FAST NITROGEN ATOMS FROM DISSOCIATIVE EXCITATION OF N_2 BY ELECTRON IMPACT

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ABSTRACT

The Doppler profiles of one of the fine structure line.s of the N I (1 200 Å) $g\,^4S^0$ --^{4}1' multiplet and of the N11 (1085 Å) $g\,^3P^0$--^3D multiplet have been measured. Exci tation of the multiplets is produced b y electron impact dissociative excitation of N_2. The full-width-half-maximum (FWHM) is measured by a high resolution UV spectrometer ($\lambda/\Delta\lambda$ = 5 0 0 0 0). The experimental line profiles are evaluated by fast Fourier transform (FFT) 1 echniques and analysis o f the profiles yields the kinetic energy distr bution of fragments. The FWHM of NI(1200 Å) increases from 27 ± 6 mÅ at 30 eV to 37± 4 mÅ at 100 eV as the emission cross section of the dissociative ionization excitation process becomes more impor tant re lative to th c dissociative excitation process. The kinetic energy distribution function of the two frag ment N] atoms at 30 CV impact ener gy is much broader than thermal with a FWHM of 5 ±1 cV. The FWHM of the NII(1085 Å) line is 36± 4 mÅ and is produced only b y dissociative ionization excitation. At 100 CV impact energy t he FWHM of each of the emission line profiles of the NI(1200 Å) and NII (1 0 8 5 Å) atoms i n d i c a t e s that the kinetic energy distribution is described by 1 0 ± 2 CV FWHM. Dissociative excitation processes a r e

shown to be a small part of the total quantum yield Of NI atoms. 1 Iowever, all dissociation processes appear to produce NI atoms with kinetic energy distributions having mean energies above ().5 eV and can lead to a substantial escape flux of N] atoms from the satellites, Titan and Triton of the outer planets.

INTRODUCTION

It was discovered by Erdman and Zipf (1983) that electron impact dissociative excitation of N_2 produced highly broadened Doppler line! profiles for N](1200 Å). '1'heir measurement of the infrared lines, ^4P <--^{4}] 1(', $^4P^0$ N1(8691 Å, 8212 Å), showed that cascade radiation to the upper level of N](1200 Å) is broadened to ~0.34 Å FWHMin the dissociation" process. Line width studies of the NI(1200 Å), itself, arc paramount for understanding the radiative transfer of the N] (1200 Å) multiplet in the Earth's thermosphere (Meier et a]., 1980). A radiative analysis of the altitude dependence of the NI(1200 Å) multiplet in the UV dayglow required a substantial number of N(^{4}P) atoms in the thermal core of the ambient velocity distribution. However, Meier (1991) in his review of the UV dayglow realize.d that the indirect laboratory evidence for kinetic energies of N(^{4}P) atoms, to date, did not justify this assumption. The direct measurement of the line profiles presented in Ibis study indicate that less than 2% of the N] atoms have thermal kinetic energy as opposed to the 50- 70% required by Meier (1980) to explain the dayglow altitude distribution of NI(1200 Å).

Recent re-analysis of the Voyager 1 ultraviolet spectrometer observations from the. Titan encounter showed conclusively the importance of magnetospheric electrons in exciting the UV airglow of NI and NII emissions, among other processes (Hall et al., 1 992). Consideration of escape of N] and N]] atoms produced in the dissociation process may be important in interpreting energetic ions found in the Saturn magnetosphere by the low-energy particle detector (Hamilton et al., 1983).

In this study we concentrate on measuring line profiles of two strong resonance emission lines formed in the dissociation of N_2 molecules from highly-excited and super-excited states (Hatano, 1994). These lines contribute strongly to the total dissociative excitation cross section. The emission cross sections at 100 eV are 3.8 x 10^{-18} cm^2 for NI(1200 Å) and ?..6 x 10^{-18} cm^2 for NII(1085 Å) (James et al., 1990) The emission lines are formed by three processes:

$$N_2 + e \rightarrow N_2^* + e \rightarrow N + N + e + h\nu, \qquad 1)$$

$$N_2 + e \rightarrow N_2^{++*} + 2e \rightarrow N^+ + N + 2e + h\nu, \qquad 2)$$

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$$N_2 + e \rightarrow N_2^{+++*} + 3e \rightarrow N^+ + N^+ + 3e + h\nu \qquad 3)$$

where * refers, in our application, to a highly-excited, repulsive state of the molecule. We have recently demonstrated this technique in the first measurement of the I 1 Lyman α line profile (Ajello et al., 1995a,b). Previous studies of the excitation function of NI (1200 Å) multiplet (Ajello and Shemansky; 1985, Itikawa et al., 1986) and NII (1085 Å) multiplet (James et al., 1990) indicate two principal processes for formation of each multiplet. Reaction 1) and 2) contribute to NI (1 200 Å) ant] reactions 2) and 3) contribute to NII (1085 A). The observed UV thresholds indicate that the accompanying fragment atom (ion) is most likely in the ground state. in the same way, Rall et al. (1988) have shown that the threshold structure for dissociative excitation emission cross sections in the visible and infrared for cascade lines that contribute to the strong NI resonance lines, can be explained by a large yield of' $N(2p^2 (^3P) nl) + N(^4S^0)$ fragment atoms.

Recent experimental data on the kinetic distribution of N-atoms from electron impact dissociation Of fast N_2 molecules has been measured by Cosby (1 993). The discrete structure in the kinetic energy distribution can be explained by a very large quantum yield of $N(^2D^0) + N(^4S^0)$ atoms in the predissociation of N_2 from bound

states. 1 .aser excitation of the Rydberg and valence states of N_2 show that for excitation energies above 13.91 eV [here is a strong change in the mix of dissociation products with an increase in the quantum yield of $N(^2P^0)$ + $N(^4S^0)$ atoms. '1'here. is the total absence of $N(^4S^0)$ + $N(^4S^0)$ branching. Predissociation is probably the most important process in the dissociation of N_2. However, neither the cross section 1101 the quantum yield of neutral ground state configuration atoms ($N(^4S^0)$, $N(^2D^0)$, $N(^2P^0)$) from repulsive states has been measured. This quantity can, in principle, be determined rom a knowledge of all other dissociative excitation channels as well as the total cross section. The dissection of the total absolu c cross sections for N_2 dissociati vc processes has been given once before by McI .aughlin and Zipf (19'/6) and the results used by Fox an Victor (1988) in quantifying electron energy loss processes in an N_2 gas. The work by M c] .aughlin and Zipf (1976) must be viewed with caution, since the absolute cross sec tio ns were based on a UV calibrati on sta ndard t h a t has been drastically revised (Ajello c(al., 1989). The work O f McI .aughlin and Zipf is also the basis for determining the $N(^2D)$ yiel d in aeronomic chemistry, generally assumed to be **50 to 60%** (Gerard et al., 1995). The atmospheric chemistry of NO is one case in point

Where the quantum yield and energy distribution of N-atoms is important in the gain and loss mechanisms of NO in the mesosphere and 10WCI" the.rlnosphcrc (Schematovich et al., 1991 ; Gerard et al., 1991, 1995; Barth, **1995).**

in addition, Cosby (1 993) measured the total cross section of reaction 1) for the dissociation of N_2 into two neutral fragments (predissociation + direct dissociation into atoms in the ground state configuration + dissociation from highly-excited and super-cxcitc~i stales) and compared his results to Winters (1966) who measured the total cross section for all types of dissociation, including dissociative. ionization (Reactions 2 and 3). Our previous work measuring predissociation cross sections and direct dissociative excitation (and dissociative ionization) cross sections (Ajello et al., 1985; Ajello et a]., 1989; James et al., 1990; Shemansky et al., 1995) from highl y-excited and super-excited states can be used with the estimates of total dissociation cross sections 10 give important information on the rela ive importance of the various dissociation processes as well as the kinetic energy distribution of products.

EXPERIMENTAL

The experimental system has been described by (Liu et al., 1995; Ajello et al., 1995a, b). In brief, the experimental system consists of a high-resolution 3-meter uv spectrometer in tandem with an electron impact collision chamber. A resolving power of 50,000" is achieved by operating the spectrometer in third order. The line shapes were measured with experimental conditions that ensure linearity of signal with electron beam current and background gas pressure. All the cross sections and spectra were measured in the crossed beams mode. The multiplet structure for N 1(12.()() Å) is Shown in Fig 1a. It is an allowed quartet-quartet resonance multiplet consisting of three fine structure lines. The wavelengths and statistical weights for the fine structure lines can be found from the work of Kelly (1982) and Wiese et al. (1966). The electron-impact-induced-fluorescence line profiles at 30 and 100 eV impact energies of the $g^4s\ ^6P_{3/2}$ - $^4P_{5/2}$ fine structure line, the strongest N1(1200 Å) line, arc shown in the high resolution spectra in Fig. 2a, along with the instrumental slit function of the spectrometer. The measured line profiles arc different at the two energies; and the line

profiles have the indicated FWHM of 32 mÅ at 30 eV, broadening to 44 mÅ at 10[) eV. Data points arc obtained every 1.333 mÅ in single scans. Both the 30 anti i ()() eV profile s arc. symmetric. The N 11 (1085 Å) multiplet which is a compound triplet with six component fine structure lines is shown in Fig. 1b. The NI1(1085 Å) $g\,^3P^0, --^3D_3$ fine structure line, the strongest component line, which is also safely isolated from the other fine structure lines, is shown in Fig. 2b. It h as a measured FWHM of 43 mÅ, compared to the slit function of 24 mÅ. 1 However, this line. profile is asymmetric with a broadened I ed w ng, nearly 10 mÅ broader with respect to line center than the ɔlue w ng. In this experiment, the. line profiles were measured at 90° angle both to the el ect ron and molecular b eam axes. We assu me that th e anisotropy in inte nsity i s small.

LINE PROFILES AN]) KINETIC ENERGY DISTRIBUTION OF FAST PRODUCTS

In Fig. 2, the range O f the measured FWHM O f 32 mÅ to 44 m Å is not na rrow with respect to tile instru mental slit function (FWH M =24 mÅ). FFT tech niques were used to recover the actual line p r o f i l e

(1'less et al., 1986). The measured line profile is the Convolution of the true line profile and [he. instrumental slit function. Expressed mathematically the measured line profile, I(λ), is given by the convolution integral

$$I(\lambda) = \int T(\lambda')\, A(\lambda - \lambda')\, d\lambda', \qquad (4)$$

where "1'(A') is the true line profile at wavelength λ' and A(λ-λ') is the instrumental response function. The FFT technique used in the Doppler line profile analysis has been previously provided (Ajello et al., 1995a, b). We selected a step filter to remove high frequency noise from both 1 ₁ and Al. The true line profile, the measured line. profiles and the slit function are all approximately Gaussian. The root-sum-square of the FWHM of the true line shape and the slit function should approximately equal the FWHM of the measured profile. This is found to be the case to within 2 mÅ for the 100" CV line profiles. The difference in the two methods for estimating the true line profile degrades as the measured line width approaches the slit function measurement. The uncertainties in the [rue line profiles at 30 eV impact energy is about 25% and at 100 eV is found to be about 1 2%.

We show in Fig. 3a the inverse FFT (FFT^{-1}) for the three line profiles. The deconvolved line profile is discovered to have a FWHM Of 27 ± 6 mÅ and 37 ± 4 mÅ for the 30 and 100 CV N](1200 Å) line profiles, respectively and 36 ± 4 mÅ for the 100 CV N]](1085 Å) line profile. For each of the line profiles in Fig. 3, the corresponding kinetic energy distribution of the fragments, P(E), is given by

$$P(E) = k(dT/d\lambda) \quad , \qquad (5)$$

where k is a multiplicative constant (Ogawa and Higo, 1979, 1980 and Ogawa et al., 1992). The kinetic energy distributions of the $NI(^4P_{5/2})$ and $NII(^3D_3)$ fragments arc Shown in Fig. 3b. The fragment distribution of $NI(^4P_{5/2})$ and $NII(^3D_3)$ atoms have FWHM of 10 ± 2 eV with a peak energy at 3.5 ± 1.0 eV for 100 eV electron impact energy. The value for $NII(^3D_3)$ atoms is based on the blue wing structure. The red wing indicates a slightly broader energy distribution. In all cases the fragment population extends to energies of 16 eV or beyond. The fragment distribution of NI (41)5,2) atoms has a FWHM of 5 ± 1 eV with a peak value at 2.0 ± 0.5 eV for 30 eV electron impact energy. The peak energy value for dissociative excitation can be compared to the two peaks found by Cosby (1993)

for the case of predissociation. He finds discrete peaks at 0.8 and 1.1 eV which arc attributed primarily to the c $^1\Pi_u(0,1)$ vi brational levels. in addition, the fragment distribution extended to about 4 cV. The fragment population measured here extends to an energy of 8 cV. The sensitivity for high energy fragments is larger in this experiment. in the experiment of Cosby a minority of the observed dissociation products arises from dissociative excitation.

The emission line profile results can also be compared to t h c N(Rydberg) atom time-of-fjight (TOF) results of Wells et al. (1976). Wells et al. identified many companion fragments to the Rydberg atoms, in cl udi ng thresh old s at 24.29 eV for production of $N(^4S^0)$ ground state atoms , at 34.6 CV for production of $N(^4P)$ atoms and a t 38.3 CV for production of $N^+(^3P)$ ions. The distribution function of fragment Rydberg atoms for each of these three processes spanned a broad energy range from 0.3 to 24 eV at electron impact energies above 50 cV. The energy range spanned for Rydberg fragments was smaller from 0.3 to 7.2 CV at electron impact energies between 3 () and 40 cV. The similarities in the results of Wells et al. with those found in this study arc made striking by substituting, a $N(^4P)$ atom for the Rydberg atom and taking account of the sl ghtly lower

appearance potential. The corresponding calcu ated threshold in (his experiment for the companion frag ment atom ion) to a $N(^4P)$ excited atom arc: 1) 20.14 eV for a $N(^4S^0)$ ground state atom, 2) 30.48 eV for an excited $N(^4P)$ atom and 3) 34.67 eV for an $N^+(^3P)$ ion. The kinetic energy distributions of fragments in (Dissociation of N_2 fro m repulsive states (in the Franck-Condon region) where one of t h c fragments has -10 CV excitation energy is far from thermal.

DISCUSSION

We have measured the line profiles of one neutral excited atom, $NI(^4P)$ at 30 and 100 eV and one excited ion, $NII(^3D)$. At 30 eV impact energy the excited neutral atom is accompanied by another neutral atom (Reaction I) and at 1 ()() eV the products can include a t least one ion (Reactions 2 and 3). The line profile information was used to derive the kinetic energy distribution for dissociation from highly-excited repulsive slates. Cosby (1 993) measured the distribution function for all processes giving two neutral atoms from dissociation of N_2. We distinguish three major categories of processes for producing neutral atoms. These processes arc 1:) predissociation, 2) direct dissociation and 3) dissociative excitation from a highly -

excited or super-cxcitcd slate. We classify all N-atoms produced in states above the first dipole allowed excited state (^4P) at 10.34 eV as arising from a highly-excited state of N_2. States of' N_2 produced above the first ionization potential at 15.6 eV are classified as super-excited.

The Doppler line profile study at 30 eV of this work gives a kinetic energy distribution that represents one channel of the three major types of processes observed by Cosby for the total dissociative cross section of N_2 by electron impact. Cosby dots not detect dissociative ionization processes. At 100 CV impact energy the predominant dipole-al]owc(i processes processes arc of the form,

$$N_2\ (X\ ^1\Sigma^+_g) + e(100\ eV) \text{ ---> } N_2^*\ (^1\Sigma_u^+, {}^1\Pi_u) + e, \qquad 6)$$

$$N_2^*\ (^1\Sigma_u^+, {}^1\Pi_u) \text{ -> } N + N + h\nu,$$

where N_2^* ($^1\Sigma_u^+$, $^1\Pi_u$) can be a repulsive dissociating state (in the Franck-Condon region) or a bound predissociating state. Absolute cross sections at 100 CV of two of the three types of dissociative N_2 processes found within reaction 6) have been measured in the laboratory. The three subsets of processes are represented by the reactions,

$$N_2^*\ (b', c_4', C\ ^1\Sigma_u^+, b, c, c, ()\ ^1\Pi_u) \text{ -> } N(2p^3\ ^2D^0,\ 2p^3\ ^2P^0) + N(2p^3\ ^4S^0)$$

(principal predissociation paths), 7)

$N_2^*(^1\Sigma_u^+, ^1\Pi_u)$- > $N(2p^3\ ^2P^0, ^2D^0) + N(2p^3\ ^2P^0, 21)(')$ (principal direct dissociation paths), 8)

and

$N_2^*(^1\Sigma_u^+, ^1\Pi_u)$- > $N(2p^4\ ^0S^2 1, ^0 ^2D^0) + N(nl, n\geq 3)$ (dissociative excitation from high] y- excited and super-excited states). 9).

The first type Of process is the predissociation process, reaction 7), which has been extensively discussed by Cosby and Co-workers (Walter et al., 1993, J 994; Cosby, 1 993). The second type Of process, reaction 8), is a direct (dissociation reaction into fragments inside the ground state. con figuration, $2p^3$. The third reaction 9) is a dissociative excitation process studied in this work. Electron spin conservation requires pairs of product N] atoms with identical spin to produce singlet states. However, excitation function studies of the doublet manifold thresholds of several Rydberg series $2p^2(^3P)\ nl(^2P,^2D,^2S)$ indicate that the doublet manifold is formed with a $^4S^0$ partner (Rall et al., 1 987). The process in Reaction 7) proceeds because of the interaction from a triplet predissociating state. (Walter et al., 1993,1994). In the same way, spin-orbit interaction of close-lying

singlet and triplet states probably contributes 10 the dissociative excitation reaction 9) for $n \geq 3$. However, reaction 8) must proceed primarily through doublet states. Cook cl al. (1973) have shown experimentally and Michels (1980) has shown from theoretical considerations that the! first dipole allowed singlet-ungerade repulsive state of N_2 is a $^1\Pi_u$ state producing two $^2D^0$ atoms. Oncc again $^4S^0$ should not contribute to the dissociation process. Its yield may bc more important near threshold in electron impact processes, where tripl et-ungerade states can bc formed by electron exchange (Michels, 1980).

For reaction 9), Rail et al. (1987) have identified that the Rydberg series of the intermediate states as bound states with large equilibria internuclear distances compared to the ground state. These states can be generated by having the $N_2^+(D\,^2\Pi_g)$ state as the parent ion convergence limit. These dissociations tend to produce at least onc $^4S^0$ atom. Recent work by Ukai et al. (1992) has shown the existence of double holed doubly excited resonances Rydberg structure in the 20-38 eV region. The cross section for these processes that decay into two excited N^* atoms is small compared to the dissociative processes considered here.

Estimates of the cross sections of reactions 6), 7), 8) and 9) and the kinetic energy distribution of the fragments are important in modeling processes in the upper atmosphere of the Earth and the satellites of the outer planets. Cosby finds that the total recommended cross section for Reaction 6) is 1.2 x I 0^{-16} cm^2 at 100 eV. 1 le makes this estimate by averaging his work with that of Winters (1 966). The two works differ by a factor of two. James et al. together with the recent update on c_4' $^1\Sigma_u^+$ (0) predissociation yield (Shemansky et al., 1995) lead to a predissocia ion cross section into $N(^2D^0, ^2P^0)$ -I $N(^4S^0)$ pairs of -5 x J $()^{-'7}$ cm^2 at 00 CV for reaction 7). The references, mentioned in the Introduction, for the measurement of NI and NII line emissions fom dissociation (and dissociative ionization) of highly-excited anti super-excited intermediate states give the total emission cross section of doublet and quartet states considered in reaction 9). The approximate total UV emission cross section (this value includes cascade cross sections from the IR and visible of Rall et al. (1 987)) at 100" eV coming from excited states resulting in ground states of $^4s^0$ symmetry is 6 x 10^{-18} cm^2, of ^{2}1) ^{0} symmetry is 5 x 10-18 cm^2 and of $^2P^0$ symmetry is 5 x 10-'8 cm^2. The excitation function measurements of NJ multiplets indicate that most

of the emission cross section is attributed to dissociative ionization excitation processes (Ajello et al., 1985). We estimate the total cross section for dissociation into one ground state atom and one atom in a highly-excited or super-excited state to be 5×10^{-18} cm^2 at **100** eV with about each one (bird of the excited fragments radiating into $^4S^0$, 21P, $^2P^0$ ground state configuration fragments, **respectively.** An amount between 3 and 6% of the total (Dissociation arises by dissociative excitation. There are other small dissociation processes: Rydberg atoms, a $^1\Pi_g$ (v' >6) predissociation, other singlet and triplet state predissociations not accounted for above, amounting to less than 1×10^{-17} cm^2 at 100 eV (Iiox and Victor, 1988). However, the large uncertainty in the total dissociation cross section renders the dissociation cross section into chemically active N($2p^3$ $^2D^0$, $^2P^0$) doublet state atoms at 1 ()() eV as very uncertain with a cross section value between **()**.2 and ().9 x 10-16 cm^2. This extent of cross sections suggests that the quantum yield of N($2p^3$ $^2D^0$), $^2P^0$) doublet state atoms is in the range of 65 to 8?. % with 75% recommended value.

The uncertainty in the yield of chemically active N($2p^3$ $^2D^0$, 2P()) atoms, generated by the uncertainty in tots] cross section, is

more than compensated for by the fact that all (dissociation processes lead to non-thermal production of N-atoms. Certainly predissociation and direct (dissociation of highly- excited and super-cxcilc(i states lead to atoms with kinetic energy distributions with mean energies above **0.5** cV. Potential curves of repulsive states that may lead to a n understanding of the dissociation process from direct (dissociation i n the ground state configuration have been published by Michels (1981) anti from direct dissociation of superexcited states by Baltzer et al., (1992) and Langhoff and Bauschlicher (**1988).** The singlet a n d triplet repulsive potential curves shown in these publ ications, converging (o two ground state configuration atoms, are extremely Sleep in the Franck-Condon region, indicating substantial kinetic energy for reaction 8). More extensive potential curves for superexcited states in 20-32 eV region show large internuclear separation asymptotes converging to a single ion anti atom. These curves arc complicated and in many cases exhibit barriers to (dissociation (Baltzer et al., 1992). Recent coincidence measurements of dissociative photoionization excitation of the N](1200" Å) b y synchrotron radiation can be compared to results of this work b y electron i m p a c t (Kitajima et a l . , 1995). The results indicate

dissociat ion from the repulsive wall of high--lying N_2^{+*} states (reaction 2). Substantial kinetic energy of -2-6 eV per atom (ion) is released in the 35 - 40 eV photon impact energy region (Kitajima et al., 1995). We find in this experiment that dissociative ionization excitation produces atoms with higher kinetic energy than dissociative excitation. Evidently the repulsive portion of (h e potential curves arc steeper in the Franck-Condon region for the ion.

The escape energy of N atoms from the satellites (Titan and Triton) of the outer planets is Icss than 0.5 cV. Wc indicate this energy region in Figure 3b for dissociation from highly-excited and super-cxcitcd states. It is assumed that the emission line profiles of NI(1200 Å) and NII(1085 Å) lead to kinetic energy distributions that arc representative of all UV radiating states. For the predissociated States Cosby has shown that the kinetic energy distribution is predominantly produced with energies above ().5 cV. Since his underlying kinetic energy continuum of fragments from repu sive states also follows this result, it is evident that more than 80% of the atoms have. sufficient energy to escape. If half of the N- atoms, w ıich arc formed n the exobase region, arc moving in the upward hemisphere, hey would escape the satel ite. The UV results from

Voyager (Broadfoot et al., 1981, 1989; hall et al., 1992) indicate the radiation is produced in the upper atmosphere of the satellites. other planetary applications of fast nitrogen atoms in a planetary atmosphere have been described by Fox and Dalgarno (1 983).

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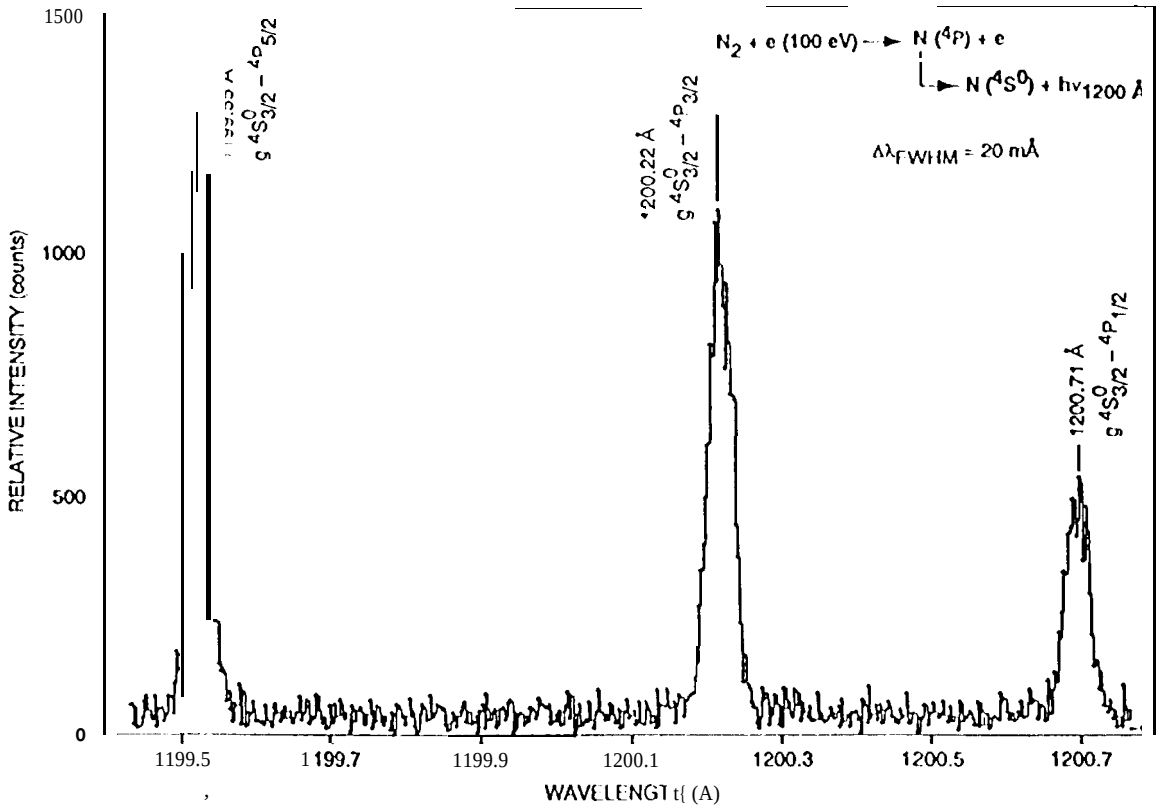
TABLE OF FIGURES

FIGURE] . Experimental spectra : a) 100 eV NI (1200 Å) multiplet (g $^4S^0$ <-- 41'); b)100 eV NII (1085 Å) multiplet (^{3}1' <-- $^3D^0$). The wavelength step size in third order was 2..667 mÅ. The operating conditions were established as follows: 1) background gas pressure of 1 x 10^{-4} torr and 2) electron beam current of 258 mA.

FIGURE 2. Experimental spectra .. a) 30 and 1(KI CV NI (1 199.5 Å) multiplet fine structure line (g $^4S_{3/2}^0$ <-- ^{4}1'$_{5/2}$) with instrumental slit function; b) 100 CV N]] (1085.70 Å) multiplet fine structure line ($^3P_2$ <-- $^3D_3^0$) with the instrumental slit function. The wavelength step size in third order was 1.333 mA. Peak signals were 7000 and 4000 counts in the N](I 199.5 Å) and N]] (1085. "/0 Å) line profiles, respectively, with background signals of under 100 counts. The FWHM of the 30 and 100 CV line profiles and slit function arc indicated in the figure.

FIGURE 3a. Deconvolution of the 30 and 100 eV line profiles of N] (I 200 Å) and NII(1 085 Å) from the measured line profiles of Fig.

2. b) Kinetic energy N] ($^4P_{3/2}$) atom distribution of slow atoms at 3 () and 100 eV. and NII($^3D_3^0$) The kinetic energy distributions are obtained from Fig. 3a as explained in [he text using FFT techniques.


1500
1000
500
0
RELATIVE INTENSITY (counts)
N_2 + e (100 eV) → N (^{4}P) + e
→ N (^{4}S^0) + hν$_{1200 Å}$
Δλ$_{FWHM}$ = 20 mÅ
1200.22 Å
g $^4S^0_{3/2} - {}^4P_{3/2}$
1200.71 Å
g $^4S^0_{3/2} - {}^4P_{1/2}$
1199.5
1199.7
1199.9
1200.1
1200.3
1200.5
1200.7
WAVELENGTH (A)

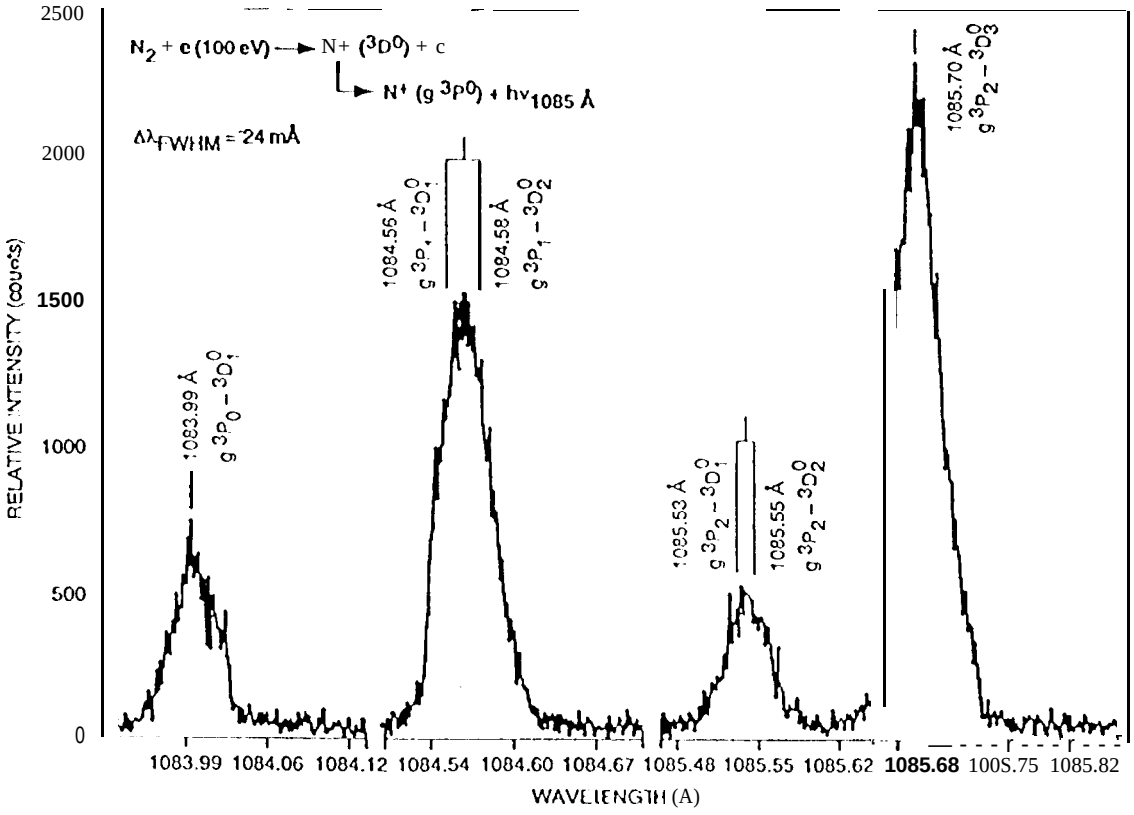

2500
2000
1500
1000
500
0
RELATIVE INTENSITY (counts)
N_2 + e (100 eV) → N+ (^{3}D^0) + e
→ N+ (g ^{3}P^0) + hν$_{1085 Å}$
Δλ$_{FWHM}$ = 24 mÅ
1083.99 Å
g $^3P_0 - {}^3D^0_1$
1084.56 Å
g $^3P_1 - {}^3D^0_1$
1084.58 Å
g $^3P_1 - {}^3D^0_2$
1085.53 Å
g $^3P_2 - {}^3D^0_1$
1085.55 Å
g $^3P_2 - {}^3D^0_2$
1085.70 Å
g $^3P_2 - {}^3D^0_3$
1083.99 1084.06 1084.12 1084.54 1084.60 1084.67 1085.48 1085.55 1085.62 1085.68 1085.75 1085.82
WAVELENGTH (A)

Fig. 1

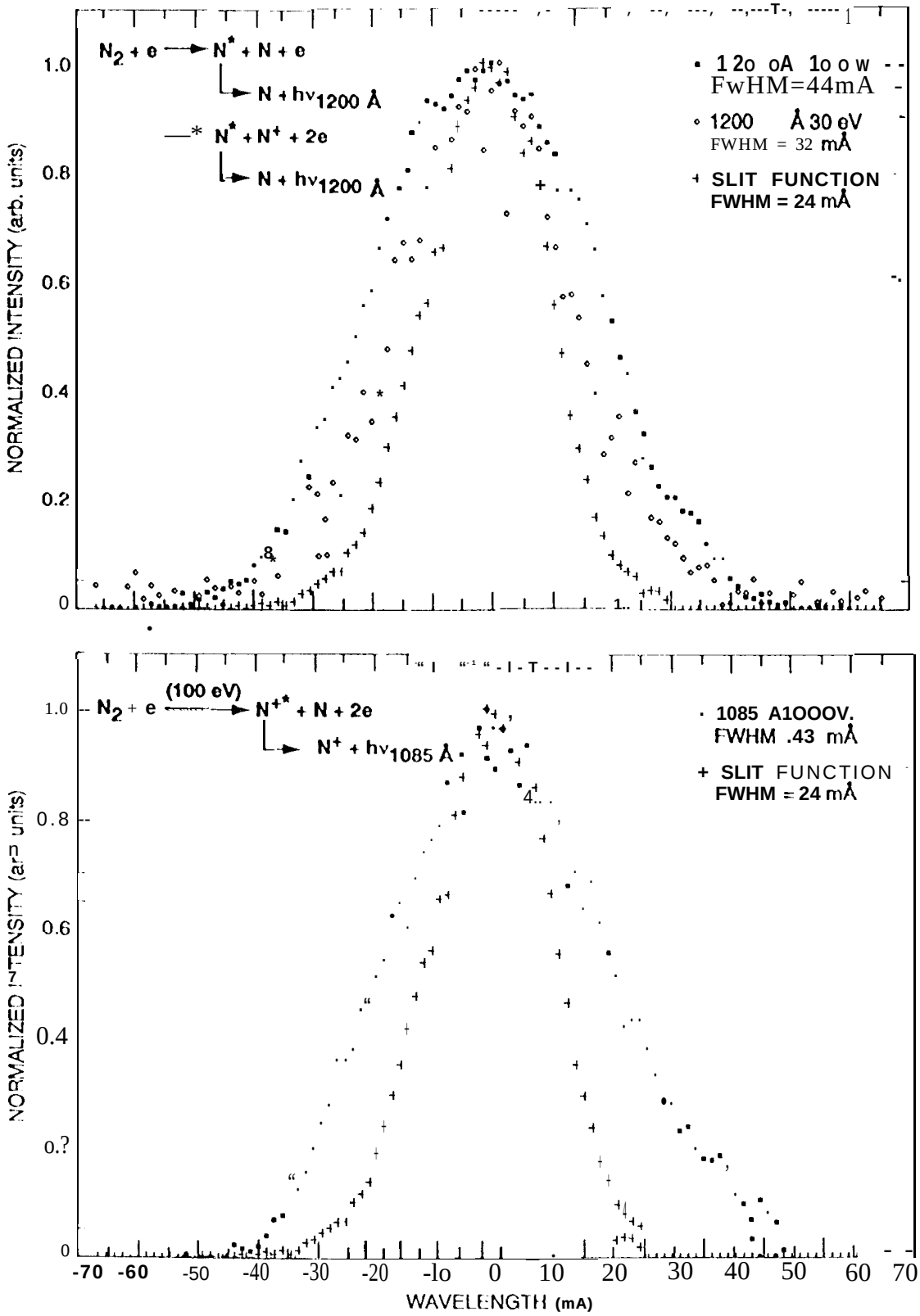
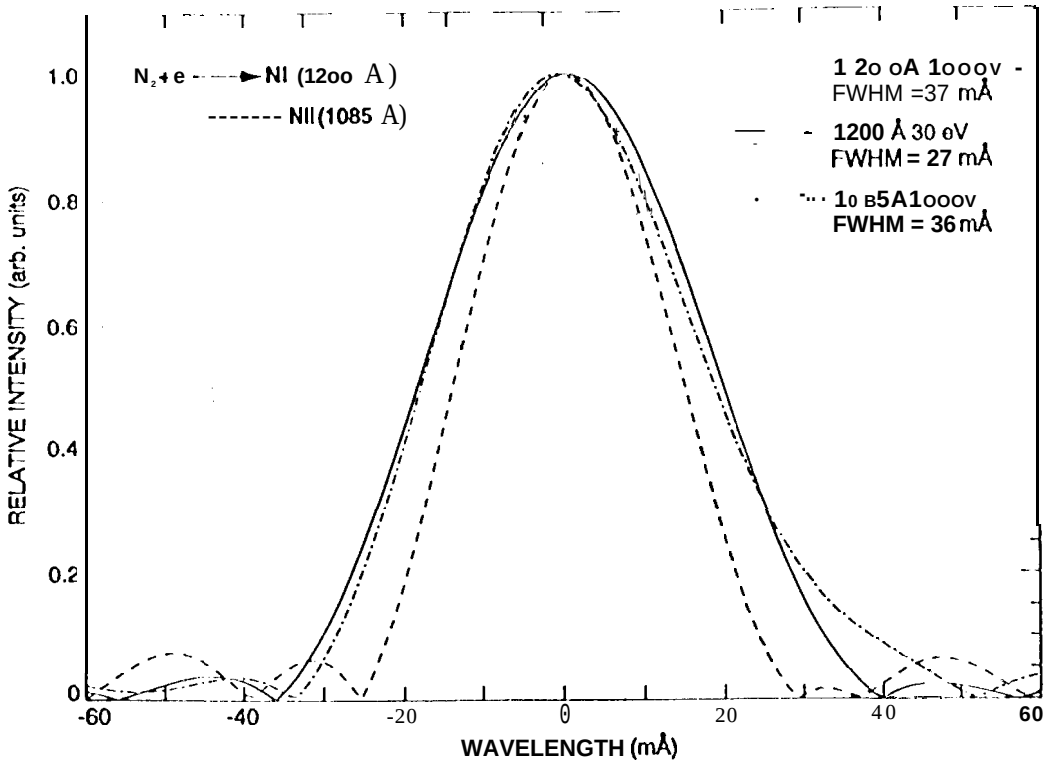

N2 + e → N* + N + e
→ N + hν1200 Å
→* N* + N+ + 2e
→ N + hν1200 Å
1200 Å 30 eV
FWHM = 32 mÅ
SLIT FUNCTION
FWHM = 24 mÅ
NORMALIZED INTENSITY (arb. units)
N2 + e (100 eV) → N+* + N + 2e
→ N+ + hν1085 Å
1085 A1OOOV.
FWHM .43 mÅ
SLIT FUNCTION
FWHM = 24 mÅ
WAVELENGTH (mA)

Fig. 2


N₂+e → NI (1200 A)
NII(1085 A)
1200 A 1000V
FWHM =37 mA
1200 A 30 eV
FWHM = 27 mA
1085A1000V
FWHM = 36mA
RELATIVE INTENSITY (arb. units)
WAVELENGTH (mA)

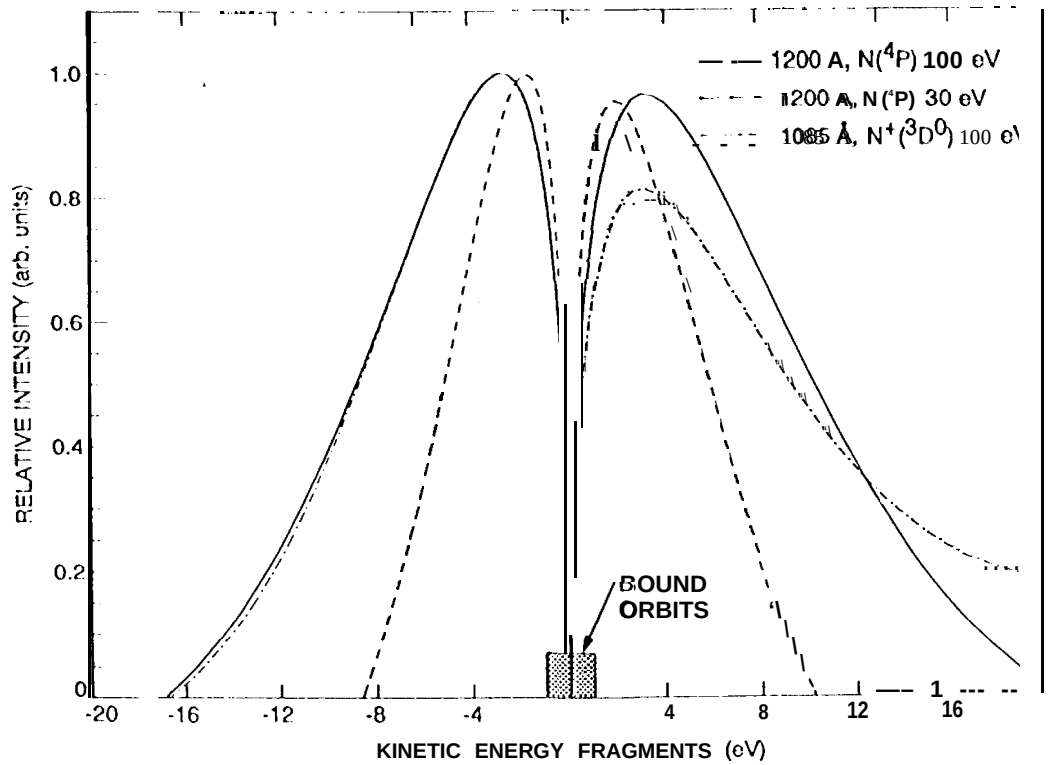

1200 A, N(⁴P) 100 eV
1200 A, N(⁴P) 30 eV
1085 A, N⁺(³D⁰) 100 eV
BOUND ORBITS
RELATIVE INTENSITY (arb. units)
KINETIC ENERGY FRAGMENTS (eV)

Fig. 3