International Low Temperature Plasma Community

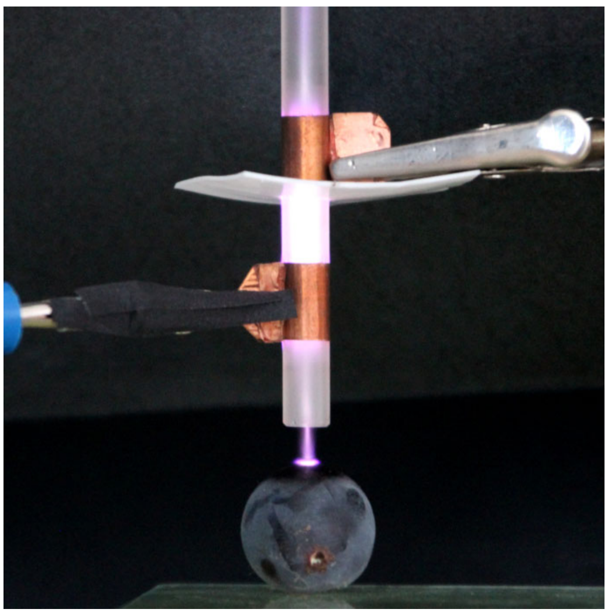
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 04

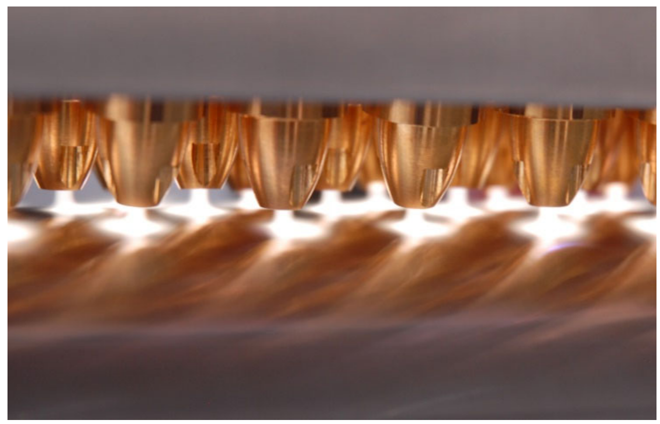
9 July 2020

Images to Excite and Inspire!

Thank you for submitting your images, some of which are shown here. Those images already submitted will appear in later Newsletters. Please do send your images (with a short description or source) to iltpc-central@umich.edu.



Atmospheric Pressure Plasma Jet incident onto the unprocessed (unwashed) surface of a red grape berry. He flow 2 slm, 14 kV, 48 kHz, 5 mm tube nozzle-grape surface gap.
Dr. Andrei Vasile Nastuta, Physics and Biophysics Education Research Laboratory, Faculty of Medical Bioengineering, UMF Iasi, Romania, nastuta.andrei@umfiasi.ro.



Plasmatrix2: A detailed picture of several PlasmaJets out of an assembly of 120 individual jets, all connected to the same 60 kW power supply, operating with air and discharging against a reflecting, metallic roller, used for surface modification. Source: AFS Entwicklungs + Vertriebs GmbH, Germany. **Dr. Florian Brehmer**, Brehmer@AFS.biz, www.afs.biz.

In this issue:

- Images
- Call for Contributions
- General Interest Announcements
- Meetings and Online seminars
- Community Initiatives and Special Issues
- Research Highlights and Breakthroughs
- New Resources
- Career Opportunities
- Collaborative Opportunities

Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **July 31, 2020**.

In particular, please send **Research Highlights and Breakthroughs** using this ***template*** (https://mipse.umich.edu/iltpc/highlight_template_v03.docx). The highlight consists of an image and up to 200 words of text. The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related. Please see the *Research Highlights and Breakthroughs* for examples.

General Interest Announcements

- The ILTPC is maintaining a list of LTP conferences. With many meetings being canceled and rescheduled, we thought this would be useful for minimizing conflicts and planning future trips. The data may not be 100% accurate, so please let us know of changes in conference scheduling. View-only link to the schedule: https://docs.google.com/spreadsheets/d/1XoD6Fn7AP0HFTQJpPCETrRIQhx8IDisz4XUMyv9X7zo/edit?usp=sharing.

  Contact:
  ILTPC
  iltpc-central@umich.edu

- **Survey on Research Data Management in Low Temperature Plasmas (Extended Deadline 31 July 2020)**

A survey on research data management in low-temperature plasma physics is being conducted with the goal of developing a FAIR system for LTP *data Findability, Accessibility, Interoperability and Re-usability*. For a data platform that serves your needs, we require information on the methods and standards you use. Please take a few minutes to fill out our anonymous survey on research data management in low-temperature plasma science:

https://survey.plasma-mds.org/index.php/352444

(Extended deadline: 31 July 2020)

If you know people who might also be interested in participating in this survey or have access to other information channels, you are welcome to pass on this announcement.

This survey is part of the joint project *Quality Assurance and Linking of Research Data in Plasma Technology* (QPTDat) at the Leibniz Institute for Plasma Science and Technology (INP) together with FIZ Karlsruhe-Leibniz-Institut für Informationsinfrastruktur GmbH, and Hamburg University of Applied Sciences, which aims at building a data platform for data in Low Temperature Plasma Science.

Contact:
Dr. Markus Becker
Leibniz Institute for Plasma Science and Technology (INP)
markus.becker@inp-greifswald.de

- **24th International Plasma School on "Low Temperature Plasma Physics: Basics and Applications" (3-15 October 2020)**

The 24th International Plasma School on "Low Temperature Plasma Physics: Basics and Applications" will be held 3-15 October 2020. Due to the situation with Covid-19, the Plasma School will be an online course conducted over two weeks. Unfortunately, the Master Class "Spectroscopy" has to be cancelled for 2020. However, this Master Class will take place during the next school year in 2021.

We changed the original schedule for the convenience of participants. Some of the courses will be posted online in advance, so that you can decide when to watch the videos. Other teachers prefer to do their courses live, so there will be a defined time slot to watch the lectures. However, all teachers of the corresponding day will be available online for Q & A discussions in the afternoon.

In order to guarantee an optimal interaction between teachers and students, we are limiting the number of students; registration is required. Please, register until July 15th if you would like to attend the online format of the school. After this date, the organization team will decide on the participants. All previously registered students will of course also be considered for the school's online format.

More information and registration: http://www.plasma-school.org.

Contact:
Drs. Ana Sobota, Richard Engeln, Marina Prenzel, Achim von Keudell, and Marc Böke
Research Department Plasmas with Complex Interactions
Ruhr-Universität Bochum
RD-Plasma@rub.de

Meetings and Online Seminars

- **Online LTP Seminar**

  Reminder!! Upcoming seminars: **July 21, August 4**. More information on the Online LTP Seminar: https://mipse.umich.edu/ltp_seminars.php.

- **International Online Plasma Seminar**

  Reminder!! Upcoming seminars: **July 16, July 30, August 13**. More information on the International Online Plasma Seminar (IOPS): https://mipse.umich.edu/online_seminars.php.

- **14th Frontiers in Low Temperature Plasma Diagnostics (FLTPD), 2-6 May 2021**

  The 14th Frontiers in Low Temperature Plasma Diagnostics (FLTPD) workshop is being organized by the Atomic and Molecular Physics Laboratory (Trento University) and the Institute for Plasma Physics and Technology (CNR–Bari). This workshop is the continuation of a very successful biennial series which began in 1995 at Les Houches (France). It will be held in Levico Terme (Trentino, Italy, at the Bellavista Relax Hotel during 2-6 May 2021.

  More information: https://www.unitn.it/fltpd-xiv.

  Contact:
  Dr. Paolo Tosi
  Trento University
  paolo.tosi@unitn.it

Community Initiatives and Special Issues

- ***Coatings* Special Issue on *Plasma Processing and Thin Films Formation Applications***

We invite submissions to this Special Issue of the journal *Coatings* on *Plasma Processing and Thin Films Formation Applications*. Examples of topics for submissions are:

- Plasma thin films physics and chemistry and transition towards industrial applications
- Design and diagnostics of plasma sources for deposition and polymerization

- Experimental studies on polymerization and growth mechanisms in pulsed plasmas
- Growth process modelling and plasma chemistry simulation
- New insights on relationships between operational parameters, plasma parameters, and thin films properties
- New observations on the use and performance of plasma thin films in life sciences, textile industry, extreme environments, energy production, quantum technologies, micro and nanoelectronics, and corrosion and wear protection

Deadline for submissions is **31 December 2021**. More information and submission instructions:
https://www.mdpi.com/journal/coatings/special_issues/Plasma_Process_Thin_Film_Form_Appl

Contact:
Dr. Ionut Topala
Alexandru Ioan Cuza University of Iasi
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- **Special Issue on *Frontiers in Atmospheric Pressure Plasma Technology* in *Applied Sciences* (Open Access journal, IF: 2.474)**

There will be Special Issue of the open access journal *Applied Sciences* (Impact Factor 2.474) on *Frontiers in Atmospheric Pressure Plasma Technology*. The deadline for contributions is 31 January 2021.

Atmospheric pressure plasmas represent a feasible and eco-friendly alternative to conventional physico-chemical methods used in technology today for modifying materials. The complex physical and chemical processes occurring when plasma interacts with materials offer a rich source of short- and long-lived chemical species, mostly reactive nitrogen and oxygen species (RNS/ROS). They are also crucial for many applications ranging from the food industry, environmentally related fields, agriculture, and healthcare; to material science and automotive. Exciting novel applications of plasma–surface, plasma–liquid, and plasma–gas interactions are at the focus of many challenging multidisciplinary scientific inquiries. This Special Issue on *Frontiers in Atmospheric Pressure Plasma Technology* is open but not limited to recent findings in novel and possible future applications. Papers providing fundamental insights into the understanding of plasmas and detailed analysis of electrical discharges, pushing forward cutting-edge techniques in plasma science and technology, are especially welcome.

More information:
https://www.mdpi.com/journal/applsci/special_issues/atmospheric_pressure_plasma_technology

Contact:
Dr. Andrei Vasile Nastuta
Grigore T. Popa University of Medicine and Pharmacy Iasi, Romania
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- **Special Topic Issue on *Plasma Liquid Interactions* in *Journal of Applied Physics***

  Plasma discharges are traditionally associated with a gaseous phase; however, discharges can be generated in all phases. Plasma discharges formed in liquids and interfacing with liquids represent an emerging and fast-growing field of research, not the least because they offer unique conditions that enable decontamination of pathogens, synthesis of nanostructures, and treatment of contaminated water. With the variety of discharge regimes and types of liquids comes a rich field of multiphase phenomena to be discovered, measured, modeled, and utilized. In this Special Topic, we explore this richness of relatively unexplored phenomena.

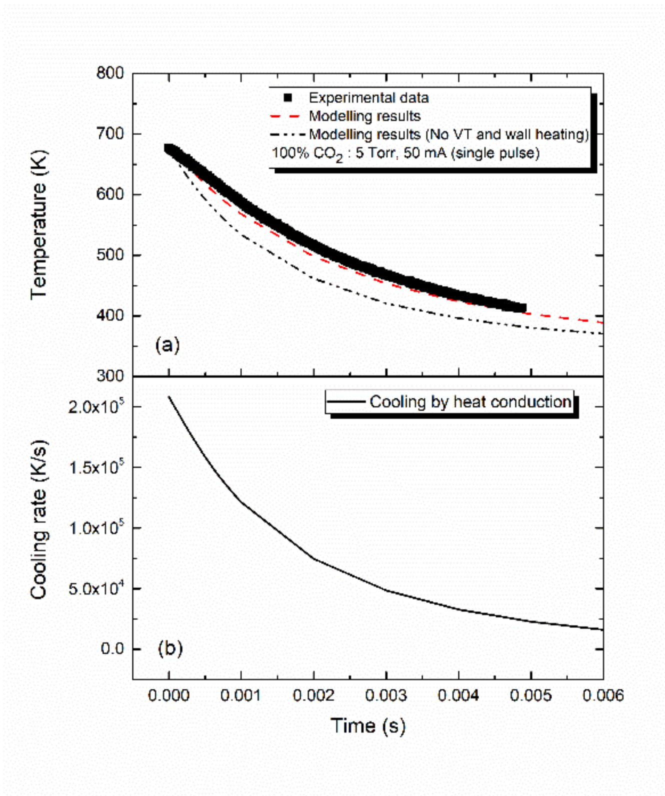
  Topics covered include, but are not limited to:
  - Discharges in and interfacing with liquids
  - Plasma phenomena at the liquid-plasma interface
  - Synthesis and characterization of nanomaterials utilizing plasmas interfacing with liquids
  - Tailoring plasma liquid-interactions for life sciences including medicine, environment, agriculture, food and energy
  - Characterization / diagnostics / modeling of multiphase systems involving plasmas and liquids
  - Laser-generated plasma in liquids

  Submission deadline: **December 15, 2020**.

  More information and submission instructions: https://publishing.aip.org/publications/journals/special-topics/jap/plasma-liquid-interactions/

  Guest Editors:
  Prof. Annemie Bogaerts, University of Antwerp, Belgium
  Prof. Peter Bruggeman, University of Minnesota, USA
  Dr. Jean-Michel Pouvesle, GREMI, CNRS/Université d'Orléans, France
  Dr. Eric Robert, GREMI, CNRS/Université d'Orléans, France
  Dr. Endre Szili, University of South Australia, Australia

Towards a Sustainable Energy Transition Using Electrically Plasma-Produced Chemical Fuels



The recent increase in utilization of renewable sources calls for large-scale seasonal energy storage. A very promising and environmentally friendly solution to this issue relies on the storage of energy in chemical fuels produced from the recycling of CO_2. In the group N-PRiME (N-Plasmas Reactive: Modelling and Simulation), with Instituto de Plasmas e Fusão Nuclear (IPFN) of Instituto Superior Técnico (IST), Lisbon, Portugal we have been investigating the potential of non-thermal plasmas to activate CO_2, while producing value-added products for energy storage applications. In collaboration with Laboratoire de Physique des Plasma with École Polytechnique, Palaiseau, France we have been exploring the role of electron- and vibrational- driven excitation for an efficient molecular excitation / dissociation. Recent studies have tackled: (i) the electron impact dissociation cross section of CO_2 [1] and (ii) the role of CO_2 vibrations for gas heating in CO_2 plasmas [2]. Future works will be oriented towards the definition of a detailed reaction mechanism set for vibrational chemistry in non-thermal CO_2 plasmas.

Contact: **Dr. Tiago Silva**, tiago.p.silva@tecnico.ulisboa.pt

Sources:

[1] A. S. Morillo-Candas et al, Plasma Sources Sci. Technol. **29**, 01LT01 (2020). https://doi.org/10.1088/1361-6595/ab6075

[2] T. Silva et al, Plasma Chem. Plasma Proc. **40**,713 (2020). https://doi.org/10.1007/s11090-020-10061-7

Plasma-Powder Processing by Tapered-Bed Dielectric Barrier Discharge (TBD) Reactor

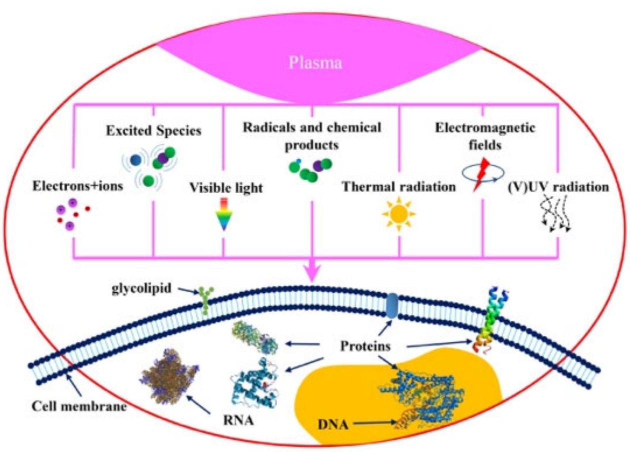
TBD reactor

The Tapered-Bed Dielectric Barrier Discharge (TBD) reactor was fabricated for plasma-powder treatment at atmospheric pressure. Using a conical geometry, the TBD reactor facilitates fine powder-plasma processing such as plasma modification of starch. Modification of native potato starch in the reactor was led to production of high temperature (HT) drilling starch according to the API standard specifications. Fluidization of the starch granules with a non-thermal argon plasma fluid having a in 0.7-0.73 eV electron temperature, results in the HT-starch production. The tapered shape of this reactor enables uniform and homogeneous fluidization of solid particles in the plasma fluid and more efficient treatment.

Contact: **Dr. Saeed Kooshki**, saeedkoushki@gmail.com

Source: Vacuum, 156, 224 (2018)
https://doi.org/10.1016/j.vacuum.2018.07.006.

On the Dose for Plasma Medicine: Equivalent Total Oxidation Potential (ETOP)



Plasma interacts with a cell.

Plasma medicine has attracted a great deal of attention in the past decade. However, one of fundamental questions of plasma medicine, *what the definition of "Plasma Dose"*, has not yet been answered.

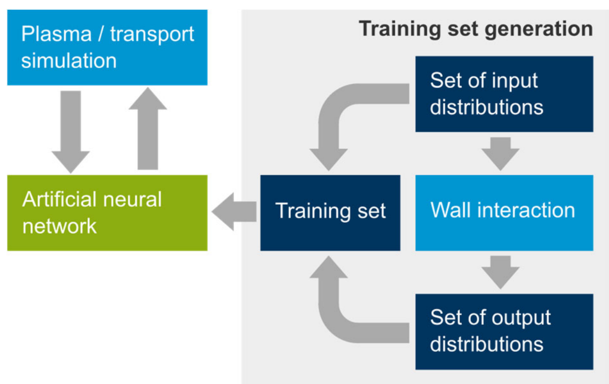
Based on the dominant role of RONS in plasma biological effects, we propose the equivalent total oxidation potential (ETOP), as the definition of plasma dose. The ETOP includes three parts. The first part is ETOP of the RONS generated by plasma. The second part is due to the reactive agents unrelated to RONS, such as electric field. The third part is due to the synergistic effects.

There is still a great deal of work that needs to be done to use the ETOP. These topics are discussed in the cited paper, with the goal of solving the problem of "plasma dose" in the future.

Contact: **Dr. XinPei Lu**, luxinpei@hotmail.com

Source: Phys. Plasmas **27**, 063514 (2020).
https://doi.org/10.1063/5.0008881

A Machine Learning Plasma-Surface Interface for Sputtering Simulations



Conceptual diagram of the ANN plasma-surface interface model and the data flow for training set generation and run-time model evaluation.

A computational plasma-surface model of sputtering deposition requires a consistent coupling of the surface dynamics and the plasma transport phenomena. The respective length and time scales of both the solid and the gas phase span orders of magnitude, rendering a consistent coupling difficult. A potential remedy for bridging the inherent scales was demonstrated by Florian Kruger and co-workers from Brandenburg University of Technology. The work entitled "Machine Learning Plasma-Surface Interface for Coupling Sputtering and Gas-Phase Transport Simulations" researches the applicability of a machine learned surrogate model for high-fidelity physics regression at moderate computational cost. The proof of principle is proposed for sputtered particle energy-angular distributions, obtained for different energy distributions of Ar ions impinging a Ti-Al composite using Monte Carlo surface simulations. The concept is illustrated in the accompanying figure.

A multilayer perceptron neural network was trained and verified with a set of incident/outgoing distributions. An error analysis was carried out for the obtained training results, assessing their quality and validity for diff t sets of hyperparameters. Specifically, the influence of artificial neural network depth and width, activation functions, as well as regularization and early stopping was investigated. The trained network's ability to predict the sputtered particle energy-angular distributions for unknown, arbitrarily shaped incident ion energy distributions was demonstrated. It is consequently argued that the trained network may be readily used as a machine learning based model interface, sufficiently accurate also in scenarios which have not been previously trained.

The proposed results establish a reliable and data-compact scale bridging. They will hence prepare the path for a comprising plasma-surface model. The conceptual methodology is envisioned also for cases with more complex surface and gas compositions, e.g., as encountered in reactive sputtering.

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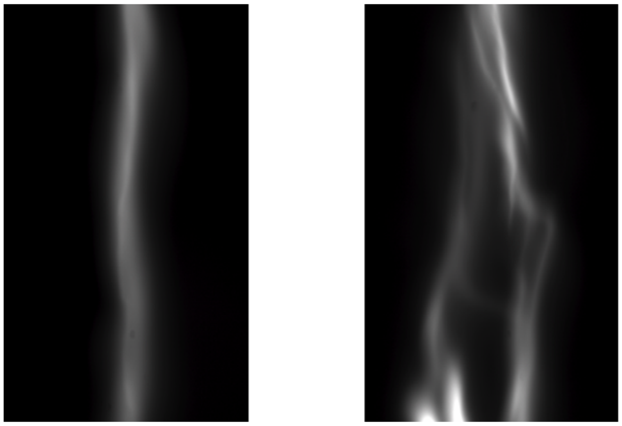
Source: Plasma Sources Science Technol. **28**, 035002 (2019). https://iopscience.iop.org/article/10.1088/1361-6595/ab0246/meta

The Effect of Different Pulse Patterns on the Plasma Reduction of CO_2 for Nanosecond Discharges



(a) (b)

(a): $\Delta T_p = 10\ \mu s$, 7 pulses
(b): $\Delta T_p = 100\ \mu s$, 7 pulses

Endothermic reactions can be used to store renewable electricity in chemical form. To this purpose, we assess the reduction of CO_2 to CO and O_2 using a nanosecond repetitively pulsed discharges at atmospheric pressure. We find that by changing the inter-pulse duration (ΔT_p), different values for the CO_2 dissociation and energy efficiency can be obtained for the same energy input.

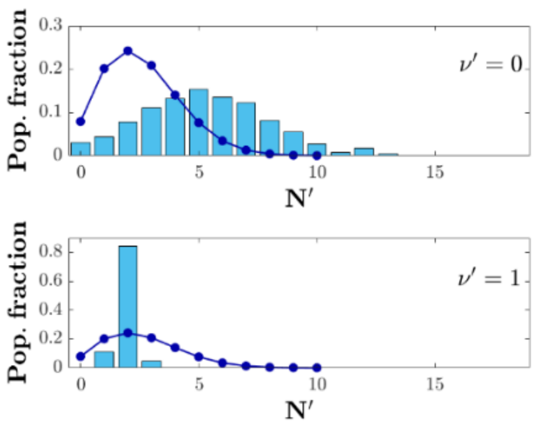
The variation of ΔT_p induces two different discharge time regimes. The first is an independent-pulse regime, in which the discharge channels are spatially independent, and much of the energy is dissipated in a condition of high electron-energy and relatively low electron-density. The second is a memory-dominated regime, with spatially entangled discharge channels, in which a significant portion of the energy is dissipated in a condition of comparatively lower electron-energy and higher electron-density. The memory-dominated regime appears to favor vibrational excitation, due to both the more favorable conditions for electron-impact vibrational-excitation and to the fact that the spatial superposition of single discharges might lead to a build-up of vibrationally excited CO_2.

This striking result shifts the focus to the possibility of a better channeling of the injected energy into the more efficient dissociation mechanisms.

Contact: **Dr. Paolo Tosi,** paolo.tosi@unitn.it

Source: C. Montesano *et al.* “The effect of different pulse patterns on the plasma reduction of CO_2 for a nanosecond discharge”, Journal of CO_2 Utilization **39**, 101157 (2020). https://www.sciencedirect.com/science/article/abs/pii/S2212982020301633

Non-Thermal Rate Constants of Quenching and Vibrational Relaxation in the OH($A^2\Sigma^+$; $\nu' = 0,1$) Manifold



Histograms of the rotational distributions of OH($A^2\Sigma^+$; $\nu' = 1$) and OH($A^2\Sigma^+$; $\nu' = 0$). CO_2 at 2 mbar pressure is used as collider; $T =$ 300 K. The laser is tuned to the $P_1(3)$ line of OH at 283.009 nm, N'= 2 excitation. The Boltzmann rotational distribution at $T_{rot} =$ 300 K (dark blue line and dots) is also displayed for comparison.

Knowledge of molecular energy-transfer processes is a key ingredient for using laser-induced fluorescence, LIF, as a quantitative optical diagnostic method at high pressure. At present, rate constants of electronic quenching and vibrational energy transfer in the OH($A^2\Sigma^+$; $\nu' = 0,1$) manifold are known for many colliders only in the condition of thermal equilibrium of the rotational population of the A electronic state. However, this condition is seldom met in molecular gases. Therefore, the rotational distributions in the OH($A^2\Sigma^+$; $\nu' = 0,1$) manifold are often non-thermal and close to the nascent ones. A new set of rate constants has thus been measured in the condition of non-thermal rotational distribution, for the excitation of three rotational levels, $N' = 0,1,2,$ of OH($A^2\Sigma^+$; $\nu' = 1$) with CO_2, CO, O_2, CH_4 and H_2 as colliders. For $N' = 2$ the temperature dependence of the rate constants has also been measured for the first time from 300 to over 2000 K. These new data are crucial for the quantification of OH by LIF in gas discharges at high pressure and to fully exploit the CET-LIF (Collisional Energy Transfer LIF) technique for measuring the CO_2 dissociation as a function of time in a nanosecond repetitively pulsed discharge.

Contact:

Dr. Matteo Ceppelli, matteo.ceppelli@unitn.it

Source: M. Ceppelli et al, "Non-thermal rate constants of quenching and vibrational relaxation of the OH(A, v'=0,1) manifold", Plasma Source Sci. Technol. **29**, 065019 (2020). https://iopscience.iop.org/article/10.1088/1361-6595/ab9235

New Resources

- **Listing of Worldwide Virtual Seminars**

  A master list of virtual seminars has been assembled: https://researchseminars.org/. It is not quite complete as plasma physics seminars are not listed. However, there are many interesting virtual seminars related to plasma physics.

Career Opportunities

- **Postdoctoral Position in Plasma Physics and Electric Discharges, Technological Institute of Aeronautics – ITA, Brazil (Extended Deadline - 30 July 2020)**

  The São Paulo Research Foundation (FAPESP), Brazil, announces a postdoctoral fellowship associated with a research project entitled "*Applications of non-thermal atmospheric plasmas in Dentistry: from the bench to the clinic*". This project seeks to consolidate a collaborative network of research centers, in order to clarify relevant aspects of the application of atmospheric pressure plasma in biology, medicine and dentistry. The postdoctoral position will explore the generation of Plasma Activated Liquid (PAL) for applications related to biomedical engineering, especially for dentistry. The research linked to the project will be developed at the Plasma and Process Laboratory (LPP) of ITA (http://www.lpp.ita.br) located at the São José dos Campos, SP, Brazil. We are looking for candidates with Ph.D. in plasma science, engineering or related field and experience in plasmas and their diagnostic techniques. The postdoctoral researcher must have excellent oral and written communication skills and the ability to supervise graduate students and collaborate with a team of multidisciplinary researchers. The nomination period for FAPESP's postdoctoral fellowship is generally 2 years, although an extension can be discussed. If the postdoctoral fellow lives outside the city where the research institution is located and needs to move, he/she may be entitled to an installation allowance. More information about the FAPESP Postdoctoral Scholarship is available at www.fapesp.br/bolsas/pd.

  Candidates for the position must provide a letter of interest describing in detail their previous work experience, an updated CV and two letters of recommendation (in PDF format). All documents must be sent to **Prof. Rodrigo S. Pessoa** (rspessoa@ita.br) until **July 30, 2020**.

- **Postdoctoral Position in Computational Plasma Science and Engineering, University of Michigan**

  A postdoctoral research fellow (PDRF) position in computational low temperature plasmas (LTPs) is available in the research group of Prof. Mark J. Kushner at the University of Michigan, Ann Arbor, MI, USA. The position entails development and application of computer models for low temperature plasmas, plasma chemistry and plasma surface interactions, plasma liquid interactions, and nano-scale modeling of surface evolution for microelectronics fabrication. The PDRF will work on several projects in these areas. The PDRF should have expertise in the fundamental processes of LTPs, plasma chemistry, and plasma surface interactions, and expertise in developing and maintaining parallel computer models for LTPs using high level languages, including Fortran. An experimental background with a desire to learn computations can be discussed. Excellent oral and written communication skills are desired. The PDRF will help supervise graduate students; and interact with research colleagues in academia, national laboratories, and industry. More information about the research group is at: http://uigelz.eecs.umich.edu.

  With the current COVID-19 crisis, it is possible to start the position remotely, with later relocation to Ann Arbor. The appointment period for PDRF is usually 2 years, though this can be discussed.

  Applicants should send a cover letter (including date applicant is available), CV, and reprints of representative publications to **Prof. Mark J. Kushner** (mjkush@umich.edu). Application deadline is **1 August 2020**.

Collaborative Opportunities

Please submit your Collaborative Opportunities to: iltpc-central@umich.edu.

Disclaimer

The content of this Newsletter comes from the contributions of members of the ILTPC. The Newsletter editors are attempting to provide as inclusive a communication as possible. However, inclusion of items in the Newsletter should not be interpreted as an endorsement by the editors nor as advertisement for commercial purposes. The content of this newsletter should also not be interpreted as an endorsement by our sponsors – the US National Science Foundation, the US Department of Energy, or the University of Michigan. The Newsletter editors may do some light editing of the original submissions, to maintain a consistent tone and style.

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