

BIOGRAPHY

Ph.D. Candidate

Andrés Ramírez Aguilera

Graduate Academic Unit

Physics

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**February 8, 2023**

**2:30 p.m. (Atlantic)**

**Active Learning Lab (rm 303)  
Research Commons, Harriet Irving Library**  
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Examining Board:

Dr. Ben Newling (Physics)

Dr. Dennis Tokaryk (Physics)

Dr. Anna Ignaszak (Chemistry)

Dr. Bruce Balcom (Physics) Supervisor

External Examiner: Dr. Alexej Jerschow
Department of Chemistry
New York University

The Oral Examination will be chaired by:

Dr. Kevin Englehart, Associate Dean of Graduate Studies

Universities attended (with dates & degrees obtained):

2015 – present Ph.D. candidate, University of New Brunswick
2010 Master in Physics, Universidad de la Habana
2005 Bachelor in Physics, Universidad de Oriente

Selected Publications:

A. R. Aguilera, K.J. Sanders, G.R. Goward, B.J. Balcom. The Parallel-Plate Resonator: An RF Probe for MR and MRI Studies Over a Wide Frequency Range, **Submitted to *Magnetic Resonance Letters* (2022)**
K.J. Sanders, **A.R. Aguilera**, J. Keffer, B.J. Balcom, G.R. Goward. Transient lithium metal plating on graphite: Operando ⁷Li nuclear magnetic resonance investigation of a battery cell using a novel RF probe. *Carbon* (2022), 189, 377-385.
S. Ahmadi, **A.R. Aguilera**, B. MacMillan, I. Mastikhin. Studies of periodic seawater spray icing with unilateral NMR. *Journal of Magnetic Resonance* (2022), 334, 107109-107119
A. R. Aguilera, B. MacMillan, S.A. Krachkovskiy, K.J. Sanders, F. Alkhayri, C.A. Dyker, G.R. Goward, B.J. Balcom, A Parallel-Plate RF probe and battery cartridge for ⁷Li ion battery studies, *Journal of Magnetic Resonance* (2021), 325, 106943-106950.
S. A. Krachkovskiy, M. Reza, **A.R. Aguilera**, I.C. Halalay, B.J. Balcom, and G.R. Goward. Real-Time Quantitative Detection of Lithium Plating by In Situ NMR Using a Parallel-Plate Resonator. *J. Electrochem. Soc.* (2020), 167, 130514.

Selected Conference Presentations:

A.R. Aguilera, B. MacMillan, S.A. Krachkovskiy, K.J. Sanders, F. Alkhayri, C.A. Dyker, G.R. Goward, B.J. Balcom, A Parallel-Plate RF Probe and Battery Cartridge for ⁷Li ion Battery Studies, 22nd International Society of Magnetic Resonance Conference, August 22-27, 2021, Osaka, Japan (ONLINE) (*POSTER*)
A.R. Aguilera, B. MacMillan, S.A. Krachkovskiy, F. Alkhayri, C.A. Dyker, G.R. Goward, B.J. Balcom, Parallel-Plate MR Micro Coil for Studies of Materials., 102nd Canadian Chemistry Conference and Exhibition, June 03-07, 2019, Québec City, Canada. (*POSTER*)
A.R. Aguilera, B. MacMillan, S.A. Krachkovskiy, G.R. Goward and B.J. Balcom, Parallel-Plate Resonator for MRI studies of lithium-ion batteries., 15th International Conference on Magnetic Resonance Microscopy (ICMRM), August 18-22, 2019, Paris, France. (*POSTER*)
A.R. Aguilera, B. MacMillan and B.J. Balcom, Optimization of a Parallel-Plate Resonator for High Resolution Thin Film Imaging in Lithium-Ion Batteries, 14th International Conference on Magnetic Resonance Microscopy (ICMRM), August 13-17, 2017, Halifax, Nova Scotia, Canada. (*POSTER*)

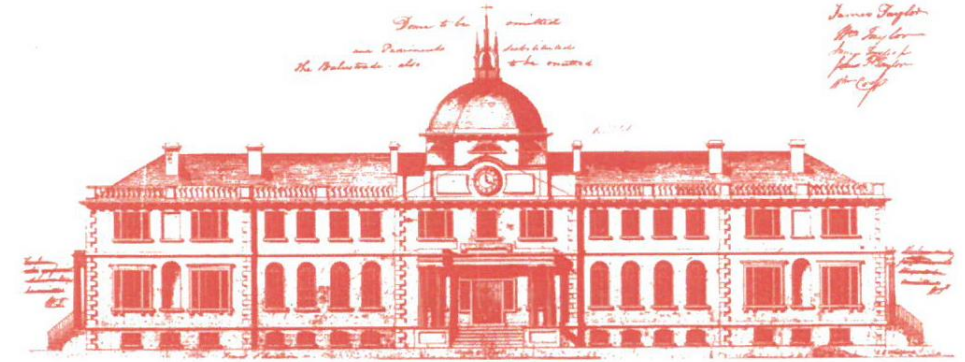
Parallel-Plate RF Probe for Magnetic Resonance and Magnetic Resonance Imaging Studies of Lithium-Ion Batteries

Abstract

Magnetic Resonance (MR) and Magnetic Resonance Imaging (MRI) have become essential techniques to interrogate Lithium-Ion Batteries (LIBs). They are non-destructive and non-invasive techniques that can be employed to study internal processes in LIBs during *ex situ*, *in situ* and *in operando* experiments. The ability to interrogate different chemical species inside the battery, has proven to be essential to study important processes such as lithium intercalation, lithium plating and the solid electrolyte interface formation. Improving MR hardware is vital for better investigation leading to performance optimization of LIBs.

The presence of conductive materials in the LIB, such as electrodes, and the thickness of these materials, poses challenges to the MR experiment. Signal attenuation during RF excitation and reception is one of the critical issues. In this thesis, Parallel-Plate Resonator (PPR) RF probes are presented and optimized for LIB studies. The PPR, with magnetic field B_1 parallel to the plates avoids RF attenuation due to the presence of the conductive electrodes. The B_1 homogeneity of the probe was improved with distributed capacitance in the corners of the probe.

The PPR was first designed and optimized for thin-film imaging. With improved homogeneity and a nominal resolution of $10 \mu\text{m}$, the PPR proved to be ideal for the study of flat cuboid samples. Bulk T_1 - T_2 relaxation correlation detected lithium intercalated into graphite in addition to other Li species. The versatility of the PPR was also explored. The RF probe was tested over a wide range of frequencies from 8 MHz to 500 MHz. The PPR performed well in all situations with no change in the quality factor after sample insertion. Finally, the PPR was combined with a variable field superconducting magnet to perform multinuclear studies on a LIB. This preliminary study showed good sensitivity to the three nuclei under study. These results open the door to the development of new methods for detection and quantification of MR data from LIBs.



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

Andrés Ramírez Aguilera

**IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF**

DOCTOR OF PHILOSOPHY