

Ph.D. Candidate

Hanif Zarringhalam

Graduate Academic Unit

Physics

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**December 9, 2021**

**1:00 p.m.**

**Virtual Defence**

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Examining Board:

Dr. Igor Mastikhin (Physics)

Dr. William Ward (Physics)

Dr. John Neville (Chemistry)

Dr. Dennis Tokaryk (Physics) Supervisor

Dr. Allan G. Adam (Physics) Supervisor

External Examiner: Dr. W. Scott Hopkins

Department of Chemistry

University of Waterloo

The Oral Examination will be chaired by:

Dr. Patricia Evans, Associate Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2014 – present Ph.D. candidate, University of New Brunswick

2008 MSc in Physics, University of Guilan

2005 BSc in Physics. Razi University

Conference Presentations:

H. Zarringhalam, A. G. Adam, C. Linton, D. W. Tokaryk, “Laser-Induced Fluorescence Spectroscopy of Two Ruthenium-Bearing Molecules: RuF and RuCl”, 72nd International Symposium on Molecular Spectroscopy: June 19-23, 2017 at The University of Illinois at Urbana-Champaign.

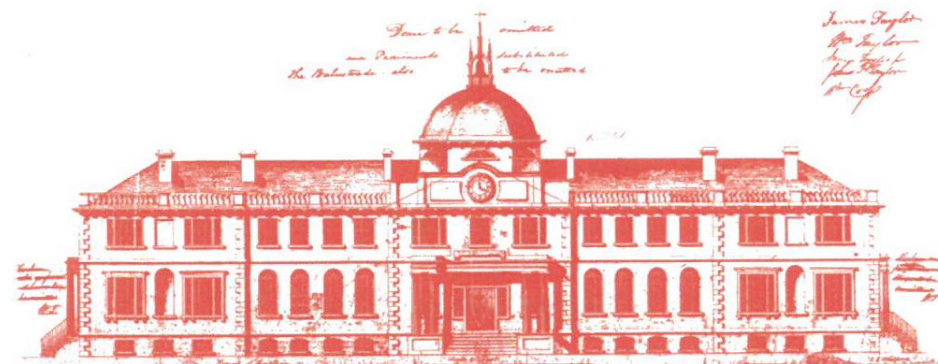
H. Zarringhalam, D. W. Tokaryk, “Studying Medium-Sized Molecules in the Far-Infrared Spectral Region with the Canadian Light Source”, CAP Congress: June 10–16, 2018 at The Dalhousie University at Halifax.

High-Resolution Laser and Far-Infrared Fourier Transform Synchrotron-Based Spectroscopy of Selected Molecules

Abstract

In the first part of this thesis, three ruthenium-bearing diatomic molecules have been studied in the visible region of the electromagnetic spectrum. Ruthenium monofluoride, ruthenium monochloride and ruthenium monoxide molecules were created in a molecular beam apparatus. The high- and low-resolution spectra of these small molecules were taken with the laser-induced fluorescence technique. The dispersed fluorescence technique was used to determine the vibrational frequencies of the RuF, RuCl and RuO molecules. The results of the high-resolution analysis of the spectra revealed extensive isotopic structures of the three molecules. Spin-orbit and hyperfine interactions in ruthenium monofluoride molecule were observed and analyzed. Hyperfine structure in ruthenium monoxide molecule was also detected and studied.

In the second part of the thesis, three medium-sized ring molecules, catechol, furan and pyrrole, belonging to C_{2v} point group, have been studied in the infrared region. Vibrational bands of pyrrole and furan were collected between 826-881 cm^{-1} at the Canadian light source with an FTIR technique. Observed vibrational bands of pyrrole and furan in that region were studied. A nearby level that had A_2 symmetry which could not be accessed from the ground states had perturbed the fully overlapped bands of these molecules. Also, progress has been made in obtaining the first high-resolution rotationally resolved vibrational band of catechol at the Canadian Light source.



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

Hanif Zarringhalam

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY