# 1ˢᵗ National Conference on Electronic, Atomic, Molecular and Photonic Physics

15ᵗʰ - 18ᵗʰ May, Zaječar, Serbia
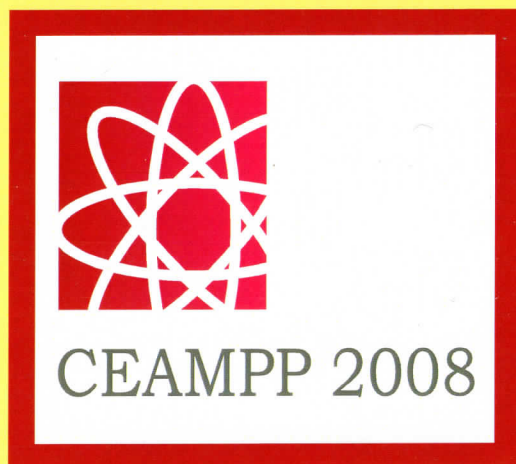


CEAMPP 2008

## CONTRIBUTED PAPERS
## &
## ABSTRACTS OF INVITED LECTURES AND PROGRESS REPORTS

Editors:
Aleksandar R. Milosavljević
Dragutin Šević
Bratislav P. Marinković

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CONTRIBUTED PAPERS & ABSTRACTS OF INVITED LECTURES
AND PROGRESS REPORTS
of the
1st NATIONAL CONFERENCE ON ELECTRONIC, ATOMIC,
MOLECULAR AND PHOTONIC PHYSICS

15th – 18th May 2008
Zaječar, Serbia

# PREFACE

This book contains the Contributed papers and abstracts of the Invited lectures and Progress reports to be presented at the 1$^{st}$ National Conference on Electronic, Atomic, Molecular and Photonic Physics – CEAMPP 2008. We wish to establish CEAMPP as a traditional national conference covering a wide range of scientific topics in atomic and molecular physics. The CEAMPP aims to bring together and support collaboration between different groups working basically in the various fields of atomic and molecular physics, so making the way to induce new ideas and interdisciplinary research. Finally, the focus of the CEAMPP is put on participation of young distinguished researchers, who are invited to give the most of the lectures. The conference will be held in Zaječar, Serbia, from May 15 to 18, 2008. The meeting is organized under the auspices and with the support of the Ministry of Science, Republic of Serbia. Also, the conference is organized under the auspices of the Serbian Physics Society.

The Invited lectures and Contributed papers are related to the following research fields: Atomic and Molecular Structure and Properties, Collision Processes and Photon Interaction with Atoms and Molecules. The length of Contributed papers is limited and each is supposed to present an original work with sufficient amount of scientific information. The Scientific and Organizing Committees believe that this conference manages to obtain the high scientific level of contributed papers and invited speakers, so to establish a model for future CEAMPP meetings.

The Editors would like to thank the members of the Scientific Committee of CEAMPP 2008 for their efforts in proposing the program and scope of the conference, as well as invited lectures and progress reports and for a review of the contributed papers and abstracts of oral presentations. We are grateful for the support of our sponsor Serbian mobile network "Mobilna Telefonija Srbije – MTS". Also we acknowledge the support of the National Museum of Zaječar in organizing the social program of the conference. Finally, we acknowledge the support of all members of the Organizing Committee who contributed to the preparing and running of the conference.

The participants have been asked to send their papers in a format already prepared for publication. After peer review of contributions, the basic corrections have been made to meet general form of the book and to avoid, as much as possible, typing, spelling and grammatical errors. The Editors apologize for all mistakes that emerged from the preparation process and software problems in the process of printing.

Finally we would like to thank all the invited speakers and the participants for taking part in this first CEAMPP, to wish them to have a pleasant stay in Zaječar, and to gain additional momentum and ideas for the future work.


Belgrade, May, 2008                                                                                     Editors

# ACKNOWLEDGEMENT

1<sup>st</sup> NATIONAL CONFERENCE ON ELECTRONIC, ATOMIC,
MOLECULAR AND PHOTONIC PHYSICS

*is organized by the*

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# CEAMPP 2008

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**3. PHOTON INTERACTION WITH ATOMS AND MOLECULES**

# CEAMPP 2008

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**Abstracts of Progress Reports**

## Contributed Papers

# Relative Angle-Diffierential Cross Sections for Elastic Scattering of Electrons from 3-hydroxytetrahydrofuran Molecule

J. B. Maljković[1], A. R. Milosavljević[1], F. Blanco[2], D. Šević[1], G. García[3] and B. P. Marinković[1]

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**Abstract.** Angle-differential cross sections for elastic scattering of electrons from 3-hydroxytetrahydrofuran (3-Furanol, Tetrahydro) are presented for incident energies of 100, 150 and 200 eV. Measurements were performed using a cross beam technique, for scattering angles from 10° to 110°. The calculations of molecular cross sections are based on a corrected form of the independent-atom method, known as the SCAR (Screen Corrected Additivity Rule) procedure and using an improved quasifree absorption model. Regarding the shape of differential cross sections, experimental and theoretical results agree very well. The present results are also compared with previous calculations.

**Keywords:** 3-hydroxytetrahydrofuran, elastic electron scattering, independent atom method
**PACS:** R34.80.Bm Elastic scattering of electrons by atoms and molecules. 34.10.+x General theories and models of atomic and molecular collisions and interactions.

## INTRODUCTION

The investigation of electron interaction with molecules which are analogues to DNA components has been motivated in recent years by the research of radiation damage in biomolecular systems [1]. Since a large number of secondary low-energy electrons are formed on the track of primary high-energy ionizing particles, they carry most of the energy and play a particularly important role in the final radiation damage. Therefore, an investigation of the electron interaction with building blocks of DNA molecule could be useful to better understand electron driven processes at molecular level which contribute to the final radiation damage. In order to investigate the electron interaction with deoxyribose sugar, which forms the backbone of the DNA, one can also perform experiments with some model molecules like tetrahydrofuran (THF), 3-hydroxy-tetrahydrofuran (3HTHF) and tetrahydrofurfuryl alcohol (THFA) [2].

The 3HTHF molecule ($C_4H_8O_2$) represents a furan ring bonding a hydroxyl (-OH) group (see Figure 1). Because of its similarity to a nucleotide ring system, 3HTHF has

been used as a simple theoretical model of the ring conformations in nucleotides [3-5]. Existing results for 3HTHF include: theoretical calculations of differential and integral cross sections for elastic collisions using independent atom method (IAM) [6], investigation of the 5-40 eV electron stimulated desorption yields of H produced by dissociative electron attachment to 3HTHF physisorbed on a polycrystalline Pt substrate [7,8], investigation of dissociative electron attachment 3HTHF [9] and, the most recently, measurements of positron scattering from 3HTHF by Zecca et al [10]. The experimental results for elastic scattering of electrons by similar molecules THF and THFA, in the present energy and angular ranges, have been also reported [11,12]. Finally, a comparative study of all three molecules: THF, 3HTHF and THFA has been reported very recently [13].



3-hydroxytetrahydrofuran
$(C_4H_8O_2)$

2-deoxy-D-ribose
(deoxyribose)
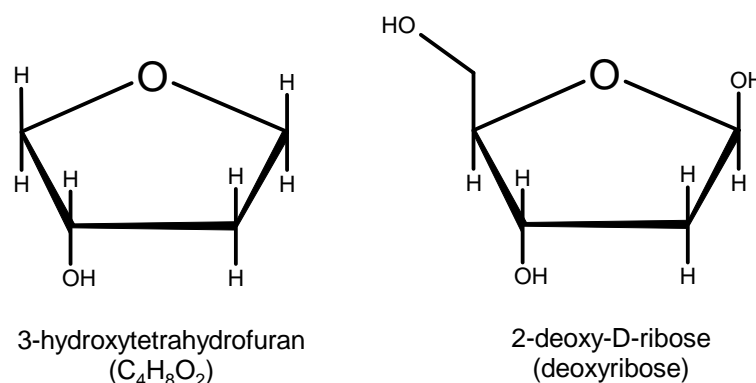
**FIGURE 1.** Schematic drawing of 3-hydroxy-tetrahydrofuran and deoxyribose molecules.

In the present contribution, both experimental and theoretical results on elastic electron interaction with 3HTHF molecule have been reported. The experimental relative DCSs are obtained for 100, 150 and 200 eV, in the angular range from 10° to 110°. Present calculations of molecular cross-sections are based on a corrected form of the independent-atom method, known as the SCAR (Screen Corrected Additivity Rule) procedure. The SCAR has been proved already to give a very good agreement with the measurements, for similar molecules THF and THFA [12,13]. This is also confirmed, regarding DCS shapes, in the present work for 3HTHF. In addition, in the present study, a new procedure has been developed to investigate the behavior of theoretical DCSs in the forward direction, which seemed to be overestimated in previous calculations.

## EXPERIMENTAL

A detailed description of the present crossed-beam experimental set-up has been given elsewhere [14]. Briefly, an electron gun produces a nonmonochromated, well collimated incident electron beam, which is crossed perpendicularly by a molecular beam produced by a stainless still needle. The gun can be rotated around the needle in the angular range from about -40° to 120°. The scattered electrons are retarded and focused by a four–element cylindrical electrostatic lens into a double cylindrical

mirror analyzer, followed by three–element focusing lens and a single channel electron multiplier. The base preasure of about $4\times10^{-7}$ mbar was obtained by a turbo-molecular pump. The working pressure was usually less than $5\times10^{-6}$ mbar and was checked for each experimental point. The uncertainty of the incident energy scale was determined to be less than $\pm0.4$ eV, by observating a threshold for $He^+$ ions yield. The best energy resolution of about 0.5 eV is limited by a thermal spread of primary electrons. The angular resolution was better than $\pm2°$. The experimental procedure was checked according to benchmark DCSs for elastic electron scattering by Kr. The anhydrous 3HTHF was purchased from Merck KGaA with declared purities better than 98%. Because of rather low vapor pressure of 3HTHF, the sample container was heated during a measurement at the temperature of about 55-65°C.

The background contributions, which were typically below 10%, have been subtracted from the measured electron yields. The errors for the relative DCSs measured as a function of scattering angle include statistical errors (0.1–1.3%) according to Poisson's distribution and short-term stability errors (0.4– 3%), according to a discrepancy of repeated measurements at the same incident energy and scattering angle.

# THEORY

Present calculations of molecular cross- sections are based on a corrected form of the independent-atom method (IAM), known as the SCAR (Screen Corrected Additivity Rule) procedure. This procedure has been extensively described in the previous work [15]. In the standard IAM approximation the electron-molecule collisions is reduced to the problem of collision with individual atoms by assuming that each atom of the molecule scatters independently and that redistribution of atomic electrons due to the molecular binding is unimportant. At low energies, where atomic cross-sections are not small compared to (squared) interatomic distances in the molecule, the IAM approximation fails because the atoms can no longer be considered as independent scatterers and multiple scattering within the molecule is not negligible. These large low-energy atomic cross sections would overlap inside the molecule if geometrically visualised. As a result the atoms screen each other from the incident electrons, and the molecular cross section is no longer the sum of atomic ones. The role of SCAR correction is just reducing the values obtained from the standard additivity rule for those geometrical overlappings.

An additional limitation of IAM procedure when applied to differential calculations is the overestimation of the resulting interference contributions at small angles. This also causes the integrated elastic cross section not to satisfy the additivity rule. The interference terms where here normalised (reduced) as much as necessary to ensure that integrated elastic values also satisfy the (corrected) additivity rule (SCARN procedure in the following). The main effect of that correction is an appreciable reduction of the differential elastic values at small angles.

# RESULTS AND DISCUSSION

The experimental relative DCSs are obtained for the incident electron energies of 100 and 150 eV, in the angular range from 20° to 110°; and for 200 eV in the angular range from 10° to 110°. The DCSs, experimental and theoretical, are normalized at 50° and presented in Figure 2. Both present calculations, using either SCAR or the normalized – SCARN procedure, agree very well with experimental data, especially in the angular range from 20° to 60°, for all incident energies. However, theoretical results diverge at small scattering angles, below about 20°. Due to a strong influence of the high-current incident beam, it was impossible to perform accurate measurements in this angular region. At 200 eV the electron beam was better focused and the experimental results are obtained down to 10°. The comparison of theoretical curves with the experiment (see inset in Figure 2c) suggests that the SCAR procedure overestimates DCSs at low angles but the new SCARN procedure seems to underestimates DCSs slightly. Still, for an accurate judgment more detailed measurements in the low angular region are needed.

We have also compared our results with calculations of Možejko and Sanche [6] (for 100 and 200 eV), which are based on the independent atom method (IAM). A good agreement of relative behavior of these results [6] can be seen at all presented energies, although the present measurements show better agreement with the SCAR procedure. The previous theoretical DCSs [6] show more pronounced minima, especially at 200eV.

It should be noted a very similar behavior of present DCSs for 3HTHF in comparison with other similar molecules THF and THFA [12,13], which have been also used to model deoxyribose sugar. For all molecules, the DCSs at 100eV are characterized by a minimum at about 85°, which disappears with increasing the electron energy.
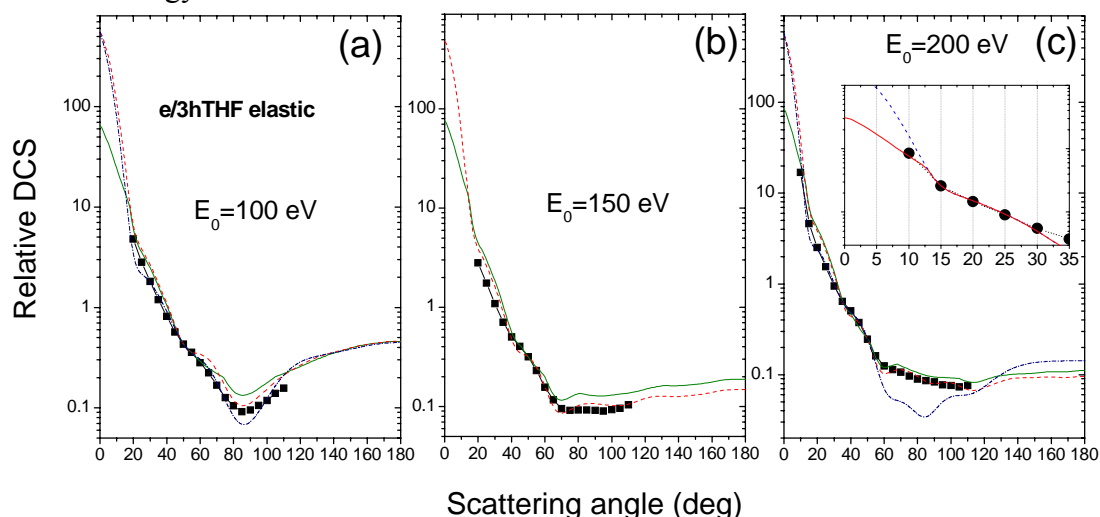


**FIGURE 2.** Angular dependence of relative DCSs for elastic electron scattering from 3HTHF molecule at 100, 150, and 200eV: (∎), present experiment; (⁃⁃), present theory (SCAR); (━), present theory (SCARN); (⋯), theory by Možejko and Sanche [6]. The DCSs are normalized at 50°. Inset in figure 2(c) shows a comparison of present experimental and theoretical results in the low angular region (the theoretical curves are renormalized to achieve better agreement with the experiment in this region).

To conclude, the elastic scattering of electrons from 3HTHF has been investigated, both experimentally and theoretically. The measurements were performed using cross-beam technique, for incident electron energies of 100, 150 and 200 eV, and scattering angles from 10° to 110°. Calculations were based on SCAR procedure, using an approximate model potential known as quasi-free absorption model. The shape of the present experimental DCSs for elastic electron-3HTHF scattering is very well reproduced by the present calculations.

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# Effective Path Length Correction Factor in Electron – Indium Atom Scattering Experiments

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**Abstract.** The effective path correction factor in electron beam - In atom beam scattering experiments has been discussed. Scattering geometry changes with scattering angle in crossed beam experiments. The approach of R. T. Brinkmann and S. Trajmar [1] is adopted for our experimental conditions to determine the effective path correction factor and accordingly to transfer angular distributions of scattered electrons to relative differential cross sections

**Keywords:** Effective path correction factor
**PACS:** 34.80.Bm, 34.80.Dp

## INTRODUCTION

A scattering geometry changes with the scattering angle in crossed beam experiments and that is why effective path length correction factor has to be introduced. In early scattering experiments the correction problem was resolved by the correction factor of $sin\theta$ except at low scattering angles. But this method leads to serious errors.

Now, in our measurement we used a well known work by R. T. Brinkman and S Trajmar [1]. This calculation treatment is derived by the relationship between scattering intensity, cross section and the geometrical integral called "effective path length". The effective path length is normalized to unity at $90^o$ nominal scattering angle. Volume correction factor is the reciprocal of effective path length.

The electron beam is considered to originate from a distant point with small divergence and the atom beam with substantial divergence. The intersection of these circularly symmetric beams within the view cone of the detector represents the scattering volume.

These correction factors depend on the kind of molecular target under investigation, geometry applied in the experiment, flow conditions of the effusive beam, and the steepness of differential cross sections (DCS). Here, we present our experimental apparatus and results for volume correction in electron-indium atom scattering.

# EKSPERIMENTAL PROCEDURE

In the crossed–beam arrangement, the electron beam has been perpendicularly crossed by effusive indium atom beam. The scattered electrons have been analyzed by the hemispherical analyzer in the spectrometer called "ESMA". This experimental set-up has been described elsewhere [2,3]. Experimental procedure consists of the following treads. The electron beam was emitted from a hairpin cathode, with the current at the end of the hemispherical monochromator of the order of 1 to 10 nA. The indium vapor beam was produced by heating the oven crucible containing In metal. The monochromator is fixed, and the analyzer can rotate around the atomic beam. The real zero position was determined before each run by checking the symmetry at positive and negative scattering angles. The energy loss scale was determined by the positions of the elastic feature and resonant peak of the $6s\,^2S^{1/2}$ excitation of indium at 3.022 eV according the value from Tables by Moore [4].

In the present work relative DCSs for the elastic scattering are obtained as follows. For a given incident energy $E_0$, the position of the analyzer was changed from $10^o$ to $150^o$ and the signal of the angular distribution of scattered electrons was measured. A channeltron was used for single electron counting. In order to convert the data of angular distributions of scattered electrons into relative cross section data, one needs to apply the effective path length correction factors.

# RESULTS

The interaction volume in our measurement consists of the target atomic beam, electron beam and view cone. The atomic beam was effused through a 20 mm long channel in the cap of the oven crucible that has an inner diameter of 2.5 mm, so the aspect ratio was large ($\gamma = 0.125$). The range of validity of the $\gamma$ is $\gamma<K_{nL}<10$, which includes the normal operating range of atomic beam sources. $K_{nL}$ is Knudsen number based upon tube length:

$$K_{nL} = \frac{\langle \lambda \rangle}{L}$$

The mean free path of the vapor atoms in the source reservoir is denoted with $\langle \lambda \rangle$, and tube length with $L$.

We use the effective path length correction factor from ref. [1] (see Fig.11 in [1] ) for a large-aspect-ratio tube for hypothetical species with gas kinetic cross section of 2.2 $Å^2$ and 100 Å and at 0.1 and 10 Torr tube back pressure. For all cases the curve type B is used (Fig.10 in [1]). That type B corresponds to DCSs which decrease as $10^{0.0322}$ (three decade) with increase of scattering angle up to $90^o$. Effective path length is normalized to unity at $90^o$. From these curves we apply the extrapolations to our experimental conditions (p= 0.07 Torr and gas kinetic cross section for indium atom is 12.56 $Å^2$ ). The atomic radius is r = 2Å (taken from [5]), and the kinetic cross section is obtained according the formulae $\sigma = r^2\pi$. The obtained results are presented in Figure 1 and Table 1.
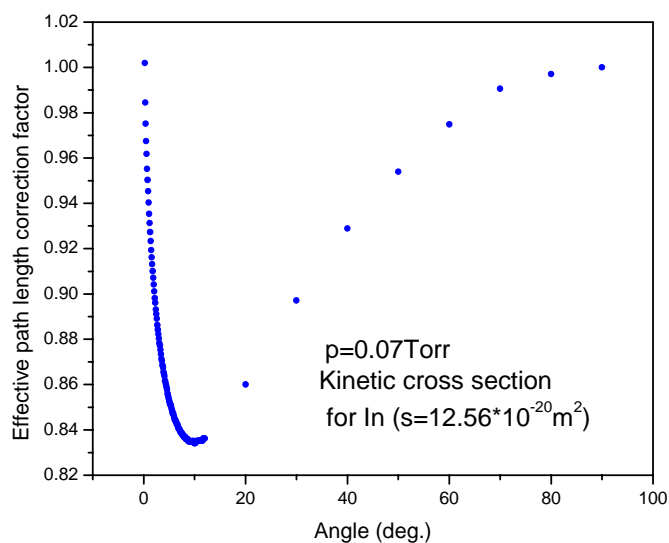
**FIGURE 1.** Effective path length correction factors for the Indium atom kinetic cross section of $12.56\text{Å}^2$ and pressure of 0.07 Torr.

| Table 1. Effective path-length correction factor. | | | |
|---|---|---|---|
| Angle (deg.) | Effective path Corr. factor | Angle (deg.) | Effective path Corr. factor |
| 1 | 0.9404 | 10 | 0.8342 |
| 2 | 0.9041 | 20 | 0.8601 |
| 3 | 0.8803 | 30 | 0.8971 |
| 4 | 0.8646 | 40 | 0.929 |
| 5 | 0.8531 | 50 | 0.954 |
| 6 | 0.8454 | 60 | 0.9749 |
| 7 | 0.8406 | 70 | 0.9906 |
| 8 | 0.8369 | 80 | 0.9971 |
| 9 | 0.835 | 90 | 1 |

# ACKNOWLEDGMENTS

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# Uniformity of CTEM Magnetic Field: Practical Considerations

## D. Šević, A. R. Milosavljević, and B. P. Marinković

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**Abstract.** This paper describes practical considerations in using of our five-coil system for producing a uniform magnetic field used in our SELE experiment, regarding the characteristics of electron beam.

**Keywords:** CTEM, Magnetic field generator
**PACS:** 34.80.Dp

## INTRODUCTION

In our SELE experiment we use cylindrical trochoidal electron monochromator (CTEM) [1]. Crossed magnetic and electric fields in cylindrical symmetry are used to select the electrons. For this kind of monochromator, the uniform magnetic field is one of the basic requirements. Because of the large spatial range in which uniform magnetic field is required in our experiment, the most common solution of using Helmholtz coil is abandoned. Three-coil system has been described earlier [2], while the five-coil system [3] solved the problem of overheating of the windings. However, this system is actually a three-coil case, since outer coils are placed one to another, as closely as possible. We compared [3] practical characteristics of our system with a system very similar to ours [4], concluding that physical dimensions of coils should be always included in analysis.

In this paper we present first results regarding characteristics of electron beam produced by our CTEM. Influences of magnetic field imperfections on electron beam are analyzed.

## RESULTS

Current of electron beam was measured using digital electrometer. Collector is placed about 1 cm after designed position of electron-atom interactions. Filament current was maintained constant at 2 A. Measured beam current was of the order of a few hundreds of pA. Potentials of CTEM electrodes were experimentally optimized regarding the intensity of electron beam. Magnetic field was measured by digital gaussmeter. Outer coils current of 0.95 A and inner coil current of 1.9 A result in uniform magnetic field of 30 Gauss, as measured by gaussmeter. Results of electron

beam current measurements are summarized in Table 1. Outer coils current was constant, inner coil current was varied, so uniformity of field was degraded.

**TABLE 1.** Electron beam current

| Outer coils current [A] | Inner coil current [A] | Electron beam current [100pA] |
|---|---|---|
| 0.95 | 1.44 | 7.8 |
| 0.95 | 1.48 | 8.5 |
| 0.95 | 1.57 | 9.5 |
| 0.95 | 1.66 | 10.5 |
| 0.95 | 1.76 | 10.5 |
| 0.95 | 1.78 | 10.6 |
| 0.95 | 1.85 | 10.2 |
| 0.95 | 1.90 | 10.1 |
| 0.95 | 2.00 | 10.0 |
| 0.95 | 2.30 | 8.0 |
| 0.95 | 2.80 | 6.4 |

It is interesting to note that maximum beam current was not obtained for expected value of inner coil current of 1.9 A, which gives a uniform magnetic filed.

# CONCLUSION

As expected, the intensity of the electron beam produced by CTEM is sensitive to the characteristics of the magnetic field. Also, it is possible to obtain an intensive electronic beam even if magnetic field is not uniform. The further step in the present work will be to investigate both intensity and an energy resolution of the electron beam produced by CTEM. In near future, the energy resolution of the beam should be determined using retarding potential method.

# ACKNOWLEDGMENTS

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# Development of Time–Resolved Laser–Induced Fluorescence Spectroscopic Technique for the Analysis of Biomolecules

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**Abstract.** Our developments of the time–resolved laser–induced fluorescence (TR–LIF) detection system for biomolecules are presented. This system is based on the tunable (320 nm to 475 nm) Nd:YAG laser pulses used to excite various biomolecules. The detection part is the Streak System for Fluorescence Lifetime Spectroscopy (Hamamatsu, Japan). The system consists of a C4334–01 streakscope, as a detector, DG 535 digital pulse/delay generator, C5094–S Spectrograph and HPD–TA System, as a temporal analyzer. The TR–LIF spectrometer is designed primarily to study the temperature and pressure effect on fluorescence behavior of biomolecules upon excitation with a single nanosecond pulse. The design of this system has capability to combine laser–induced breakdown (LIB) with fluorescence, as well to study optodynamic behavior of fluorescence biomolecules.

## INTRODUCTION

Laser–induced fluorescence (LIF) spectroscopy is one of the most widely used spectroscopic techniques in the fields of life sciences, biochemistry and molecular biophysics today [1,2]. LIF introduce advantages such as short pulse excitation, wavelength tunability, and narrow bandwidth excitation. This technique is of great importance for environmental monitoring of bioaerosols, due to capabilities for *in situ* analysis and remote sensing [3]. LIF technique was applied to imaging and tracking a single molecule or particle in a biological cell [4,5]. Fluorescence has been used to study the structure and conformations of DNA and proteins with techniques such as fluorescence resonance energy transfer [6]. Different LIF designs have been employed to induce and collect fluorescence with the aim of probing a wide range of fundamentally different physical, biological and chemical processes.

Time-resolved (TR) detection modalities is a promising tool for examining microenvironment, molecular dynamics of proteins in complex environment

molecules, dynamic of excited state, etc [1,2]. TR–LIF technique is based on a train or a series of short laser pulse excitation, followed by temporally resolved fluorescence signal.

Laser–induced breakdown (LIB) method has been applied for analysis of liquids, solids or gases [7]. A limited number LIB and LIF combined techniques have been reported up to now [8,9]. A new design of LIB–LIF system will be developed in future effort in order to investigate biomolecules.

When matter is irradiated with a laser pulse a part of the incoming light energy is converted to mechanical energy. Optodynamic (OD) waves are created and they propagate outward from the source. By detecting and analyzing the outgoing waves the characteristics of the light – matter interaction can be determined [10,11]. Joint analyses by OD and LIB–LIF can afford new possibilities in investigation of biomolecules in different environments. This is the reason we are going to set a combined system that can simultaneously detect OD and LIB–LIF effects.

# INSTRUMENTATION

The instrumental of LIF spectroscopy consists of a laser excitation source with specified narrow band-width, focusing and collection optics, a spectrometer, and a sensitive spectroscopic CCD detector. To suppress the excitation light, a cut off filter in front of the spectrograph is required. These instruments can be put together in different ways, depending on desired application. We have designed the experimental setup which facilitates TR–LIF spectroscopy and combines laser–induced breakdown with laser induced fluorescence that is shown schematically in Figure 1. The main components of this system are described as follows.
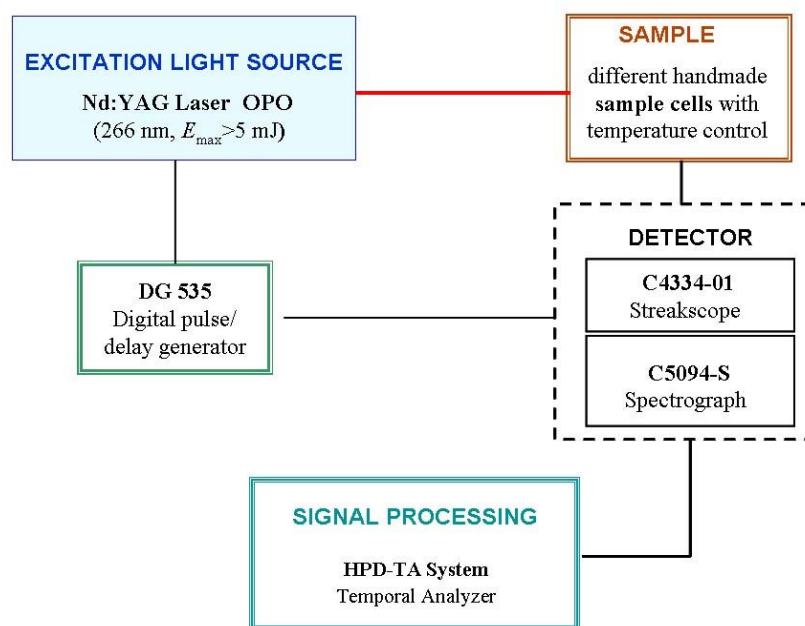


**FIGURE 1.** Schematic illustration of experimental setup for TR–LIF spectroscopy.

# Continuously Tunable Laser System

The fluorescence of biomolecules is produced by using a tunable laser system (Vibrant models 266-I made by Opotek, Inc.). This system (Fig. 2) includes the optical parametric oscillator (OPO) that is pumped by the fourth harmonics of the Nd:YAG Brilliant laser at 266 nm, and control electronics. The sample can be excited over the wavelength range from 320 nm to 475 nm with pulse widths of 5 ns at a repetition rate of 10 Hz. The linewidth of OPO increases dramatically as the output wavelength approaches the degeneracy point (Fig. 3).
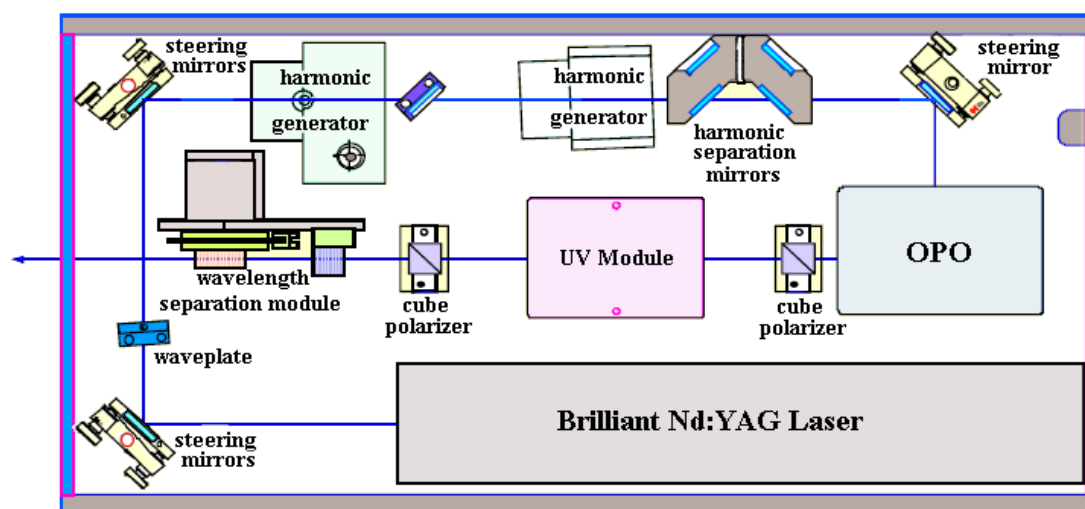
**FIGURE 2.** Schematic representation of tunable laser System.
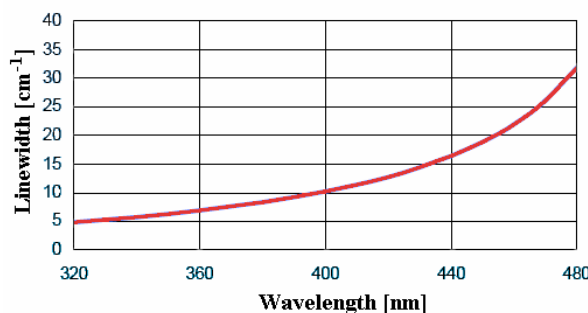
**FIGURE 3.** The spectral linewidth versus wavelength.

The main part of the laser beam is focused on the sample in different hand-made sample cells. Part of laser pulse (~1%) is transmitted to trigger the system. The trigger is controlled by software, which also initiate the CCD camera. Trigger delays are generated by DG535 delay generator (Stanford Research Systems, Sunnyvale, CA).

## Detection System

Picosecond time-resolved fluorescence spectroscopy is performed by a streakscope (Hamamatsu, C4334-01) with integrated video streak camera. The C4334 streakscope is used with the streak method, which enables a wide range of fluorescence lifetime measurement from ps to ms with high accuracy. The heart of the streakscope is an electron tube (S– tube). The spectroscope covers the wavelength region from 200 to 850 nm, with the temporal resolution better than 15 ps, and with repetition rate up to 2 MHz.

The combination of the streakscope (Hamamatsu, C4334-01) with the spectrograph (Hamamatsu, C5094–S, focal length 250 mm) enables simultaneous multiple–wavelength measurements to be made. In the same design of the system it is also possible to use another spectrograph C5094-S-S3 (Acton Research, Princeton Instruments) with focal length of 300 mm, with interchangeable grating.

## Signal Processing

All fluorescence data are acquired in photon-counting mode using the Hamamatsu HPD-TA streak software. This software is designed specifically for reading out the image on phosphor screen of streak and framing cameras. The HPD–TA controls the C4334–01 spectroscope and spectrograph C5094–S in order to carry out data acquisition, data correction and data analysis. The collected data are fitted using the Hamamatsu fitting module and deconvoluted for the laser pulse profile.

## EXPERIMENT

At the beginning we plan to study the temperature effect on fluorescence behavior (TR–LIF) of formic acid, alanine and glycine in different environments upon excitation with a single nanosecond pulse. The obtained results of the TR–LIF spectroscopy can be used to test the transient energy state of the molecules under study and thereby understand the mechanisms of the damages induced by the radiation. The more detailed data can be obtained if one combines the TR–LIF and the high resolution energy loss spectra [12-15].

## CONCLUSION

We report here the development of the time–resolved laser induced fluorescence life time (TR–LIF) system using a streak camera. In future, with small modifications this system can be adapted to simultaneously detect OD and LIB–LIF effects in biomolecules.

# ACKNOWLEDGMENTS

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