20th Summer School and International
Symposium on the Physics of Ionized Gases

20th SPIG

September 4 - 8, 2000, Zlatibor, Yugoslavia

CONTRIBUTED PAPERS

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ABSTRACTS OF INVITED LECTURES,
TOPICAL INVITED LECTURES AND PROGRESS REPORTS

Editors:
Z. Lj. Petrović, M. M. Kuraica, N. Bibić and G. Malović

Institute of Physics
Faculty of Physics, University of Belgrade
Institute of Nuclear Sciences "Vinča"
Belgrade, Yugoslavia

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PREFACE

This book contains the Contributed papers and abstracts of the Invited lectures, Topical invited lectures and Progress reports to be presented at the 20th Summer School and International Symposium on the Physics of Ionized Gases – SPIG 2000. The Symposium will be held in Zlatibor, Yugoslavia, from September the 4th to September the 8th, 2000.

The Contributed papers are related to the following research fields: Atomic Collision Processes, Particle and Laser Beam Interaction with Solids, Low Temperature Plasmas and General Plasmas. The length of a Contributed papers is limited to a maximum of four pages, each of them presenting an original work with sufficient amount of scientific information.

The Scientific and Organizing Committees believe that this Symposium, with its Invited lectures and Contributed papers, managed to maintain the high scientific level established by previous SPIG conferences in the 40 years long tradition. To mark the occasion of the 20th SPIG a special, *fifth*, section was introduced dealing with the history of SPIG. A separate session will be arranged with a lecture on the history of SPIG. All the participants, especially those that took part in early SPIG conferences are invited to share their memories, impressions and thoughts on the future of the conference.

The Organizers of the 20th SPIG are the Institute of Physics, Faculty of Physics – University of Belgrade and Institute of Nuclear Science “Vinča”. The Organizer gratefully acknowledges the support of the Ministry of Science and Technology of the Republic of Serbia and Ministry of the Development, Science and Environment of the Federal Republic of Yugoslavia. We also acknowledge support of PTT Serbia and Jumko. The Organizing committee appreciates the help from the previous Organizers, Mr. I. Videnović in particular.

The participants have been asked to send their papers camera ready, so no typing, spelling and grammatical errors have been corrected in the course of preparation of this book.

June, 2000. Editors

DIFFERENTIAL OSCILLATOR STRENGTHS FOR N_2O IN THE 5 TO 14 eV ENERGY LOSS REGION

S. Čučković and B. P. Marinković[1]

Institute of Physics, Belgrade, P.O.Box 68, 11080 Zemun, Yugoslavia

Abstract. In the present study, electron energy loss spectrum of nitrous oxide at 50 eV impact electrons energy and scattered electrons at zero angle have been used and apparent oscillator strength distribution derived from it, is compared with other elecron impact studies and photoabsorption measurements that have previously been reported.

1. INTRODUCTION

Increasing interest in the energetic radiation processes in nitrous oxid arises from alarming danger caused by depletion of the ozone layer. Since photodissociation of N_2O is the major natural source of nitric oxides that limit present ozone concentrations in the stratosphere, it is an important component in any detailed analysis of this problem. It is important to note that N_2O is widely used as an electron scavenger in radiation chemistry.

The determined absolute differential cross section (DCS) values for the excitation of the $2\ {}^1\Sigma^+$ and ${}^1\Pi$ states of N_2O [1] and it's electron energy-loss measurements data [2] have been used for deriving the apparent differential oscillator-strength distribution for N_2O. Measurements were obtained at electron impact energies of 15, 20, 30, 50, and 80 eV, using the electron spectrometer with crossed electron-molecule beam arrangement .

The energy-absorption properties (i.e. the oscilator-strength distribution) of N_2O are very important in many problems where energetic radiations encounter N_2O. Close connection between the excitation of molecules by electron impact and by the absorption of radiation has been recognized long ago [3].

At sufficiently high kinetic energies for the incident electrons and at sufficiently small scattering angles the excitation of molecules by electron impact is governed by selection rules which are the same as the (dipole) selection rules that apply to the absorption of radiation. This assertion was not, in fact new, because it was already established by Bethe 1930 [4] who introduced the concept of generalized oscillator strength, $f_n(K)$, where K is the momentum transfer. Lassettre and coworkers [5] established new theory of limitation the generalised oscillator strength that results from Bethe concept and is also deduced from the Born approximation :

$$\lim f_n(K)=f_n, \quad \text{(for all impact electron energies T)}, \tag{1}$$

where f_n is the optical (dipole) oscillator strength. It is an important relationship that connects the collision of fast charged particles with photoabsorption.

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[1] e-mail: bratislav.marinkovic@phy.bg.ac.yu

A comperhensive review on the experimental and theoretical results obtained for the optical absorption of N_2O is provided by Chan *et al.* (1994) [6] and will not be discussed in much detail here. A useful review of experimental data is also provided by Shaw *et al.* (1922) [7] who used the best available data from six different sources to compose an absorption spectrum from 7.75 eV to 124 eV and who revealed the lack of good data over certain regions of the spectrum, most notably the absence of photoabsorption data covering the energy region from 11.8 to 12.4 eV.

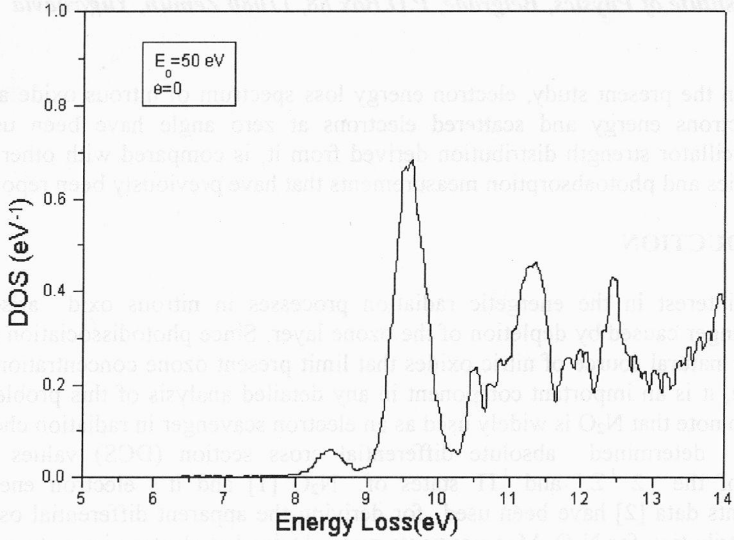

Figure.1. *A differential oscillator strength spectrum for nitrous oxide obtained in the present electron impact work*

2. THEORY

For sufficiently large elecron energy T and small scattering angle $\theta \cong 0$ the inelastic electron scattering intensity distribution I(E) is related to the differential optical oscillator strength distribution *df*/dE. Such a relation will hold only over a limited range of energy losses, E, such that E/T <<1. For an apparatus with small circular apertures which define a finite maximum acceptance angle $\hat{\theta}$, the measured intensity will be proportional to the differential electron scattering cross section $d\sigma/d\Omega$ integrated over the finite solid angle $\Delta\Omega$, corresponding to $\hat{\theta}$. Thus,

$$I(E) \propto \Delta\sigma/\Delta\Omega = \int \frac{d\sigma}{d\Omega} d\Omega \Big/ \int d\Omega \qquad (2)$$

where $d\Omega = 2\pi \sin\theta \; d\theta$. Using the Born approximation expression [8] for $(d\sigma/d\Omega)$ and further assuming the Lassettre limitation theory (1), one can derive the expression

$$df/dE \propto (\mathrm{E/R})\hat{\theta}\left\{\ln\left[1+\left(\hat{\theta}/\gamma\right)^2\right]\right\}^{-1} \mathrm{I(E)}, \tag{3}$$

where

$$\gamma^2 = (E/2T)^2(1-E/T)^{-1} \text{ for constant T.} \tag{4}$$

However, this expression neglects the second and higher order terms in the expansion of df/dE [8] and may limit the accuracy of Eq.(3), particularly when the amount of energy loss represents a substantial fraction of the incident energy(e.g. large E/T). If the absolute energy loss cross section is not determined, then some suitable normalization procedure is needed to fix the relative df/dE values from Eq.(3) on an absolute scale.

3. EXPERIMENT

The electron spectrometer used in this experiment is designed for crossed beam measurements. The electron beam is formed in a system of cylindrical electrostatic lenses and hemispherical energy selector. It is focused by means of a zoom lens to intersect the molecular beam (formed by a 2.5 cm long and 0.05 cm wide tube) at 90°. The scattered electrons are detected by a rotating analyser that covers an angular range from -30° to 150°, in the plane perpendicular to the molecular beam. A constant position between an

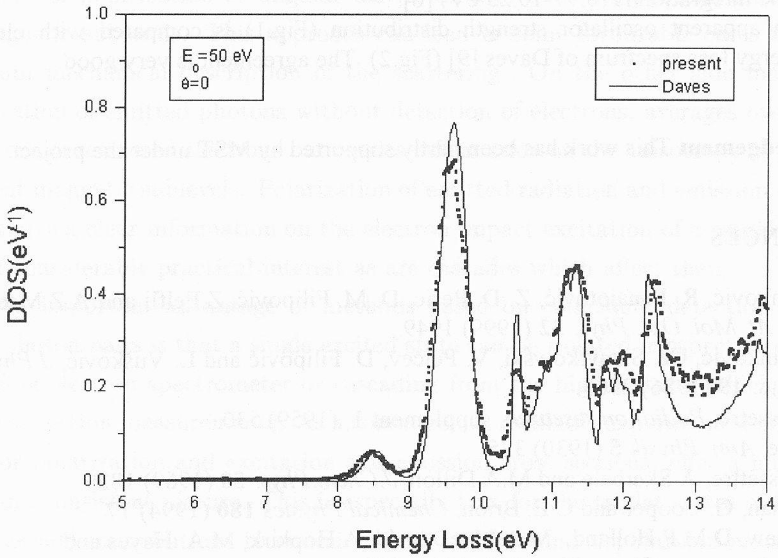

Figure.2. *Differential oscillator strength spectra for nitrous oxide.* ●●● *Present work,* — *Daves.* [9]

analyser and the molecular beam source has been provided by fixing the gas-tube to the analyser support and rotating them together. The analyser is of the same construction as the electron monohromator except that it has a channel electron multiplier as a single-electron detector at the end. All materials used in the apparatus were carefully checked not to be magnetic and the external magnetic fields were minimized by a double μ-metal shield inside the vacuum chamber.Electrodes are made of OFHC copper and gold plated,while the hemispheres and diaphragmas are made of molybdenum.

The best obtained energy resolution was 38 meV and angular uncertainity was estimated to be 0.5°. Two diffusion pumps provide differential pumping of the vacuum chamber and electron-optics system. The background pressure inside the vacuum chamber during the experiment was of the order of 5 mPa.

4. RESULTS AND DISCUSSION

In the present work we have used the determined absolute diferential cross section for the excitation of the $2^1\Sigma^+$ state (9.6 eV) of N_2O, $\sigma = 10100 \times 10^{-23} m^2$ [1] and optical oscillator strength(OOS) value of 0.353 wich is adopted value from the most recent electron impact experiment [9] as our own data belong to the same group of measurements.

The last value presents the area under the differential optical oscillator strength distribution peak for $2^1\Sigma^+$ transition and together with Eq.(3) we have applied it to the electron energy loss spectrum of N_2O shown in Fig.1. With this normalization procedure we have obtained the apparent oscillator strength distribution presented in Fig.1. The range of the integration is (8.97-10.23 eV) [6].

An apparent oscillator strength distribution (Fig.1) is compared with electron impact energy loss spectrum of Daves [9] (Fig.2). The agreement is very good.

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