Ph.D. Candidate

Shahla Ahmadi

Graduate Academic Unit

Physics

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January 18, 2022

1:00 p.m.

Virtual Defence

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Examining Board:
Dr. Bruce Balcom (Physics)
Dr. William Ward (Physics)
Dr. Laura Romero-Zeron (Chemical Engineering)
Dr. Igor Mastikhin (Physics) Supervisor

External Examiner: Dr. Kimberly Brewer
Associate Professor
School of Biomedical Engineering
Dalhousie University

The Oral Examination will be chaired by:
Dr. Patricia Evans, Associate Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2015 – present	Ph.D. candidate, University of New Brunswick
2010	MSc in Medical Radiation-Nuclear Engineering, Azad University Science and Research Branch, Tehran, Iran,

Publications:

Ahmadi. S, Aguilera A.R., MacMillan. B., Mastikhin. I., Studies of periodic seawater spray icing with unilateral NMR, Journal of Magnetic Resonance (accepted).

Ahmadi S, Mastikhin I. Velocity Measurement of Fast Flows Inside Small Structures with Tagged MRI. Applied Magnetic Resonance. 2020 51(5):431-48.

Mastikhin IV, Bade KM, **Ahmadi S.** A rapid magnetization preparation for MRI measurements of sprays. Journal of Magnetic Resonance. 2017 (283) 52-60.

Conference Presentations:

Ahmadi. S, Aguilera A.R., MacMillan. B., Mastikhin. I, Studies of seawater spray icing phenomena with unilateral NMR, Virtual Canadian Association of Physicists (CAP) Congress. June 6-11, 2021, Montreal, Quebec, Canada.

Mastikhin. I.V, Bade. K.M, **Ahmadi. S**, Magnetic Resonance Imaging as a diagnostic technique for spray studies, ICLASS 2018, 14th Triennial International Conference on Liquid Atomization and Spray Systems, July 22-26, 2018, Chicago, IL, USA.

Ahmadi. S, Mastikhin. I., Evaluation of approaches to reduce a characteristic measurement time in MRI of sprays, Canadian Association of Physicists (CAP) Congress, June 11- 15, 2018, Halifax, Nova Scotia, Canada.

Mastikhin. I, Bade. K, **Ahmadi. S**, Magnetic Resonance Imaging with prepared magnetization: application to a "near-nozzle" region of a flat spray, ILASS 2017 Americas, May 15-18, 2017, Atlanta, USA.

Ahmadi. S, Mastikhin. I, MRI measurement of flowing and stationary water in a spray setup, International Conference on Magnetic Resonance Microscopy (ICMRM), August 13-17, 2017, Halifax, Nova Scotia, Canada.

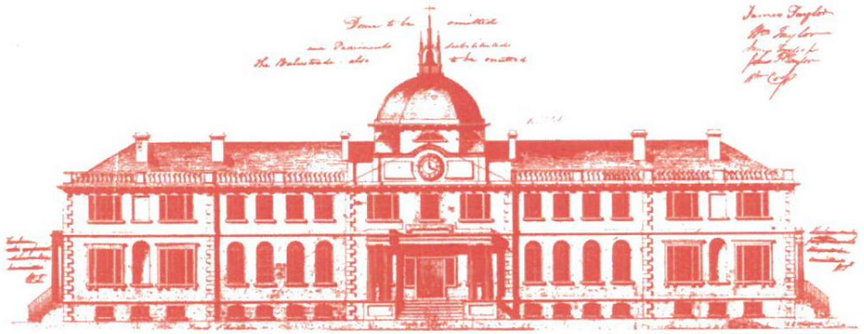
Mastikhin. I.V, **Ahmadi. S**, Bade. K.M, Water spray measurements with Magnetic Resonance Imaging: the "near-nozzle" region, Magnetic Resonance in Porous Media-13, September 4-8, 2016, Bologna, Italy.

Magnetic Resonance and Magnetic Resonance Imaging Studies of Sprays

Abstract

The process of spray atomization is ubiquitous in industry yet quite complex to analyze theoretically and study experimentally. Direct measurements of sprays are difficult because of extremely transient processes and high optical density. Magnetic resonance imaging (MRI) is a non-invasive measurement technique successfully employed to study fluid features in complex flow systems. This thesis focuses primarily on the use of MRI to study three important areas of spray research: the flow inside the spray nozzle; the "near-nozzle" region; and the freezing spray accumulation on a cold surface.

It is well-known that the features of the spray strongly depend on internal nozzle flow. Therefore, one of the areas of great interest is a measurement of flow inside the nozzles, where the flow has a high velocity (m/s) in a very small channel structure (sub-mm). In motion-sensitized MRI, when displacement during the encoding time becomes greater than the pixel size, a velocity misregistration takes place. To address this issue, the encoding time must be reduced. We demonstrate how the reduction of the encoding time can be achieved by applying a Time-Of-Flight (TOF) approach. Another interesting aspect of studying spray atomization using MRI is spray imaging in the "near-nozzle" region where liquid emerges from the nozzle. Standard preparation schemes are difficult to employ due to sprays' fast speeds (>10–20 m/s) and low density. In this thesis, the interval between the preparation and the readout stages was reduced by performing a Single Point Imaging (SPI) encoding [10] on the rising gradients. This also enabled the use of 90-degree flip angles to maximize the spray signal and saturate the stationary water signal while avoiding unwanted slice selection. There is yet another area of spray research. Its main focus is not on the spray itself but on spray deposits. One of important examples of spray deposits is sea spray icing. It causes ice accretion on ships and offshore structures in cold marine environments which leads to marine disasters and operational problems. We show that a portable Nuclear Magnetic Resonance (NMR) could be an efficient tool to evaluate the features of the sea spray spongy ice. A portable unilateral magnet permits to characterize the evolution of sea-ice brine inclusions in two types of ice: stationary seawater ice; and seawater spray ice formed by periodic spraying on horizontal and vertical surfaces. Using a unilateral NMR device, the features such as spray ice growth, brine content, and distribution can be examined.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

The University of New Brunswick recognizes that the university sits on traditional Wolastoqey territory. The river that runs right by our university – the St. John River – is also known as Wolastoq, along which live the Wolastoqiyik -- the people of the beautiful and bountiful river.

UNIVERSITY OF NEW BRUNSWICK

SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Shahla Ahmadi

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY