Jul/Aug 2017 • No. 242

ESA Newsletter

Electrostatics Society of America - The Friendly Society

President's Message

Electrostatics Joint Conferences:

I hope everyone had a great summer and busy with the start of the fall. Our ESA has a diverse membership comprising academicians, scientists, practicing engineers, and entrepreneurs. For those returning to their new academic year, with the leaves turning into pretty colours, I wish a colourful fall term, and for the rest a rejuvenated energetic work. Preparations are already under way for the 2018 Electrostatics Joint Conference, sponsored by ESA, IEEE IAS-EPC, FES and IESJ, to be held on the Boston University campus in Boston, USA, June 18-20, 2018. Looking back into our recent joint meetings, I felt bad that I did not attend the meeting in Boston in 2009; but I am very happy that the next one is also being held in Boston. Both the conference general chair and the technical program chair, Mark Horenstein and Shubho Banerjee, are working extremely hard on the conference. Updates on the call for abstracts, technical program, demo sessions and the conference venue can be found on our society web site later in the fall.

Talking about our joint meetings, I thought of sharing some information about their history and some changes that may have faded from some of our minds, as well as for the benefit of our new and young members. The ESA extended an invitation to the Institute of Electrostatic Japan in 1994, and the very first Joint Meeting, ESA-IEJ Joint Symposium on Electrostatics, was held that year in Stanford University, Palo Alto California, USA. The second ESA-IEJ Joint Symposium on Electrostatics was organized by University of Tokyo, Tokyo Japan, in 1996. The last one in the series was held again in Stanford University campus in 1998[1].

With a small gap in between, now we have four different societies hosting the joint conference; the first of this kind was held in Little Rock, on the University of Arkansas campus, USA, in 2003. The name has also been modified as the Electrostatics Joint Conference. The successive joint meetings were held once every three years; with the 2nd at Berkeley (2006), the 3rd at Boston University (2009), and the 4th at University of Waterloo (2012). To encourage a high participation, it has now been decided to hold the Electrostatics Joint Conferences during the even numbered years; avoiding the overlap of our joint meetings with the Electrostatic Conferences held in Europe during the odd numbered years. Accordingly, the 5th joint meeting was held at Purdue University (2016) and the next joint meeting is held in 2018 in Boston. Interestingly, we have been very successful in keeping the friendly environment and making these joint conferences as informal as our ESA annual meetings.

I would like to draw the attention of our potential authors to the copyright question. The authors own the copyright of all the papers published in the 2018 Electrostatics Joint Conference proceedings. That means, the authors can freely present or publish any part of their papers elsewhere without seeking permission. Also, the papers presented at the 2018 Joint Conference meet the publication submission requirement of the IEEE-IAS of having been presented at an IEEE IAS sponsored conferences.

As always we are looking for inputs from you, the readers. Please share your vision through e-mails, newsletter articles, the website, conferences, and special events like the demos.

For the Friendly Society
Shesha Jayaram, *shesha.jayaram@uwaterloo.ca*
President, Electrostatics Society of America

1. The activity of the Electrostatics Society of America in the field of environmental protection by A. E. Seaver, pp. 37-45; In Proceedings of the NATO Advanced Research Workshop on "The Modern Problems of Electrostatics with Applications in Environment Protection", 9-12 November 1998, Romania.

ESA Officers

President:
Shesha Jayaram, Univ. of Waterloo
Vice President and Awards Chair:
Maciej Noras, Univ. of North Carolina
Executive Council:
David Go, Univ. of Notre Dame
Poupak Mehrani, Univ. of Ottawa
Rajeswari Sundararajan, Purdue Univ.

Calendar

- 2017 IEEE/IAS Annual Meeting, Sept 29- Oct. 5, 2017, Cincinnati, Ohio *http://ias.ieee.org/2017annualmeeting.html* Contact: Maciej Noras *mnoras@uncc.edu*
- 2017 CEIDP, Oct. 22-25, 2017, Fort Worth, Texas Contact: Enis Tuncer *e-tuncer@ti.com*
- 36th Electrical Insulation Conference June 17-20, 2018, Hyatt Regency, San Antonio, TX, *http://electricalinsulationconference.com.,* Contacts: Diego Robalino, *diego_robalino@ieee.org* and David McKinnon, *davmckin@gmail.com, (Abstract deadline: Oct. 15)*
- 2018 Electrostatics Joint Conference, June 18-20, 2018, Boston University, Boston, MA, Contact: Mark Horenstein *mnh@bu.edu*

A.D. Moore

Not many of our current members knew our founder, Professor A.D. Moore. He was vigorous, inventive, and fun loving. But most all of our members have read or know of his little book **Electrostatics**.

In this book he described how to build a Dirod Generator, which he invented. It could produce 50,000 volts or more with careful attention to corona leaks. If you have ever built a Dirod or purchased one of the very rare commercial ones, I have an offer for you.

In 1981 A. D. produced a small paper called the Dirod Manual (it was mimeographed!!). I have several copies. If you drop me a line, I will send you one to go with your Dirod.

Glenn Schmeig
2905 N. Cramer
Milwaukee WI 53211

Electrostatic Demo Session

At the upcoming ESA Meeting scheduled for June 2018 in Boston, MA, we are planning to hold a special session devoted to electrostatics demonstrations. The goal is to provide demonstrations on a variety of topics including electrostatic fundamentals, educational experiments, safety topics, and research projects. Our session will build upon the demonstration sessions held during our 2012, 2014 and 2016 ESA Annual Meetings.

We are currently looking for volunteers to present demonstrations. If you have a favorite demonstration to share or have an idea for a new one, this event is for you. Please let me know if you need to borrow equipment for your demonstration (fieldmeter, electrostatic voltmeter, Van de Graaff generator, electrophorus, power supply, … whatever you need) and I will do my best to support your demo.

If you have any questions about our session, please contact Kelly Robinson, who is coordinating the demonstration session.

Kelly Robinson, PE, PhD
Owner, Electrostatic Answers
kelly.robinson@electrostaticanswers.com

Current Events

Getting the Biggest Bang Out of Plasma Jets

Bursts of plasma, called plasma jets, have numerous uses ranging from the development of more efficient engines, which could one day send spacecraft to Mars, to industrial uses like spraying nanomaterial coatings on 3-D objects.

Capillary discharge plasma jets are those that are created by a large current that passes through a low-density gas in what is called a capillary chamber. The gas ionizes and turns into plasma, a mixture of electrons and positively charged ions. When plasma expands in the capillary chamber due to arc energy heating, plasma ejects from the capillary nozzle forming the plasma jet. Researchers at Huazhong University of Science and Technology found that they could achieve the longest plasma jet by altering the dimensions to maximize the energy density within the capillary chamber.

"Experimental results show that the longest plasma jet length can be obtained by adjusting the geometric factors," said Jiaming Xiong, from the Huazhong Univer-

(cont'd. p. 6)

2018 Electrostatics Joint Conference

Boston University
Boston, Massachusetts, USA
June 18 - 20, 2018

The Electrostatic Society of America (ESA), Institute of Electrostatics Japan (IESJ), Industry Applications Society (IEEE-IAS) Electrostatic Processes Committee, and La Societé Francaise d'Electrostatique (SFE) invite papers in all scientific and technical areas involving electrostatics. The scope of the conference ranges from the fundamental physics underlying electrostatics to applications in industry, atmospheric and space sciences, medicine, energy, and other fields. The meeting will bring together experts across the diverse field to present the latest developments in electrostatics.

Anticipated Technical Session Topics

- Atmospheric and space applications
- Biological and medical applications
- Breakdown phenomena
- Contact charging and triboelectric effects
- Electrically-induced flows and electrokinetics
- Flows, forces and fields
- Gas discharges and microplasmas
- Electrospinning
- Material processing
- Measurements and instrumentation
- Particle control and charging
- Safety and hazards


Photonics Center Boston University

Conference information, including abstract submission, registration, student travel grants and lodging, will be updated and available at http://www.electrostatics.org.

Student paper competition: Presentations by students (undergraduate and graduate) are eligible; please indicate participation when submitting abstract.

Important dates:

March 1, 2018 Abstract submission deadline (submit on-line at http://www.electrostatics.org)
March 17, 2018 Notification of paper acceptance
May 16, 2018 Final manuscripts due
June 17, 2018 Reception (6-9PM)
June 18, 2018 Conference begins (8AM)
June 20, 2018 Conference ends after evening banquet (7 PM – 10 PM)

Contact information:

For questions regarding the technical program and abstract submission, contact
Technical Chair: Dr. Shubho Banerjee, Rhodes College, Memphis, banerjees@rhodes.edu , (901) 843-3585
For questions about local arrangements and conference hosting, contact
General Chair: Dr. Mark Horenstein, Boston University, mnh@bu.edu, (617) 353-9052

About Boston University: Boston University is a private research university located in Boston, Massachusetts. The university has over 33,000 undergraduate and graduate students from more than 130 countries, nearly 10,000 faculty and staff, 17 schools and colleges, and 250 fields of study. The conference venue is the Photonics Center which houses the Dept. of Electrical and Computer Engineering

2017 ESA Annual Meeting Highlights

The 2017 Annual Meeting of the Electrostatics Society of America was held on the campus of the University of Ottawa in the heart of downtown Ottawa, Canada's capital. Since the capital was preparing for Canada's 150th birthday, the conference attendees enjoyed the festive atmosphere of the city along with attending the meeting. Nearly 90 electrostatics experts and enthusiasts from 14 countries worldwide attended the meeting, representing one of the largest non-joint ESA meetings. Participants were from as far as Japan, China, Taiwan, Hong Kong, South Korea, New Zealand, Russia, Finland, Poland, France, United Kingdom, Czech Republic, in addition to Canada and the United States. General Chair Prof. Poupak Mehrani (University of Ottawa) led the local organizing committee with exceptional help from her graduate students and Technical Chair Prof. Shubho Banerjee (Rhodes College) put together an outstanding technical program of presentations and posters.

The technical program consisted of 55 oral presentations organized into 13 sessions, and 11 posters presented at a poster session. The meeting featured a number of keynote and invited talks. Keynote speaker Dr. Charles Fan from General Motors Company (USA) presented computer simulations of electrostatic spray painting of vehicles aimed at achieving a uniform coating and minimizing paint loss. Prof. Phillip C. L. Kwok from the University of Hong Kong (Hong Kong) gave a talk on electrostatics of pharmaceutical aerosols to improve drug delivery. Dr. Elyse Rosenbaum from the University of Illinois at Urbana-Champaign (USA) delivered a great talk on the threat posed by electrostatic discharges to the reliability of integrated circuits and designing safeguards to counter this threat. Prof. Karen Aplin from Oxford University (United Kingdom) spoke on the fascinating electrical processes that occur in planetary atmospheres.

As the "friendly society," the ESA continues to encourage participation by students, providing them with a welcoming venue to present their latest research findings. This year, nearly 25% of the technical talks and posters were delivered by students. First, second and third place awards were given out to 15 students by a panel of judges. The first prize recipients were Gontran Richard, Fahad Chowdhury, Chaoao Chi, Joseph Toth, and Janne Peltonen.

As a tradition, the ESA banquet included an entertaining talk given by Prof. Mark Horenstein from Boston University entitled "The Physics of Puppies." Special honors and recognitions were also given at the banquet: Prof. Wamadeva Balachandran, Brunel University, UK (ESA Lifetime Achievement Award); Mr. Shethar (Duke) Davis, Wabash Instrument Corporation (ESA Honorary Life Member Award). In addition, the President's Appreciation Award was given to the 2017 conference General Chair Prof. Poupak Mehrani and the Technical Program Chair Prof. Shubho Banerjee.

The organizers would like to give a special thanks to the staff at the University of Ottawa reservation, accommodation and catering offices for doing a fantastic job, the technical staff from the computing office for being present throughout all talks to ensure the audio/visual ran smoothly, and the graduate students of Prof. Mehrani's research group as well as Prof. Banerjee's team for assisting with the organization of the meeting. We would also like to thank this year's industry sponsors: Trek Inc., Mystic Tan Inc., and grants received from The University of Ottawa as well as the Faculty of Engineering.

Next year, the meeting will be a joint conference, sponsored by ESA, IEEE IAS-EPC, FES and IESJ, and will be held at Boston University (Boston, USA) from June 18 to 20, 2018 . Prof. Mark Horenstein will serve as the General Chair and Prof. Shubho Banerjee (Rhodes College) will serve as the Technical Program Chair.

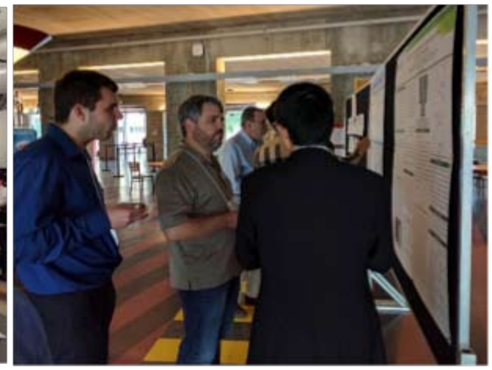
Poupak Mehrani, General Chair

Shubho Banerjee, Technical Program Chair

2017 ESA Annual Meeting Highlights

Presentations

Poster Session



Banquet

Shesha Jayaram (ESA President) &
Poupak Mehrani (General Chair)

Award Presentation

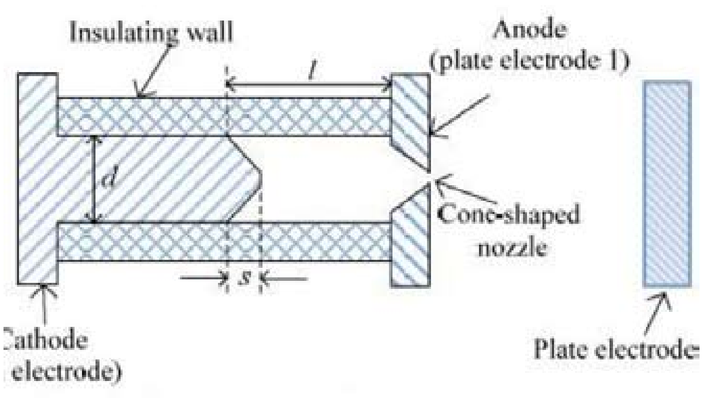
Student Award Presentations

2017 ESA Annual Meeting Highlights

Current Events (cont'd.)

sity of Science and Technology and one of the authors. "Capillary plasma jets have a wide range of applications and the length of the plasma jet is an important characteristic parameter."

Previous studies in this area have focused on the formation of the plasma jet and numerical simulations of the capillary discharge plasma, but few researchers have looked at how the structure of the capillary influences the size of the plasma jet.



This is a diagram of the mechanical structure of the capillary. Credit: Li/Xiong/Cheng/Peng/Pan

Xiong and the group of researchers set up their capillary plasma jet under normal atmospheric pressure with a camera to photograph the plasma jet's length. The capillary system consists of a pin electrode for the negatively charged cathode side of the current supplying device, and a plate electrode for the positively charged anode. An insulating wall surrounds the cathode, creating a chamber where the gas ionizes when they apply a trigger pulse.

The plasma ejected through a cone-shaped nozzle within the anode of the capillary chamber. By varying the length of the capillary chamber, the diameter of the cathode and the length of the cathode tip, the researchers determined the best proportions to generate the longest jet.

The study suggests that the dimensions offering the greatest energy density inside the chamber will yield the longest plasma jet. As length of the capillary increases, the energy deposited in the arc channel increases as well, but only up to a point. Thus, there is an optimum chamber length to maximize the energy density in the capillary chamber.

Additionally, they showed that increasing the cathode diameter and the cathode tip length shortens the plasma jet, because these changes reduce the energy deposited in the arc channel. In their next study, the researchers will use combinations of different pulse discharge circuits and discharge energies to see how these factors impact the plasma jet length.

(excerpted from *http://www.sciencenewsline.com/news/2017062020130005.html*)

Spiky Ferrofluid Thrusters Can Move Satellites

Kim Geiger

Brandon Jackson, a doctoral candidate in mechanical engineering at Michigan Technological University, has created a new computational model of an electrospray thruster using ionic liquid ferrofluid—a promising technology for propelling small satellites through space. Specifically, Jackson looks at simulating the electrospray startup dynamics; in other words, what gives the ferrofluid its characteristic spikes.

A ferrofluid is a magnetic liquid that turns spiky in a magnetic field. Add an electric field and each needle-like spike emits a jet of ions, which could solve micropropulsion for nanosatellites in space.

More than 1,300 active satellites orbit the Earth. Some are the size of a school bus, and others are far smaller, the size of a shoebox or a smart phone. Small satellites can now perform the missions of much larger and more expensive spacecraft, due to advances in satellite computational and communications systems. However, the tiny vehicles still need a more efficient way to maneuver in space. Scaled-down plasma thrusters, like those deployed on larger-class satellites, do not work well. A more promising method of micropropulsion is electrospray.

Electrospray involves microscopic, hollow needles that use electricity to spray thin jets of fluid, pushing the spacecraft in the opposite direction. But the needles have drawbacks. They are intricate, expensive and easily destroyed.

To solve this problem, L. Brad King, Ron & Elaine Starr Professor in Space Systems at Michigan Tech, is creating a new kind of microthruster that assembles itself out of its own propellant when excited by a magnetic field. The tiny thruster requires no fragile needles and is essentially indestructible. "We're working with a unique material called an ionic liquid ferrofluid," King says, explaining that it's both magnetic and ionic, a liquid salt. "When we put a magnet underneath a small pool of the ferrofluid, it turns into a beautiful hedgehog structure of aligned peaks. When we apply a strong electric field to that array of peaks, each one emits an individual micro-jet of ions." The phenomenon is known as a Rosensweig instability. The peaks also heal themselves and re-grow if they are somehow damaged.

Without a magnetic field, ferrofluids look like a tarry, oil-based fuel. With a magnetic field, the propellant self-assembles, raising into a spiky ball.

King came up with the idea of using ferrofluids for thrusters in 2012. He was trying to make an ionic liquid that behaved like a ferrofluid when he learned about a research team at the University of Sydney led by Brian Hawkett and Nirmesh Jain. They had developed a ferrofluid from magnetic nanoparticles made by the life sciences company Sirtex.

King's early work with the ferrofluid sample was pure trial and error; the results were good, but the physics were poorly understood. That's when the Air Force Office of Scientific Research (AFOSR) gave King a contract to research the fluid physics of ferrofluid. Enter Jackson, whose doctoral work is advised by King.

Working in King's Ion Space Propulsion Laboratory, Jackson conducted an experimental and computational study on the interfacial dynamics of the ferrofluid, and created a computational model of ionic liquid ferrofluid electrosprays. Computer models of the deformed ferrofluid compare well against laboratory images of the fluid under matching conditions.

"We wanted to learn what led up to emission instability in one single peak of the ferrofluid microthruster," Jackson says, who developed a model for a single peak and conducted rigorous testing to ensure the model was correct.

The team gained a much better understanding of the relationships between magnetic, electric and surface tension stresses. Some of the data gathered through the model surprised them.

"We learned that the magnetic field has a large effect in preconditioning the fluid electric stress," Jackson says, explaining this discovery might lead to a better understanding of the unique behaviors of ferrofluid electrosprays.

The AFOSR recently awarded King a second contract to continue researching the physics of ferrofluids, and he says, "Now we can take what we've learned, and instead of modeling a single peak, we'll scale it up and model multiple peaks."

Their next set of experiments will be more like a thruster, though a working thruster is still several years away. Although making 100 peaks or more, all thrusting identically, will be much more challenging. "Often in the lab we'll have one peak working and 99 others loafing. Brandon's model will be a vital tool for the team going forward," King says. "If we are successful, our thruster will enable small inexpensive satellites with their own propulsion to be mass produced. That could improve remote sensing for better climate modeling, or provide better internet connectivity, which three billion people in the world still do not have."

The team has also begun collaborating with Juan Fernandez de la Mora, a professor of mechanical engineering and materials science at Yale University, one of the world's leading experts in electrospray.

In addition to spacecraft propulsion, ferrofluid electrospray technology could be useful in spectrometry, pharmaceutical production, and nanofabrication. Michigan Tech has a pending patent for the technology.

(excerpted from *http://www.mtu.edu/news/stories/2017/july/spiky-ferrofluid-thrusters-can-move-satellites.html*)

Smart Surface Enables Advanced Manipulation of Droplets

For many years, engineers have sought to create a special kind of surface: one that can both repel and absorb liquids, and whose ability to do so — its "wetting behavior" — can be quickly and precisely controlled. The technology would have a wide range of potential applications, from water filtration and biomedical devices to liquid optical lenses and lab-on-a-chip systems.

Such a "smart surface" has now been developed by researchers at the University of British Columbia. Inexpensive, scalable and powered by just a conventional electric battery, the copper-based surface changes from being very water-repellent (superhydrophobic) to very water-absorbent (superhydrophilic) as electric potential is applied.

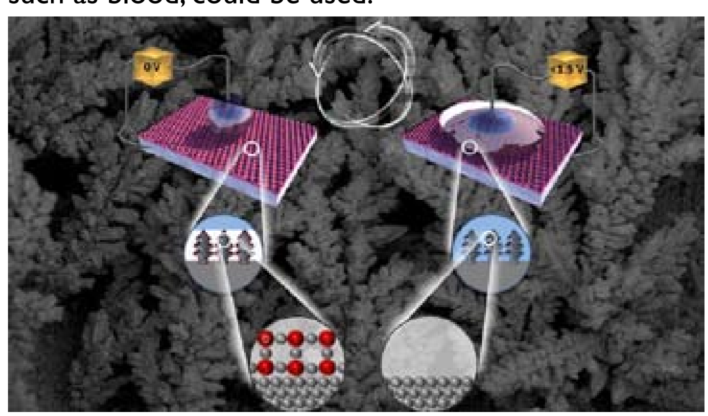
"When tiny voltages are applied to the surface, water droplets that initially roll off stick to it more and more tightly," says Ben Zahiri, the study's co-lead author. "By changing the magnitude of the voltage and how long it is applied, we can easily control the angle that each droplet forms with the surface and how quickly this happens." When the electric potential is removed, the droplet retains its shape and remains pinned in place.

Other groups have modified the wetting behavior of copper surfaces using stimuli like heat, UV radiation and X-rays. But in order to achieve this, the required temperatures are high — up to 300 degrees Celsius — and the required exposure times are long — from tens of minutes to days. This makes them impractical for a number of consumer and industrial purposes.

In contrast, the electrical stimulus used by the UBC team modifies wetting behavior rapidly (from a few seconds to a few minutes) and reversibly, at voltages found in everyday batteries (less than 1.5 V). It does so by changing the oxidation state of the copper surface, which contains a mixture of hydrophilic CuO and hydrophobic Cu2O: as copper loses electrons, it becomes less attracted to water.

The ability to control surface wettability could be useful wherever droplets, or solid particles absorbed by droplets, need to be manipulated, including microfluidic devices and hazardous material handling systems. It also offers advanced self-cleaning capabilities by enabling the controlled roll-off of fluids.

Although the UBC team chose to investigate copper because it is cheap, abundant and one of the most commonly used metals in the world, Zahiri believes that the electrochemical manipulation of other metals, metal oxides and mixed oxides may yield similarly promising results. As for the liquid, any conductive fluid, such as blood, could be used.



Applying low voltage to a nanostructured copper surface changes its oxidation state, and hence its ability to attract and repel liquids.

"These findings could open up a new area of exploration for smart surfaces," says UBC mechanical engineering professor Walter Mérida, who supervised the work.

(excerpted from *https://apsc.ubc.ca/spotlight/research/smart-surface-enables-advanced-manipulation-of-droplets*)

Gazing into the flames of ionic winds

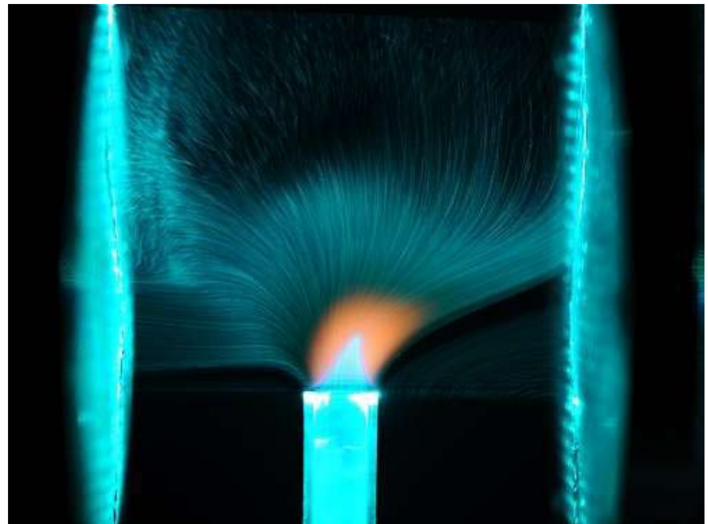
New 3-D visualizations that reveal how flames respond to electric fields could help improve combustion efficiency and reduce pollution.

The ability to precisely control flames could lead to greater energy efficiency and fewer harmful emissions from transport and industry. Flames contain charged ions and electrons, which can be manipulated using electricity. KAUST researchers have now produced the first detailed 3-D visualizations of ionic winds flowing from a flame in response to both direct (DC) and alternating (AC) electric fields.

Minsuk Cha and coworkers previously developed a theoretical model explaining how ions in a flame respond to electric fields. For their latest work, the researchers ejected a mixture of methane and air through a jet flame nozzle positioned between two electrodes. They illuminated the flame using an argon-ion laser and detected the scattered light in order to trace the motion of individual particles through the flame—a technique called particle image velocimetry or PIV. To improve this visualization, they had to add to the flame reflective seeding particles made from titanium oxide and oil.

"The particle seeding to the ambient flame was quite difficult," says Cha. "We used a smoke generator, but we had to control the timing of the smoke generation very carefully so that we didn't disturb the main flow. It was a time-consuming step requiring a lot of patience."

The researchers acquired images that reveal unprecedented details of how flame dynamics respond to electricity. When they used a DC field, the flame visually bent towards the negative electrode because positive ions (which vastly outnumber negative ions in the flame) were attracted that way (see image).



Counter-intuitively, however, the ionic wind blew toward both electrodes, indicating an important role for negative ions. In an AC field, the ionic wind dynamics depended on the applied AC frequency, though only at low frequencies. These ionic winds could influence the combustion process by allowing a controlled redistribution of heat and combustion products by convection.

Cha says he hopes that this work could have a very positive impact on the future design of flame-generating machinery. Most importantly, it wouldn't require the building of completely new industrial equipment, as Cha explains:

"The beauty of this method is that it can be retrofitted—it can be added in as an active control method for any pre-existing combustion system. Depending on the system configuration and the type of combustion that we need to control, we could use our knowledge and understanding to work out the appropriate locations of electrodes and choose the best operational parameters, such as voltage or frequency.

(from *https://phys.org/news/2017-09-flames-ionic.html*)

"I'm not sure I want to see things in high definition."

Electrostatics Society of America

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