ELECTRON IMPACT EXCITATION OF NITRIC OXIDE

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Excitation of the Rydberg $A^2\Sigma^+$ state of nitric oxide has been studied by electron impact in the energy region from threshold to 15eV. Absolute emission and integral cross sections for excitation of v=0 and v=1 vibrational levels of the $A^2\Sigma^+$ state have been measured. Emission spectra of the $A^2\Sigma^+ \rightarrow X^2\Pi$ transition (γ-system) of nitric oxide have been also obtained for selected value of electron energy.

1. Introduction

In this communication we present studies of electron impact excitation of nitric oxide (NO) in the electron energy region below 15 eV. Nitric oxide is a constituent of the Earth's thermosphere and its emission bands are identified in the dayglow and twilight of the atmosphere. This radiation has been used to investigate the abundance of NO which is produced through ionization and dissociation of the major atmospheric species in the thermosphere. The above natural phenomena suggest nitric oxide as a subject for laboratory research and it has been studied in a few electron impact investigations. Skubenich *et al.* [1] and Brunger *et al.* [2] measured integral cross sections for excitation of several electronic states of nitric oxide in a wide energy range. Scattering experiments of Zecca *et al.* [3] and Szmytkowski and Maciąg [4] concentrated on measurements of total cross section. Immami and Borst [5] and Ajello *et al.* [6] obtained emission cross sections for different fluorescence lines of nitric oxide. Brunger *et al.* [7] and Mojarrabi *et al.* [8] measured differential cross sections for electronic excitation and elastic scattering in nitric oxide respectively while Stubbs *et al.* [9] reported energy loss spectra. Little theoretical work has been performed on electron scattering by nitric oxide. Lee *et al.* [10] applied Born-closure Schwinger variational method to calculate the elastic differential cross section for electron scattering in the 5–500 eV energy range.

In the present work we have obtained absolute emission and integral cross sections for excitation of vibrational levels of the $A^2\Sigma^+$ state of nitric oxide in near-threshold energy region up to 15 eV.

2. Experimental details and results

In our measurements an electron spectrometer equipped with a trochoidal electron selector to monochromatize the incident electron beam has been used and excitation of nitric oxide has been detected by the optical method [11,12]. The molecular fluorescence produced in the scattering region is transmitted via a quartz lightguide to the entrance of a 0.25 m Ebert grating monochromator and then is detected by a photomultiplier. In the wavelength range from 190 nm to 320 nm the main contribution to the emission spectra comes from the (v', v'') bands of the γ-system, which are due to excitation of vibrational levels of $A^2\Sigma^+$state. Much less intense bands corresponding to the ε-system generated by the $D^2\Sigma^+ \rightarrow X^2\Pi$ transition have been observed at higher incident electron energy of 12 eV in the wavelength range from 190 nm to 210 nm of the measured spectra. An emission spectrum obtained in nitric oxide with an optical resolution of 2 nm at fixed incident electron energy of 6.15 eV is shown in Fig. 1.

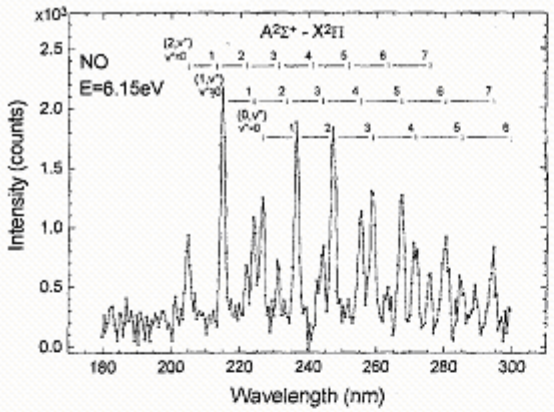

Fig. 1. Emission spectrum of nitric oxide obtained at an incident electron energy of 6.15 eV. The spectrum is not corrected for transmission of the optical detection channel.

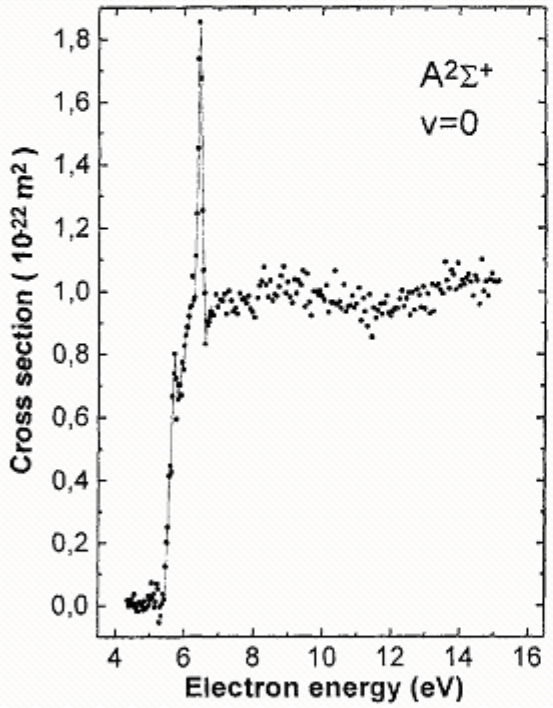

Fig. 2. Cross section for excitation of the v=0 level of the $A^2\Sigma^+$ state of nitric oxide measured from threshold to 15 eV.

In the present studies we have measured the cross sections for excitation of v=0,1 vibrational levels of the $A^2\Sigma^+$ state. In the first step the absolute emission cross sections have been determined at an energy of 7.2 eV for the (0, v'') and (1, v'') lines of the γ-system by normalizing the photon intensities of the emission lines to that of the (0,0) line of the second positive system of nitrogen and using the value of its emission cross section determined previously [11]. Next the emission cross sections have been summed over v'' final levels for each vibrational level of the $A^2\Sigma^+$ state to obtain the excitation cross sections. The energy dependence of the cross sections has been determined in measurements of excitation function of the (0,1) line at 236.3 nm and (1,0) line at 215 nm, which have been normalized to the obtained values of the cross sections at 7.2 eV. The cross section for excitation of v=0 vibrational level obtained in the electron energy range from threshold to 15 eV is shown in Fig. 2. The cross section displays resonant variation in the energy region close to the excitation threshold with a strong peak at 6.46 eV due to the $(3p\pi)(3p\sigma)\ ^3\Pi$ negative-ion resonance [13] but is quite flat in the energy region above 7 eV.

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ЗБУДЖЕННЯ ОКСИДУ АЗОТУ ЕЛЕКТРОННИМ УДАРОМ

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Збудження рідбергівського $A^2\Sigma^+$ стану оксиду азоту досліджено методом електронного удару в області енергії від порогу до 15 еВ. Виміряно абсолютні перерізи випромінювання та інтегральні перерізи збудження коливних рівнів стану $A^2\Sigma^+$ з v=0 та v=1. Також отримано спектри випромінювання переходу $A^2\Sigma^+ \rightarrow X^2\Pi$ (γ-система) оксиду азоту для вибраного значення енергії електронів.