	6.917
46.59	11.000	6.849
47.09	7.000	6.783
47.60	4.000	6.721
48.10	9.000	6.663
48.60	17.000	6.608
49.10	8.000	6.556
49.60	4.000	6.507
50.10	5.000	6.460
50.60	6.000	6.416
51.10	9.000	6.373
51.60	13.000	6.332
52.10	9.000	6.294
52.61	7.000	6.256
53.11	7.000	6.221
53.61	10.000	6.186
54.11	9.000	6.153
54.61	4.000	6.122
55.11	4.000	6.091
55.61	6.000	6.061
56.11	4.000	6.032

```
INTERCEPT-1 IS 2502.0061      SLOPE-1 IS    -0.1865      TAU-1 IS     5.3626 NSEC

INTERCEPT-2 IS     6.6528      SLOPE-2 IS    -0.0218      TAU-2 IS    45.8764 NSEC
THE PEAK IS AT OR NEAR CHANNEL     19 .
THE RATIO OF COEFFICIENTS AT THE FOIL IS:    88.58157
RUN PROCESSED 3 JULY 72.

        CHISQR

    1  2.05506380 00
    2  1.46592240 00
    3  1.35949680 00
    4  1.25887150 00
```

Figure XV. A. Part one of the 100 keV lifetime fit for the line at 2979.7 A

2979.7A RUN #3 PART 1 FOIL #2 TIME ON FOIL 0 TO 4 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.24200 MM/CHANNEL
START FIT IN CHANNEL NO 21

DIST(NS)	DATA	FIT
0.43	13.000	1.0000
0.86	6.000	1.0000
1.28	5.000	1.0000
1.71	7.000	1.0000
2.14	8.000	1.0000
2.57	8.000	1.0000
2.99	8.000	1.0000
3.42	12.000	1.0000
3.85	19.000	1.0000
4.28	5.000	1.0000
4.70	10.000	1.0000
5.13	7.000	1.0000
5.56	16.000	1.0000
5.99	24.000	1.0000
6.41	45.000	1.0000
6.84	134.000	1.0000
7.27	383.000	1.0000
7.70	717.000	1.0000
8.12	856.000	1.0000
8.55	904.000	1.0000
8.98	837.000	880.785
9.41	836.000	807.259
9.83	777.000	740.015
10.26	709.000	678.515
10.69	663.000	622.268
11.12	595.000	570.823
11.54	544.000	523.768
11.97	504.000	480.729
12.40	452.000	441.360
12.83	434.000	405.348
13.25	259.000	372.405
13.68	321.000	342.268
14.11	297.000	314.696
14.54	266.000	289.471
14.96	283.000	266.390
15.39	253.000	245.272
15.82	189.000	225.946
16.25	202.000	208.261
16.67	191.000	192.075
17.10	162.000	177.261
17.53	147.000	163.701
17.96	166.000	151.287
18.38	127.000	139.922
18.81	130.000	129.516
19.24	134.000	119.986
19.67	128.000	111.259
20.09	135.000	103.264
20.52	88.000	95.941
20.95	94.000	89.231
21.38	94.000	83.081
21.80	75.000	77.445
22.23	82.000	72.278
22.66	65.000	67.540
23.09	70.000	63.195
23.51	54.000	59.209
23.94	78.000	55.551
24.37	58.000	52.193
24.80	64.000	49.111
25.22	59.000	46.280
25.65	59.000	43.679
26.08	45.000	41.289
26.51	35.000	39.091
26.93	33.000	37.069
27.36	43.000	35.209
27.79	29.000	33.496
28.22	32.000	31.919
28.64	29.000	30.465
29.07	32.000	29.124
29.50	22.000	27.887
29.93	25.000	26.745
30.35	29.000	25.689
30.78	23.000	24.714
31.21	25.000	23.811
31.64	23.000	22.975
32.06	24.000	22.200
32.49	30.000	21.481
32.92	24.000	20.813
33.35	25.000	20.193
33.77	15.000	19.616
34.20	21.000	19.078
34.63	11.000	18.577
35.06	21.000	18.109
35.48	25.000	17.672
35.91	14.000	17.263
36.34	8.000	16.879
36.77	24.000	16.520
37.19	15.000	16.182
37.62	18.000	15.864
38.05	12.000	15.564
38.48	18.000	15.282
38.90	15.000	15.015
39.33	19.000	14.762
39.76	16.000	14.523
40.19	17.000	14.296
40.61	23.000	14.080
41.04	16.000	13.874
41.47	10.000	13.678
41.90	14.000	13.491
42.32	10.000	13.313
42.75	19.000	13.141
43.18	11.000	12.977
43.61	22.000	12.820
44.03	7.000	12.668
44.46	14.000	12.522



INTERCEPT-1 IS 5611.6918 SLOPE-1 IS -0.2096 TAU-1 IS 4.7704 NSEC

INTERCEPT-2 IS 28.6466 SLOPE-2 IS -0.0286 TAU-2 IS 34.9206 NSEC
THE PEAK IS AT OR NEAR CHANNEL 20
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 41.68316
RUN PROCESSED 3 JULY 72.

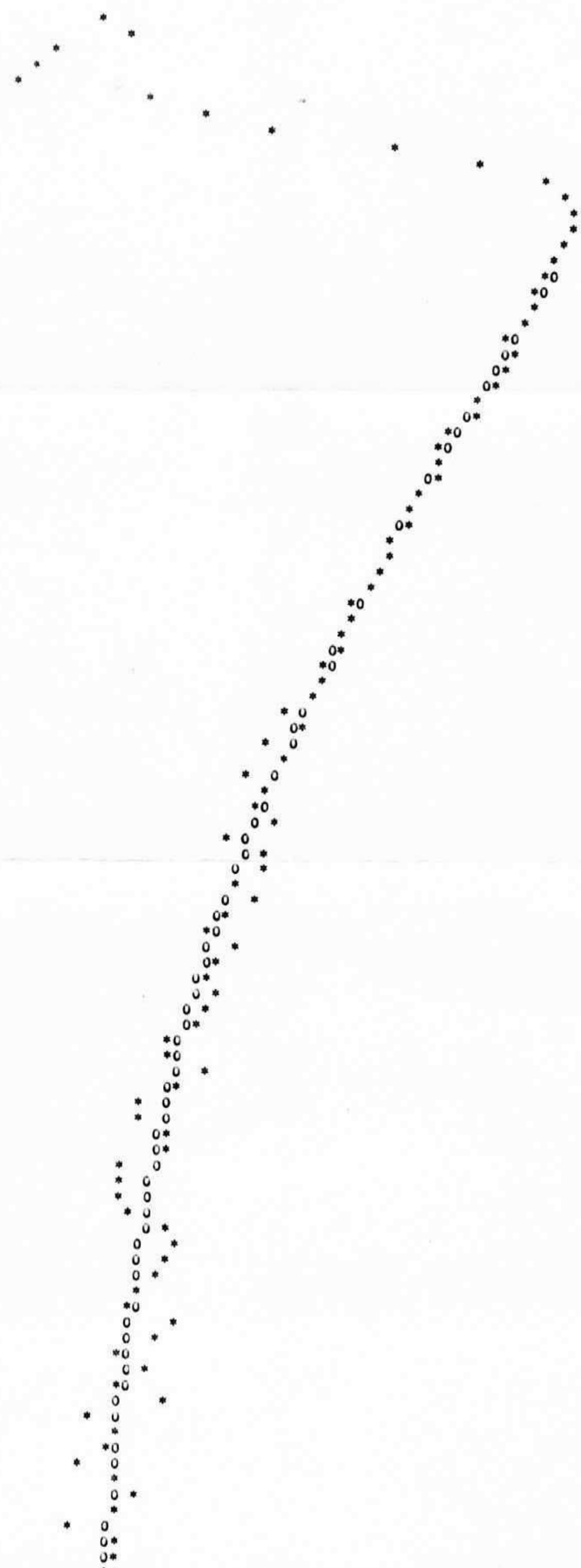
CHISQR

1 2.10516350 00
2 2.10388890 00
3 2.10269200 00
4 2.10151290 00

Figure XV. B. Part two of the 100 keV lifetime fit for the line at 2979.7 A

2979.7A RUN #3 PART 2 FOIL #2 TIME ON FOIL 0 TO 4 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.24200 MM/CHANNEL
START FIT IN CHANNEL NO 15

DIST(NS)	DATA	FIT
0.43	11.000	1.0000
0.86	15.000	1.0000
1.28	7.000	1.0000
1.71	6.000	1.0000
2.14	5.000	1.0000
2.57	17.000	1.0000
2.99	29.000	1.0000
3.42	55.000	1.0000
3.85	184.000	1.0000
4.28	447.000	1.0000
4.70	817.000	1.0000
5.13	1022.000	1.0000
5.56	1078.000	1.0000
5.99	1049.000	1.0000
6.41	982.000	1043.252
6.84	950.000	953.664
7.27	854.000	871.930
7.70	791.000	797.359
8.12	749.000	729.321
8.55	676.000	667.244
8.98	592.000	610.603
9.41	607.000	558.921
9.83	590.000	511.763
10.26	503.000	468.730
10.69	439.000	429.462
11.12	422.000	393.627
11.54	319.000	360.924
11.97	309.000	331.077
12.40	306.000	303.837
12.83	301.000	278.973
13.25	254.000	256.279
13.68	222.000	235.562
14.11	221.000	216.650
14.54	188.000	199.384
14.96	195.000	183.615
15.39	177.000	169.225
15.82	153.000	156.080
16.25	132.000	144.075
16.67	130.000	133.110
17.10	116.000	123.094
17.53	119.000	113.943
17.96	102.000	105.583
18.38	101.000	97.942
18.81	93.000	90.959
19.24	69.000	84.576
19.67	86.000	78.740
20.09	59.000	73.403
20.52	69.000	68.522
20.95	50.000	64.056
21.38	56.000	59.970
21.80	53.000	56.229
22.23	64.000	52.805
22.66	40.000	49.668
23.09	58.000	46.795
23.51	56.000	44.162
23.94	42.000	41.747
24.37	52.000	39.533
24.80	39.000	37.502
25.22	34.000	35.637
25.65	44.000	33.924
26.08	35.000	32.350
26.51	33.000	30.902
26.93	38.000	29.571
27.36	33.000	28.345
27.79	30.000	27.216
28.22	23.000	26.175
28.64	23.000	25.215
29.07	33.000	24.328
29.50	26.000	23.508
29.93	18.000	22.750
30.35	17.000	22.048
30.78	22.000	21.398
31.21	23.000	20.794
31.64	15.000	20.234
32.06	15.000	19.712
32.49	15.000	19.227
32.92	16.000	18.775
33.35	22.000	18.352
33.77	25.000	17.957
34.20	23.000	17.588
34.63	21.000	17.241
35.06	18.000	16.916
35.48	16.000	16.610
35.91	24.000	16.322
36.34	20.000	16.051
36.77	14.000	15.794
37.19	19.000	15.551
37.62	14.000	15.321
38.05	23.000	15.103
38.48	11.000	14.895
38.90	14.000	14.697
39.33	13.000	14.509
39.76	10.000	14.328
40.19	15.000	14.156
40.61	17.000	13.990
41.04	15.000	13.831
41.47	9.000	13.679
41.90	14.000	13.532
42.32	15.000	13.390
42.75	15.000	13.253



INTERCEPT-1 IS 4039.7828 SLOPE-1 IS -0.2151 TAU-1 IS 4.6484 NSEC

INTERCEPT-2 IS 26.4671 SLOPE-2 IS -0.0256 TAU-2 IS 38.9981 NSEC
THE PEAK IS AT OR NEAR CHANNEL 13
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 53.24791
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.18099630 00
2 1.18096220 00
3 1.18096210 00
4 1.18096200 00

Figure XV. C. Part one of the 85 keV lifetime fit for the line at 2979.7 A

2979.7 A RUN #10 PART 1 FOIL #5 TIME ON FOIL 4 TO 8 MIN .85KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 16

DIST(NS)	DATA	FIT
0.50	10.000	1.0000
1.00	15.000	1.0000
1.50	15.000	1.0000
2.00	16.000	1.0000
2.51	14.000	1.0000
3.01	7.000	1.0000
3.51	9.000	1.0000
4.01	25.000	1.0000
4.51	34.000	1.0000
5.01	139.000	1.0000
5.51	409.000	1.0000
6.01	887.000	1.0000
6.51	1163.000	1.0000
7.01	1310.000	1.0000
7.52	1259.000	1.0000
8.02	1172.000	1157.476
8.52	1021.000	1046.677
9.02	945.000	946.698
9.52	900.000	856.453
10.02	787.000	775.018
10.52	720.000	701.522
11.02	670.000	635.199
11.52	535.000	575.319
12.02	497.000	521.278
12.53	459.000	472.498
13.03	400.000	428.464
13.53	385.000	388.712
14.03	335.000	352.824
14.53	354.000	320.422
15.03	304.000	291.164
15.53	251.000	264.745
16.03	246.000	240.886
16.53	197.000	219.327
17.03	204.000	199.873
17.54	162.000	182.290
18.04	153.000	166.404
18.54	138.000	152.050
19.04	131.000	139.077
19.54	125.000	127.352
20.04	125.000	116.752
20.54	96.000	107.168
21.04	102.000	98.501
21.54	78.000	90.660
22.04	91.000	83.566
22.55	61.000	77.146
23.05	86.000	71.334
23.55	82.000	66.072
24.05	69.000	61.304
24.55	79.000	56.984
25.05	54.000	53.068
25.55	41.000	49.517
26.05	49.000	46.294
26.55	55.000	43.369
27.05	41.000	40.713
27.56	50.000	38.298
28.06	36.000	36.103
28.56	43.000	34.106
29.06	45.000	32.287
29.56	36.000	30.630
30.06	24.000	29.118
30.56	29.000	27.739
31.06	30.000	26.478
31.56	32.000	25.326
32.06	27.000	24.271
32.57	30.000	23.304
33.07	24.000	22.416
33.57	27.000	21.601
34.07	18.000	20.852
34.57	35.000	20.161
35.07	17.000	19.524
35.57	21.000	18.935
36.07	19.000	18.390
36.57	17.000	17.886
37.07	18.000	17.417
37.58	10.000	16.981
38.08	13.000	16.575
38.58	17.000	16.196
39.08	27.000	15.842
39.58	20.000	15.510
40.08	23.000	15.198
40.58	21.000	14.905
41.08	13.000	14.629
41.58	20.000	14.369
42.08	14.000	14.122
42.59	14.000	13.888
43.09	14.000	13.667
43.59	12.000	13.455
44.09	15.000	13.254
44.59	17.000	13.062
45.09	16.000	12.878
45.59	12.000	12.702
46.09	18.000	12.533
46.59	9.000	12.371
47.09	12.000	12.214
47.60	7.000	12.063
48.10	11.000	11.918
48.60	14.000	11.777
49.10	11.000	11.641
49.60	11.000	11.509
50.10	9.000	11.380
50.60	12.000	11.256
51.10	10.000	11.135
51.60	12.000	11.017
52.10	16.000	10.902
52.61	7.000	10.790
53.11	12.000	10.681
53.61	18.000	10.574
54.11	10.000	10.470
54.61	19.000	10.368
55.11	11.000	10.268
55.61	12.000	10.170
56.11	12.000	10.075
56.61	9.000	9.981
57.11	8.000	9.889
57.62	10.000	9.799
58.12	5.000	9.711
58.62	6.000	9.624
59.12	4.000	9.539
59.62	8.000	9.455
60.12	10.000	9.373
60.62	12.000	9.292
61.12	11.000	9.213
61.62	10.000	9.134
62.12	6.000	9.058
62.63	11.000	8.982
63.13	10.000	8.908
63.63	8.000	8.835
64.13	10.000	8.762

INTERCEPT-1 IS 5862.4638 SLOPE-1 IS -0.2055 TAU-1 IS 4.8655 NSEC

INTERCEPT-2 IS 31.4042 SLOPE-2 IS -0.0294 TAU-2 IS 33.9603 NSEC
THE PEAK IS AT OR NEAR CHANNEL 15
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 49.70569
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.22975470 00
2 1.22136670 00
3 1.21342720 00
4 1.20599920 00

Figure XV. D. Part two of the 85 keV lifetime fit for the line at 2979.7 A

2979.7 A RUN #10 PART 2 FOIL #5 TIME ON FOIL 4 TO 8 MIN 85KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25900. MM/CHANNEL
START FIT IN CHANNEL NO 19

DIST(NS)	DATA	FIT
0.50	1.000	1.000
1.00	1.000	1.000
1.50	1.000	1.000
2.00	1.000	1.000
2.51	1.000	1.000
3.01	2.000	1.0000
3.51	11.000	1.0000
4.01	14.000	1.0000
4.51	7.000	1.0000
5.01	12.000	1.0000
5.51	13.000	1.0000
6.01	20.000	1.0000
6.51	46.000	1.0000
7.01	145.000	1.0000
7.52	394.000	1.0000
8.02	788.000	1.0000
8.52	1022.000	1.0000
9.02	1127.000	1.0000
9.52	1015.000	1071.842
10.02	941.000	969.667
10.52	892.000	877.465
11.02	834.000	794.260
11.52	764.000	719.170
12.02	653.000	651.401
12.53	587.000	590.236
13.03	587.000	535.029
13.53	473.000	485.197
14.03	449.000	440.214
14.53	382.000	399.605
15.03	357.000	362.941
15.53	365.000	329.839
16.03	271.000	299.947
16.53	225.000	272.953
17.03	237.000	248.574
17.54	221.000	226.553
18.04	199.000	206.660
18.54	193.000	188.686
19.04	158.000	172.445
19.54	141.000	157.767
20.04	132.000	144.500
20.54	139.000	132.505
21.04	110.000	121.658
21.54	108.000	111.847
22.04	101.000	102.972
22.55	97.000	94.940
23.05	98.000	87.670
23.55	68.000	81.098
24.05	87.000	75.125
24.55	72.000	69.723
25.05	74.000	64.826
25.55	60.000	60.386
26.05	61.000	56.358
26.55	51.000	52.701
27.05	48.000	49.381
27.56	46.000	46.363
28.06	41.000	43.620
28.56	40.000	41.124
29.06	38.000	38.852
29.56	41.000	36.781
30.06	45.000	34.893
30.56	47.000	33.170
31.06	29.000	31.596
31.56	36.000	30.157
32.06	27.000	28.839
32.57	37.000	27.632
33.07	40.000	26.525
33.57	32.000	25.507
34.07	26.000	24.571
34.57	17.000	23.710
35.07	25.000	22.915
35.57	24.000	22.180
36.07	27.000	21.501
36.57	29.000	20.872
37.07	21.000	20.288
37.58	19.000	19.744
38.08	24.000	19.238
38.58	26.000	18.766
39.08	20.000	18.325
39.58	31.000	17.912
40.08	18.000	17.524
40.58	24.000	17.159
41.08	29.000	16.816
41.58	18.000	16.492
42.08	25.000	16.185
42.59	18.000	15.895
43.09	22.000	15.619
43.59	15.000	15.357
44.09	26.000	15.107
44.59	16.000	14.869
45.09	16.000	14.641
45.59	15.000	14.423
46.09	14.000	14.213
46.59	8.000	14.012
47.09	14.000	13.819
47.60	11.000	13.632
48.10	16.000	13.452
48.60	16.000	13.278
49.10	14.000	13.110
49.60	14.000	12.947
50.10	15.000	12.789
50.60	12.000	12.635
51.10	13.000	12.486
51.60	14.000	12.341
52.10	14.000	12.199
52.61	9.000	12.062
53.11	16.000	11.927
53.61	6.000	11.796
54.11	10.000	11.668
54.61	12.000	11.543
55.11	9.000	11.421
55.61	11.000	11.301
56.11	14.000	11.184
56.61	9.000	11.069
57.11	12.000	10.956
57.62	12.000	10.846
58.12	7.000	10.738
58.62	8.000	10.632
59.12	7.000	10.528
59.62	10.000	10.426
60.12	10.000	10.325
60.62	11.000	10.227
61.12	15.000	10.130
61.62	9.000	10.035
62.12	9.000	9.942
62.63	6.000	9.850
63.13	5.000	9.760
63.63	5.000	9.671
64.13	9.000	9.584

INTERCEPT-1 IS 7364.3427 SLOPE-1 IS -0.2058 TAU-1 IS 4.8592 NSEC

INTERCEPT-2 IS 39.3647 SLOPE-2 IS -0.0305 TAU-2 IS 32.7947 NSEC
THE PEAK IS AT OR NEAR CHANNEL 18
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 38.49967
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.28461730 00
2 1.25416170 00
3 1.23703310 00
4 1.22067850 00

Figure XVI. A. Part one of the 100 keV lifetime fit for the line at 3124.9 A

3124.9A RUN #4 PART 1 FOIL #2 TIME ON FOIL 4 TO 10 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 18

DIST(NS)	DATA	FIT
0.46	5.000	1.0000
0.91	4.000	1.0000
1.37	1.000	1.0000*
1.82	5.000	1.0000
2.28	2.000	1.0000
2.73	3.000	1.0000
3.19	4.000	1.0000
3.65	11.000	1.0000
4.10	5.000	1.0000
4.56	12.000	1.0000
5.01	12.000	1.0000
5.47	62.000	1.0000
5.93	153.000	1.0000
6.38	311.000	1.0000
6.84	519.000	1.0000
7.29	563.000	1.0000
7.75	542.000	1.0000
8.20	548.000	546.429
8.66	544.000	497.621
9.12	430.000	453.261
9.57	397.000	412.941
10.03	323.000	376.294
10.48	341.000	342.984
10.94	337.000	312.705
11.39	261.000	285.180
11.85	253.000	260.159
12.31	246.000	237.413
12.76	247.000	216.734
13.22	213.000	197.932
13.67	212.000	180.838
14.13	164.000	165.294
14.58	166.000	151.160
15.04	158.000	138.306
15.50	146.000	126.616
15.95	137.000	115.984
16.41	130.000	106.313
16.86	96.000	97.515
17.32	99.000	89.511
17.78	72.000	82.229
18.23	63.000	75.602
18.69	42.000	69.571
19.14	52.000	64.082
19.60	56.000	59.085
20.05	41.000	54.536
20.51	50.000	50.394
20.97	55.000	46.621
21.42	39.000	43.184
21.88	49.000	40.053
22.33	39.000	37.199
22.79	36.000	34.598
23.24	35.000	32.227
23.70	25.000	30.064
24.16	34.000	28.092
24.61	26.000	26.291
25.07	18.000	24.648
25.52	38.000	23.148
25.98	24.000	21.777
26.43	28.000	20.525
26.89	31.000	19.380
27.35	17.000	18.333
27.80	18.000	17.375
28.26	18.000	16.498
28.71	20.000	15.694
29.17	17.000	14.958
29.63	18.000	14.282
30.08	14.000	13.662
30.54	15.000	13.093
30.99	11.000	12.570
31.45	12.000	12.089
31.90	12.000	11.646
32.36	16.000	11.238
32.82	23.000	10.862
33.27	6.000	10.515
33.73	10.000	10.194
34.18	12.000	9.898
34.64	8.000	9.623
35.09	12.000	9.369
35.55	10.000	9.133
36.01	12.000	8.913
36.46	11.000	8.710
36.92	8.000	8.520
37.37	8.000	8.343
37.83	11.000	8.177
38.28	10.000	8.023
38.74	10.000	7.878
39.20	5.000	7.742
39.65	9.000	7.615
40.11	11.000	7.495
40.56	7.000	7.382
41.02	14.000	7.275
41.48	8.000	7.175
41.93	10.000	7.080
42.39	6.000	6.990
42.84	7.000	6.904
43.30	7.000	6.823
43.75	6.000	6.746
44.21	9.000	6.672
44.67	3.000	6.602
45.12	8.000	6.535
45.58	8.000	6.471
46.03	3.000	6.409
46.49	5.000	6.350
46.94	11.000	6.294
47.40	5.000	6.239
47.86	6.000	6.187
48.31	9.000	6.136
48.77	6.000	6.088
49.22	6.000	6.041
49.68	2.000	5.995
50.13	10.000	5.951
50.59	8.000	5.909

INTERCEPT-1 IS 2936.1560 SLOPE-1 IS -0.2104 TAU-1 IS 4.7537 NSEC

INTERCEPT-2 IS 15.2183 SLOPE-2 IS -0.0418 TAU-2 IS 23.9313 NSEC
THE PEAK IS AT OR NEAR CHANNEL 16
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 57.39299
RUN PROCESSED 3 JULY 72.

CHISQR

1	1.54311980 00
2	1.54181400 00
3	1.54062530 00
4	1.53949820 00

Figure XVI. B. Part two of the 100 keV lifetime fit for the line at 3124.9 A

3124.9A RUN #4 PART 2 FOIL #2 TIME ON FOIL 4 TO 10 MIN
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM 100 KV
THERE WERE 0.25800 MM/CHANNEL DARK COUNTS= 4.
START FIT IN CHANNEL NO 12

DIST(NS)	DATA	FIT
0.46	7.000	1.0000
0.91	5.000	1.0000
1.37	7.000	1.0000
1.82	3.000	1.0000
2.28	12.000	1.0000
2.73	29.000	1.0000
3.19	85.000	1.0000
3.65	208.000	1.0000
4.10	290.000	1.0000
4.56	361.000	1.0000
5.01	391.000	1.0000
5.47	346.000	349.479
5.93	321.000	319.984
6.38	268.000	293.048
6.84	258.000	268.446
7.29	260.000	245.975
7.75	220.000	225.450
8.20	244.000	206.700
8.66	202.000	189.572
9.12	163.000	173.923
9.57	160.000	159.625
10.03	157.000	146.560
10.48	142.000	134.620
10.94	127.000	123.709
11.39	136.000	113.736
11.85	118.000	104.619
12.31	88.000	96.285
12.76	87.000	88.665
13.22	47.000	81.698
13.67	87.000	75.326
14.13	68.000	69.498
14.58	53.000	64.166
15.04	64.000	59.289
15.50	53.000	54.825
15.95	46.000	50.741
16.41	39.000	47.002
16.86	43.000	43.579
17.32	49.000	40.444
17.78	56.000	37.574
18.23	41.000	34.944
18.69	30.000	32.534
19.14	34.000	30.326
19.60	29.000	28.302
20.05	26.000	26.445
20.51	18.000	24.743
20.97	18.000	23.181
21.42	17.000	21.747
21.88	21.000	20.431
22.33	21.000	19.223
22.79	27.000	18.113
23.24	19.000	17.093
23.70	14.000	16.155
24.16	31.000	15.292
24.61	12.000	14.499
25.07	16.000	13.768
25.52	20.000	13.096
25.98	13.000	12.476
26.43	15.000	11.905
26.89	12.000	11.378
27.35	5.000	10.892
27.80	21.000	10.444
28.26	15.000	10.029
28.71	11.000	9.646
29.17	10.000	9.292
29.63	9.000	8.965
30.08	8.000	8.661
30.54	12.000	8.380
30.99	8.000	8.120
31.45	12.000	7.878
31.90	8.000	7.653
32.36	13.000	7.445
32.82	12.000	7.251
33.27	15.000	7.070
33.73	6.000	6.902
34.18	14.000	6.746
34.64	16.000	6.600
35.09	8.000	6.463
35.55	7.000	6.336
36.01	5.000	6.217
36.46	6.000	6.106
36.92	4.000	6.001
37.37	12.000	5.903
37.83	16.000	5.812
38.28	7.000	5.725
38.74	6.000	5.644
39.20	7.000	5.568
39.65	3.000	5.497
40.11	8.000	5.429
40.56	5.000	5.365
41.02	2.000	5.305
41.48	7.000	5.248
41.93	6.000	5.195
42.39	6.000	5.144
42.84	5.000	5.096
43.30	2.000	5.050
43.75	3.000	5.007
44.21	9.000	4.966
44.67	5.000	4.927
45.12	10.000	4.890
45.58	6.000	4.855
46.03	5.000	4.821
46.49	7.000	4.789
46.94	4.000	4.759
47.40	8.000	4.730
47.86	5.000	4.702
48.31	5.000	4.676
48.77	4.000	4.650
49.22	1.000	4.626*
49.68	6.000	4.603
50.13	6.000	4.581
50.59	5.000	4.560
51.05	21.000	4.540
51.50	8.000	4.520
51.96	3.000	4.501
52.41	2.000	4.484
52.87	3.000	4.466
53.33	5.000	4.450
53.78	3.000	4.434
54.24	3.000	4.419
54.69	3.000	4.404
55.15	5.000	4.390
55.60	5.000	4.377
56.06	6.000	4.364
56.52	2.000	4.351
56.97	6.000	4.339
57.43	5.000	4.327
57.88	4.000	4.316
58.34	6.000	4.306

INTERCEPT-1 IS 996.2389 SLOPE-1 IS -0.2011 TAU-1 IS 4.9737 NSEC

INTERCEPT-2 IS 20.4297 SLOPE-2 IS -0.0725 TAU-2 IS 13.7939 NSEC
THE PEAK IS AT OR NEAR CHANNEL 11
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 25.59626
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.67396180 00
2 1.66884550 00
3 1.66473070 00
4 1.66136900 00

Figure XVI. C. Part one of the 85 keV lifetime fit for the line at 3124.9 A

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3124.0A  RUN #9 PART 1   FOIL #5   TIME ON FOIL 0 TO 4 MIN            85KV
MASS=  52.     ENERGY=  72. KEV     1/V=   1.9419 NSEC/MM     DARK COUNTS=   4.
THERE WERE  0.2580   MM/CHANNEL
START FIT IN CHANNEL NO  20
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DISTANCE	DATA	FIT
0.52	12.000	1.0000
1.02	9.000	1.0000
1.50	1.000	1.0000
2.00	9.000	1.0000
2.51	10.000	1.0000
3.01	13.000	1.0000
3.51	12.000	1.0000
4.01	12.000	1.0000
4.51	9.000	1.0000
5.01	7.000	1.0000
5.51	7.000	1.0000
6.01	15.000	1.0000
6.51	35.000	1.0000
7.01	137.000	1.0000
7.52	453.000	1.0000
8.02	853.000	1.0000
8.52	1176.000	1.0000
9.02	1244.000	1.0000
9.52	1278.000	1.0000
10.02	1169.000	1206.444
10.52	1090.000	1091.763
11.02	961.000	988.217
11.52	912.000	894.671
12.02	845.000	810.174
12.53	733.000	733.848
13.03	717.000	664.901
13.53	646.000	602.619
14.03	529.000	546.355
14.53	473.000	495.526
15.03	412.000	449.605
15.53	433.000	408.116
16.03	402.000	370.631
16.53	354.000	336.760
17.03	285.000	306.154
17.54	266.000	278.497
18.04	261.000	253.502
18.54	209.000	230.912
19.04	201.000	210.494
19.54	187.000	192.037
20.04	155.000	175.352
20.54	139.000	160.267
21.04	162.000	146.626
21.54	118.000	134.291
22.04	109.000	123.135
22.55	125.000	113.043
23.05	116.000	103.912
23.55	112.000	95.651
24.05	88.000	88.174
24.55	84.000	81.405
25.05	80.000	75.277
25.55	66.000	69.727
26.05	69.000	64.699
26.55	69.000	60.143
27.05	63.000	56.014
27.56	55.000	52.270
28.06	37.000	48.874
28.56	46.000	45.792
29.06	52.000	42.994
29.56	31.000	40.453
30.06	47.000	38.144
30.56	46.000	36.045
31.06	38.000	34.135
31.56	26.000	32.397
32.06	32.000	30.813
32.57	37.000	29.369
33.07	30.000	28.052
33.57	40.000	26.850
34.07	32.000	25.751
34.57	21.000	24.745
35.07	25.000	23.824
35.57	29.000	22.980
36.07	11.000	22.206
36.57	19.000	21.494
37.07	34.000	20.838
37.58	22.000	20.235
38.08	13.000	19.678
38.58	27.000	19.163
39.08	23.000	18.686
39.58	28.000	18.244
40.08	21.000	17.834
40.58	17.000	17.452
41.08	20.000	17.096
41.59	18.000	16.764
42.09	18.000	16.453
42.59	31.000	16.161
43.09	29.000	15.887
43.59	12.000	15.629
44.09	17.000	15.386
44.59	14.000	15.156
45.09	15.000	14.938
45.59	15.000	14.732
46.09	18.000	14.535
46.59	15.000	14.348
47.09	14.000	14.169
47.60	10.000	13.998
48.10	14.000	13.834
48.60	15.000	13.677
49.10	18.000	13.526
49.60	13.000	13.380
50.10	11.000	13.239
50.60	13.000	13.104
51.10	9.000	12.972
51.60	12.000	12.845
52.10	6.000	12.721
52.61	14.000	12.601
53.11	7.000	12.484
53.61	9.000	12.370
54.11	17.000	12.259
54.61	13.000	12.150
55.11	9.000	12.044
55.61	13.000	11.941
56.11	13.000	11.839
56.61	13.000	11.740
57.11	16.000	11.643
57.62	15.000	11.547
58.12	12.000	11.453
58.62	11.000	11.361
59.12	15.000	11.271
59.62	13.000	11.182
60.12	15.000	11.095
60.62	11.000	11.009
61.12	9.000	10.924
61.62	17.000	10.841
62.12	16.000	10.759
62.63	9.000	10.678
63.13	13.000	10.598
63.63	10.000	10.520
64.13	5.000	10.443

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INTERCEPT-1 IS 9072.0496     SLOPE-1 IS   -0.2036     TAU-1 IS    4.9122 NSEC

INTERCEPT-2 IS   29.5552     SLOPE-2 IS   -0.0233     TAU-2 IS   42.9835 NSEC
THE PEAK IS AT OR NEAR CHANNEL     19
THE RATIO OF COEFFICIENTS AT THE FOIL IS:   57.09603
RUN PROCESSED 3 MAY 72.

     CHISQR

  1  1.37647870 00
  2  1.36994380 00
  3  1.36866080 00
  4  1.36759520 00
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Figure XVI. D. Part two of the 85 keV lifetime fit for the line at 3124.9 A

3124.9A RUN #9 PART 2 FOIL #5 TIME ON FOIL 0 TO 4 MIN 85KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 7

DIST(NS)	DATA	FIT
0.50	48.000	1.0000
1.00	215.000	1.0000
1.50	547.000	1.0000
2.00	905.000	1.0000
2.51	1222.000	1.0000
3.01	1248.000	1.0000
3.51	1238.000	1259.081
4.01	1176.000	1145.452
4.51	1028.000	1042.254
5.01	954.000	948.527
5.51	909.000	863.401
6.01	792.000	786.083
6.51	748.000	715.856
7.01	624.000	652.068
7.52	578.000	594.126
8.02	582.000	541.493
8.52	485.000	493.680
9.02	451.000	450.244
9.52	407.000	410.783
10.02	373.000	374.931
10.52	306.000	342.357
11.02	316.000	312.758
11.52	265.000	285.862
12.02	258.000	261.420
12.53	219.000	239.207
13.03	222.000	219.017
13.53	169.000	200.665
14.03	177.000	183.983
14.53	174.000	168.815
15.03	171.000	155.024
15.53	132.000	142.483
16.03	122.000	131.078
16.53	129.000	120.703
17.03	101.000	111.265
17.54	96.000	102.677
18.04	96.000	94.862
18.54	96.000	87.749
19.04	72.000	81.272
19.54	79.000	75.375
20.04	71.000	70.003
20.54	65.000	65.110
21.04	70.000	60.650
21.54	63.000	56.584
22.04	51.000	52.877
22.55	48.000	49.495
23.05	48.000	46.409
23.55	47.000	43.591
24.05	29.000	41.018
24.55	30.000	38.667
25.05	38.000	36.517
25.55	48.000	34.551
26.05	39.000	32.752
26.55	38.000	31.104
27.05	32.000	29.593
27.56	33.000	28.209
28.06	35.000	26.938
28.56	29.000	25.771
29.06	23.000	24.698
29.56	22.000	23.711
30.06	33.000	22.802
30.56	19.000	21.964
31.06	26.000	21.191
31.56	21.000	20.476
32.06	33.000	19.816
32.57	27.000	19.204
33.07	16.000	18.637
33.57	18.000	18.111
34.07	21.000	17.621
34.57	17.000	17.166
35.07	15.000	16.741
35.57	22.000	16.344
36.07	23.000	15.973
36.57	25.000	15.626
37.07	22.000	15.300
37.58	18.000	14.994
38.08	25.000	14.706
38.58	15.000	14.434
39.08	16.000	14.177
39.58	21.000	13.935
40.08	14.000	13.704
40.58	17.000	13.486
41.08	16.000	13.278
41.58	16.000	13.081
42.08	15.000	12.892
42.59	15.000	12.712
43.09	14.000	12.539
43.59	19.000	12.374
44.09	17.000	12.215
44.59	14.000	12.062
45.09	12.000	11.915
45.59	19.000	11.773
46.09	5.000	11.636
46.59	20.000	11.504
47.09	15.000	11.376
47.60	12.000	11.252
48.10	20.000	11.132
48.60	15.000	11.015
49.10	19.000	10.901
49.60	5.000	10.791
50.10	15.000	10.683
50.60	7.000	10.578
51.10	13.000	10.476
51.60	11.000	10.376
52.10	12.000	10.278
52.61	12.000	10.183
53.11	6.000	10.089
53.61	5.000	9.998
54.11	6.000	9.909
54.61	17.000	9.821
55.11	18.000	9.735
55.61	2.000	9.651
56.11	9.000	9.568
56.61	10.000	9.487
57.11	24.000	9.407
57.62	9.000	9.329
58.12	6.000	9.252
58.62	11.000	9.177
59.12	7.000	9.103
59.62	14.000	9.030
60.12	10.000	8.958
60.62	7.000	8.887
61.12	10.000	8.818
61.62	5.000	8.749
62.12	6.000	8.682
62.63	7.000	8.616
63.13	9.000	8.551
63.63	16.000	8.487
64.13	12.000	8.423

INTERCEPT-1 IS 2419.8558 SLOPE-1 IS -0.1927 TAU-1 IS 5.1896 NSEC

INTERCEPT-2 IS 26.4240 SLOPE-2 IS -0.0279 TAU-2 IS 35.8315 NSEC
THE PEAK IS AT OR NEAR CHANNEL 6
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 55.80378
RUN PROCESSED 3 JULY 72.

CHISQR

1 1.86137200 00
2 1.64781680 00
3 1.67619710 00
4 1.61790660 00

Figure XVII. A. The 100 keV lifetime fit for the
line at 3132.1 A

3132.1A RUN #5 FOIL #3 TIME ON FOIL 0 TO 4 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 16

DIST(NS)	DATA	FIT
0.46	9.000	1.0000
0.91	12.000	1.0000
1.37	16.000	1.0000
1.82	12.000	1.0000
2.28	5.000	1.0000
2.73	12.000	1.0000
3.19	13.000	1.0000
3.65	29.000	1.0000
4.10	102.000	1.0000
4.56	323.000	1.0000
5.01	689.000	1.0000
5.47	1046.000	1.0000
5.93	1294.000	1.0000
6.38	1370.000	1.0000
6.84	1369.000	1.0000
7.29	1367.000	1249.856
7.75	1155.000	1147.124
8.20	1039.000	1053.025
8.66	975.000	966.831
9.12	851.000	887.875
9.57	761.000	815.549
10.03	744.000	749.292
10.48	684.000	688.594
10.94	595.000	632.985
11.39	580.000	582.037
11.85	517.000	535.358
12.31	498.000	492.587
12.76	485.000	453.396
13.22	389.000	417.482
13.67	392.000	384.569
14.13	360.000	354.406
14.58	314.000	326.760
15.04	308.000	301.419
15.50	282.000	278.190
15.95	259.000	256.894
16.41	233.000	237.369
16.86	210.000	219.466
17.32	198.000	203.048
17.78	185.000	187.990
18.23	180.000	174.179
18.69	175.000	161.508
19.14	141.000	149.883
19.60	172.000	139.216
20.05	103.000	129.425
20.51	134.000	120.438
20.97	109.000	112.186
21.42	109.000	104.609
21.88	85.000	97.649
22.33	93.000	91.255
22.79	90.000	85.380
23.24	69.000	79.979
23.70	75.000	75.014
24.16	73.000	70.447
24.61	58.000	66.245
25.07	72.000	62.379
25.52	70.000	58.819
25.98	51.000	55.540
26.43	49.000	52.520
26.89	47.000	49.735
27.35	46.000	47.167
27.80	47.000	44.798
28.26	67.000	42.611
28.71	48.000	40.591
29.17	53.000	38.724
29.63	41.000	36.997
30.08	31.000	35.400
30.54	37.000	33.920
30.99	35.000	32.549
31.45	35.000	31.278
31.90	23.000	30.098
32.36	33.000	29.002
32.82	44.000	27.982
33.27	21.000	27.034
33.73	34.000	26.151
34.18	28.000	25.327
34.64	24.000	24.558
35.09	26.000	23.840
35.55	28.000	23.168
36.01	25.000	22.539
36.46	21.000	21.949
36.92	21.000	21.396
37.37	22.000	20.875
37.83	19.000	20.386
38.28	13.000	19.924
38.74	21.000	19.489
39.20	29.000	19.078
39.65	29.000	18.688
40.11	20.000	18.320
40.56	18.000	17.970
41.02	23.000	17.638
41.48	16.000	17.322
41.93	23.000	17.021
42.39	24.000	16.734
42.84	23.000	16.460
43.30	16.000	16.198
43.75	13.000	15.947
44.21	19.000	15.706
44.67	13.000	15.475
45.12	14.000	15.253
45.58	19.000	15.039
46.03	16.000	14.833
46.49	12.000	14.634
46.94	10.000	14.442
47.40	13.000	14.256
47.86	9.000	14.077
48.31	16.000	13.903
48.77	15.000	13.734
49.22	13.000	13.570
49.68	19.000	13.411
50.13	19.000	13.256
50.59	9.000	13.105
51.05	6.000	12.958
51.50	15.000	12.815
51.96	11.000	12.676
52.41	14.000	12.539
52.87	9.000	12.406
53.33	10.000	12.276

INTERCEPT-1 IS 4965.6476 SLOPE-1 IS -0.1934 TAU-1 IS 5.1719 NSEC

INTERCEPT-2 IS 41.9883 SLOPE-2 IS -0.0308 TAU-2 IS 32.4330 NSEC
THE PEAK IS AT OR NEAR CHANNEL 14
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 41.92534
RUN PROCESSED 3 JULY 72.

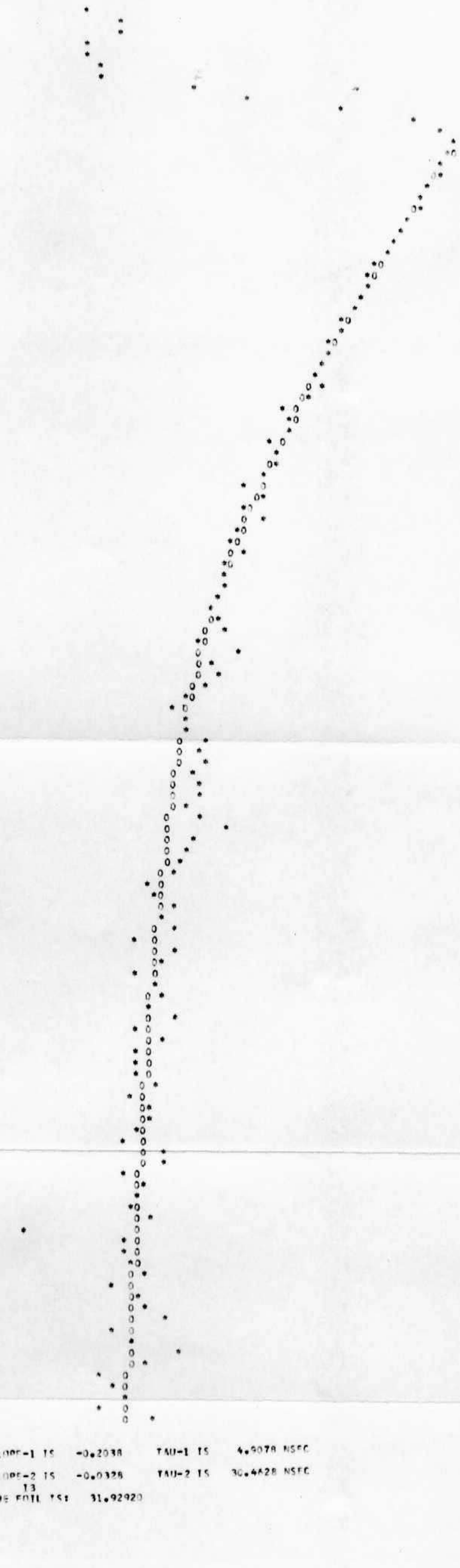
CHISQR

1 1.25079380 00
2 1.25245670 00
3 1.24819700 00
4 1.24411260 00

Figure XVII. B. Part one of the 85 keV lifetime fit for the line at 3132.1 A

3132.1A RUN #8 PART 1 FOIL #4 TIME ON FOIL 0 TO 12MIN 85 KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 14

DIST(NS)	DATA	FIT
0.50	6.000	1.0000
1.00	9.000	1.0000
1.50	9.000	1.0000
2.00	6.000	1.0000
2.51	6.000	1.0000
3.01	7.000	1.0000
3.51	7.000	1.0000
4.01	25.000	1.0000
4.51	51.000	1.0000
5.01	195.000	1.0000
5.51	529.000	1.0000
6.01	778.000	1.0000
6.51	912.000	1.0000
7.01	848.000	872.247
7.52	733.000	790.300
8.02	765.000	716.268
8.52	657.000	649.384
9.02	599.000	588.954
9.52	563.000	534.352
10.02	497.000	485.014
10.52	449.000	440.429
11.02	408.000	400.137
11.52	351.000	363.721
12.02	308.000	330.806
12.53	281.000	301.053
13.03	275.000	274.156
13.53	257.000	249.837
14.03	235.000	227.847
14.53	197.000	207.961
15.03	191.000	189.975
15.53	154.000	173.704
16.03	158.000	158.984
16.53	148.000	145.663
17.03	128.000	133.608
17.54	141.000	122.694
18.04	116.000	112.813
18.54	82.000	103.864
19.04	90.000	95.757
19.54	89.000	88.411
20.04	72.000	81.752
20.54	73.000	75.715
21.04	74.000	70.239
21.54	61.000	65.270
22.04	47.000	60.759
22.55	63.000	56.663
23.05	47.000	52.941
23.55	61.000	49.558
24.05	45.000	46.481
24.55	41.000	43.681
25.05	47.000	41.130
25.55	36.000	38.806
26.05	38.000	36.687
26.55	35.000	34.753
27.05	34.000	32.986
27.56	30.000	31.371
28.06	34.000	29.893
28.56	36.000	28.540
29.06	25.000	27.298
29.56	43.000	26.159
30.06	31.000	25.112
30.56	34.000	24.149
31.06	28.000	23.261
31.56	21.000	22.442
32.06	18.000	21.685
32.57	20.000	20.985
33.07	20.000	20.337
33.57	28.000	19.735
34.07	26.000	19.175
34.57	27.000	18.654
35.07	22.000	18.168
35.57	25.000	17.714
36.07	26.000	17.289
36.57	21.000	16.890
37.07	24.000	16.515
37.58	35.000	16.163
38.08	22.000	15.831
38.58	20.000	15.517
39.08	19.000	15.220
39.58	17.000	14.938
40.08	12.000	14.671
40.58	13.000	14.416
41.08	17.000	14.174
41.58	15.000	13.942
42.08	18.000	13.721
42.59	10.000	13.509
43.09	17.000	13.306
43.59	14.000	13.110
44.09	10.000	12.922
44.59	13.000	12.741
45.09	15.000	12.567
45.59	12.000	12.398
46.09	18.000	12.235
46.59	10.000	12.077
47.09	15.000	11.924
47.60	10.000	11.775
48.10	10.000	11.631
48.60	10.000	11.491
49.10	13.000	11.355
49.60	9.000	11.222
50.10	12.000	11.093
50.60	12.000	10.966
51.10	10.000	10.843
51.60	8.000	10.723
52.10	14.000	10.606
52.61	15.000	10.491
53.11	8.000	10.379
53.61	11.000	10.269
54.11	10.000	10.162
54.61	9.000	10.057
55.11	12.000	9.954
55.61	2.000	9.853
56.11	8.000	9.754
56.61	8.000	9.657
57.11	9.000	9.562
57.62	11.000	9.469
58.12	7.000	9.377
58.62	10.000	9.288
59.12	11.000	9.200
59.62	15.000	9.113
60.12	7.000	9.028
60.62	9.000	8.945
61.12	17.000	8.863
61.62	11.000	8.783
62.12	6.000	8.704
62.63	7.000	8.626
63.13	8.000	8.550
63.63	6.000	8.475
64.13	12.000	8.401



INTERCEPT-1 IS 3505.5010 SLOPE-1 IS -0.2038 TAU-1 IS 4.9078 NSEC

INTERCEPT-2 IS 36.0638 SLOPE-2 IS -0.0328 TAU-2 IS 30.4628 NSEC
THE PEAK IS AT OR NEAR CHANNEL 13
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 31.92920
RUN PROCESSED 3 JULY 72.

CHISOR

1 4.92885800 00
2 1.31229400 00
3 1.27304080 00
4 1.26292640 00

Figure XVII. C. Part two of the 85 keV lifetime fit for the line at 3132.1 A

3132.1A RUN #8 PART 2 FOIL #4 TIME ON FOIL 0 TO 12MIN 85 KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 18

DIST(NS)	DATA	FIT
0.50	1.000	1.000*
1.00	1.000	1.000*
1.50	8.000	1.0000
2.00	7.000	1.0000
2.51	4.000	1.0000
3.01	13.000	1.0000
3.51	15.000	1.0000
4.01	10.000	1.0000
4.51	11.000	1.0000
5.01	7.000	1.0000
5.51	9.000	1.0000
6.01	21.000	1.0000
6.51	72.000	1.0000
7.01	328.000	1.0000
7.52	617.000	1.0000
8.02	855.000	1.0000
8.52	999.000	1.0000
9.02	994.000	1011.220
9.52	945.000	916.379
10.02	841.000	830.999
10.52	734.000	753.612
11.02	679.000	683.630
11.52	614.000	620.341
12.02	574.000	563.103
12.53	528.000	511.336
13.03	448.000	464.512
13.53	404.000	422.159
14.03	411.000	383.847
14.53	351.000	349.187
15.03	329.000	317.829
15.53	261.000	289.457
16.03	274.000	263.784
16.53	240.000	240.550
17.03	191.000	219.522
17.54	189.000	200.489
18.04	182.000	183.258
18.54	163.000	167.657
19.04	148.000	153.530
19.54	146.000	140.736
20.04	142.000	129.147
20.54	115.000	118.647
21.04	110.000	109.132
21.54	113.000	100.508
22.04	98.000	92.690
22.55	76.000	85.600
23.05	83.000	79.169
23.55	67.000	73.334
24.05	68.000	68.038
24.55	58.000	63.229
25.05	46.000	58.862
25.55	65.000	54.893
26.05	49.000	51.285
26.55	47.000	48.004
27.05	52.000	45.018
27.56	46.000	42.300
28.06	42.000	39.824
28.56	35.000	37.567
29.06	42.000	35.508
29.56	39.000	33.628
30.06	25.000	31.911
30.56	28.000	30.342
31.06	33.000	28.905
31.56	33.000	27.590
32.06	29.000	26.384
32.57	25.000	25.277
33.07	26.000	24.260
33.57	28.000	23.325
34.07	29.000	22.463
34.57	27.000	21.669
35.07	28.000	20.936
35.57	21.000	20.258
36.07	22.000	19.630
36.57	18.000	19.048
37.07	29.000	18.507
37.58	23.000	18.004
38.08	22.000	17.535
38.58	25.000	17.098
39.08	8.000	16.689
39.58	17.000	16.306
40.08	18.000	15.947
40.58	12.000	15.609
41.08	22.000	15.291
41.58	15.000	14.991
42.08	11.000	14.707
42.59	17.000	14.439
43.09	19.000	14.184
43.59	15.000	13.942
44.09	26.000	13.712
44.59	10.000	13.492
45.09	10.000	13.282
45.59	12.000	13.082
46.09	14.000	12.890
46.59	18.000	12.705
47.09	17.000	12.528
47.60	15.000	12.357
48.10	9.000	12.193
48.60	9.000	12.034
49.10	22.000	11.881
49.60	17.000	11.733
50.10	8.000	11.589
50.60	13.000	11.450
51.10	10.000	11.314
51.60	11.000	11.183
52.10	14.000	11.055
52.61	12.000	10.931
53.11	8.000	10.810
53.61	13.000	10.692
54.11	9.000	10.577
54.61	12.000	10.465
55.11	8.000	10.355
55.61	11.000	10.248
56.11	10.000	10.143
56.61	6.000	10.040
57.11	8.000	9.940
57.62	8.000	9.842
58.12	14.000	9.745
58.62	10.000	9.651
59.12	8.000	9.558
59.62	11.000	9.468
60.12	10.000	9.379
60.62	9.000	9.292
61.12	5.000	9.206
61.62	10.000	9.122
62.12	11.000	9.039
62.63	5.000	8.958
63.13	12.000	8.879
63.63	11.000	8.800
64.13	5.000	8.724

INTERCEPT-1 IS 6043.6626 SLOPE-1 IS -0.2017 TAU-1 IS 4.9579 NSEC

INTERCEPT-2 IS 35.8669 SLOPE-2 IS -0.0317 TAU-2 IS 31.5850 NSEC
THE PEAK IS AT OR NEAR CHANNEL 17
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 39.59543
RUN PROCESSED 3 JULY 72.

CHISQR

1 9.87522630-01
2 9.81769520-01
3 9.77519690-01
4 9.73470740-01

Figure XVIII. A. The 100 keV lifetime fit for the line at 3180.8 A

3180.8A RUN #6 FOIL #3 TIME ON FOIL 4 TO 8 MIN 100 KV
MASS= 52. ENERGY= 87. KEV 1/V= 1.7666 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 18

DIST(NS)	DATA	FIT
0.46	7.000	1.0000
0.91	8.000	1.0000
1.37	10.000	1.0000
1.82	7.000	1.0000
2.28	10.000	1.0000
2.73	14.000	1.0000
3.19	10.000	1.0000
3.65	13.000	1.0000
4.10	8.000	1.0000
4.56	14.000	1.0000
5.01	62.000	1.0000
5.47	214.000	1.0000
5.93	425.000	1.0000
6.38	713.000	1.0000
6.84	858.000	1.0000
7.29	915.000	1.0000
7.75	945.000	1.0000
8.20	874.000	906.455
8.66	839.000	824.486
9.12	738.000	750.065
9.57	671.000	682.494
10.03	613.000	621.142
10.48	621.000	565.435
10.94	506.000	514.854
11.39	488.000	468.925
11.85	425.000	427.220
12.31	369.000	389.349
12.76	383.000	354.958
13.22	327.000	323.728
13.67	294.000	295.366
14.13	256.000	269.608
14.58	227.000	246.214
15.04	231.000	224.966
15.50	198.000	205.667
15.95	185.000	188.136
16.41	161.000	172.212
16.86	159.000	157.744
17.32	146.000	144.601
17.78	150.000	132.659
18.23	119.000	121.808
18.69	137.000	111.947
19.14	89.000	102.985
19.60	67.000	94.839
20.05	85.000	87.435
20.51	74.000	80.703
20.97	77.000	74.583
21.42	57.000	69.017
21.88	70.000	63.954
22.33	56.000	59.349
22.79	51.000	55.159
23.24	51.000	51.346
23.70	55.000	47.876
24.16	37.000	44.716
24.61	50.000	41.839
25.07	44.000	39.218
25.52	30.000	36.830
25.98	48.000	34.653
26.43	26.000	32.668
26.89	39.000	30.857
27.35	32.000	29.205
27.80	29.000	27.697
28.26	31.000	26.320
28.71	18.000	25.061
29.17	24.000	23.910
29.63	18.000	22.857
30.08	29.000	21.893
30.54	31.000	21.011
30.99	29.000	20.201
31.45	34.000	19.459
31.90	23.000	18.777
32.36	26.000	18.150
32.82	20.000	17.574
33.27	22.000	17.043
33.73	16.000	16.554
34.18	19.000	16.103
34.64	25.000	15.686
35.09	15.000	15.300
35.55	23.000	14.943
36.01	16.000	14.611
36.46	17.000	14.304
36.92	24.000	14.017
37.37	17.000	13.751
37.83	14.000	13.502
38.28	21.000	13.269
38.74	11.000	13.051
39.20	17.000	12.847
39.65	17.000	12.655
40.11	18.000	12.475
40.56	16.000	12.304
41.02	9.000	12.143
41.48	14.000	11.991
41.93	19.000	11.847
42.39	7.000	11.710
42.84	12.000	11.579
43.30	9.000	11.455
43.75	14.000	11.336
44.21	6.000	11.222
44.67	13.000	11.113
45.12	14.000	11.008
45.58	18.000	10.908
46.03	9.000	10.810
46.49	11.000	10.717
46.94	9.000	10.626
47.40	12.000	10.539
47.86	9.000	10.454
48.31	10.000	10.371
48.77	12.000	10.291
49.22	14.000	10.213
49.68	8.000	10.138
50.13	7.000	10.064
50.59	6.000	9.991
51.05	8.000	9.921
51.50	12.000	9.852
51.96	10.000	9.784
52.41	7.000	9.718
52.87	17.000	9.653
53.33	12.000	9.589
53.78	11.000	9.527
54.24	10.000	9.466
54.69	10.000	9.405
55.15	9.000	9.346
55.60	12.000	9.288
56.06	10.000	9.230
56.52	10.000	9.173
56.97	4.000	9.118
57.43	6.000	9.063
57.88	4.000	9.009
58.34	10.000	8.955

INTERCEPT-1 IS 5062.2969 SLOPE-1 IS -0.2123 TAU-1 IS 4.7104 NSEC

INTERCEPT-2 IS 18.5200 SLOPE-2 IS -0.0227 TAU-2 IS 44.1066 NSEC
THE PEAK IS AT OR NEAR CHANNEL 17
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 62.89762
RUN PROCESSED 3 JULY 72.

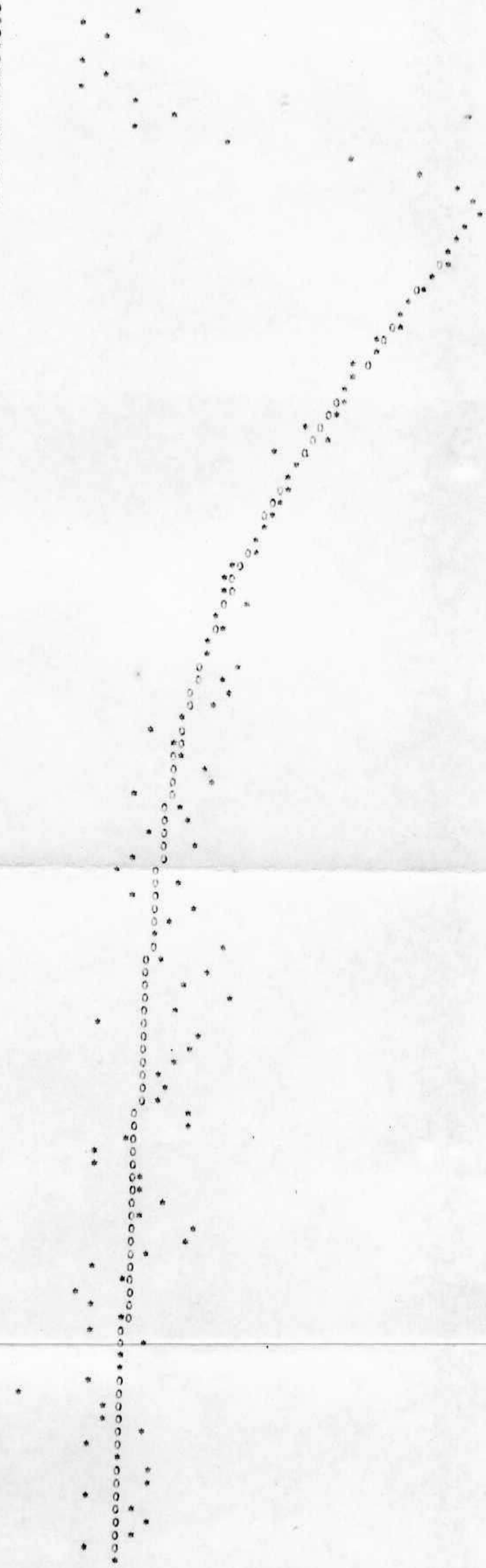
CHISQR

1 1.3447332D 00
2 1.3339899D 00
3 1.3243254D 00
4 1.3192803D 00

Figure XVIII. B. The 85 keV lifetime fit for the line at 3180.8 A

3180.8A RUN #7 PART 1 FOIL #3 TIME ON FOIL 8 TO 16MIN 85 KV
MASS= 52. ENERGY= 72. KEV 1/V= 1.9419 NSEC/MM DARK COUNTS= 4.
THERE WERE 0.25800 MM/CHANNEL
START FIT IN CHANNEL NO 17

DIST(NS)	DATA	FIT
0.50	6.000	1.0000
1.00	3.000	1.0000
1.50	4.000	1.0000
2.00	1.000	1.0000
2.51	3.000	1.0000
3.01	4.000	1.0000
3.51	3.000	1.0000
4.01	6.000	1.0000
4.51	9.000	1.0000
5.01	6.000	1.0000
5.51	17.000	1.0000
6.01	76.000	1.0000
6.51	167.000	1.0000
7.01	267.000	1.0000
7.52	323.000	1.0000
8.02	367.000	1.0000
8.52	291.000	312.901
9.02	280.000	280.065
9.52	258.000	250.794
10.02	242.000	224.698
10.52	207.000	201.434
11.02	184.000	180.692
11.52	156.000	162.198
12.02	141.000	145.709
12.53	141.000	131.006
13.03	111.000	117.895
13.53	108.000	106.203
14.03	87.000	95.776
14.53	84.000	86.476
15.03	74.000	78.181
15.53	74.000	70.781
16.03	70.000	64.179
16.53	48.000	58.288
17.03	66.000	53.032
17.54	33.000	48.341
18.04	42.000	44.153
18.54	40.000	40.415
19.04	40.000	37.077
19.54	36.000	34.096
20.04	32.000	31.432
20.54	29.000	29.053
21.04	27.000	26.926
21.54	27.000	25.024
22.04	20.000	23.324
22.55	19.000	21.802
23.05	19.000	20.440
23.55	25.000	19.220
24.05	17.000	18.128
24.55	19.000	17.148
25.05	16.000	16.270
25.55	16.000	15.491
26.05	23.000	14.773
26.55	19.000	14.136
27.05	20.000	13.564
27.56	17.000	13.049
28.06	12.000	12.583
28.56	8.000	12.163
29.06	11.000	11.784
29.56	12.000	11.441
30.06	16.000	11.131
30.56	17.000	10.849
31.06	7.000	10.592
31.56	12.000	10.359
32.06	13.000	10.146
32.57	8.000	9.952
33.07	15.000	9.774
33.57	7.000	9.610
34.07	6.000	9.460
34.57	12.000	9.322
35.07	7.000	9.194
35.57	14.000	9.075
36.07	11.000	8.965
36.57	9.000	8.862
37.07	21.000	8.766
37.58	10.000	8.676
38.08	18.000	8.592
38.58	13.000	8.513
39.08	23.000	8.438
39.58	12.000	8.366
40.08	5.000	8.299
40.58	16.000	8.235
41.08	14.000	8.174
41.58	12.000	8.115
42.08	10.000	8.059
42.59	11.000	8.005
43.09	10.000	7.953
43.59	14.000	7.903
44.09	14.000	7.854
44.59	7.000	7.907
45.09	5.000	7.761
45.59	5.000	7.717
46.09	8.000	7.674
46.59	8.000	7.631
47.09	11.000	7.590
47.60	8.000	7.550
48.10	16.000	7.511
48.60	15.000	7.472
49.10	9.000	7.434
49.60	5.000	7.397
50.10	7.000	7.361
50.60	4.000	7.325
51.10	5.000	7.289
51.60	7.000	7.255
52.10	5.000	7.221
52.61	9.000	7.187
53.11	7.000	7.154
53.61	7.000	7.121
54.11	5.000	7.089
54.61	2.000	7.057
55.11	6.000	7.026
55.61	6.000	6.994
56.11	9.000	6.964
56.61	5.000	6.934
57.11	7.000	6.904
57.62	10.000	6.874
58.12	10.000	6.845
58.62	5.000	6.816
59.12	8.000	6.787
59.62	10.000	6.759
60.12	8.000	6.731
60.62	5.000	6.704
61.12	7.000	6.676
61.62	7.000	6.649
62.12	5.000	6.622



INTERCEPT-1 IS 2132.7867 SLOPE-1 IS -0.2298 TAU-1 IS 4.3511 NSEC

INTERCEPT-2 IS 9.1599 SLOPE-2 IS -0.0201 TAU-2 IS 49.6496 NSEC
THE PEAK IS AT OR NEAR CHANNEL 16
THE RATIO OF COEFFICIENTS AT THE FOIL IS: 43.35765
RUN PROCESSED 3 JULY 72.

CHISQR

1 2.54106890 00
2 1.23353440 00
3 1.22206480 00
4 1.21697420 00

BEAM-FOIL LIFETIMES IN CrII

by

JAMES RICHARD METTLING

B.A., Southwestern College, 1971

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Physics

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

The lifetimes of four atomic levels of CrII have been measured at 85 and 100 keV using beam-foil methods. In preparation for the lifetime experiment the beam-foil spectrum of 85 keV chromium from 1900 to 4100 A was taken. The energy loss incured by 89 keV Ar+ passing through a 2.4 $\mu gm/cm^2$ carbon foil has been measured and found to be in adequate agreement with stopping power calculations. From our lifetime measurements a preliminary solar abundance for chromium of $\log N_{Cr} = 5.54$ (where $\log N_H = 12.0$) has been calculated.