

## Curriculum Vitae [last 7 years] — Patrick Brian Hall

Professor, York University

December 16, 2020

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### Degrees

- Ph.D. Astronomy, University of Arizona, Dept. of Astronomy, January 1998  
Thesis: *An Optical/Infrared Study of Radio-Loud Quasar Environments*  
Advisor: Dr. Richard F. Green
- B.A. Astronomy, University of California at Berkeley, Dept. of Astronomy, May 1990
- B.A. Physics, University of California at Berkeley, Dept. of Physics, May 1990

### Employment History

- 07/20-present     **Chair and Biophysics Program Coordinator**, Department of Physics and Astronomy, York University
- 07/16-present     Professor and Member of the Faculty of Graduate Studies, Department of Physics and Astronomy, York University
- 07/14-06/17, 07/19-06/20     Undergraduate Program Director, Dept. of Physics and Astronomy, York University
- 07/09-06/16     Associate Professor and Member of the Faculty of Graduate Studies, Department of Physics and Astronomy, York University
- 07/04-06/09     Assistant Professor and Member of the Faculty of Graduate Studies, Department of Physics and Astronomy, York University
- 10/03-06/04     Research Associate, Department of Astrophysical Sciences, Princeton University
- 10/00-9/03     Research Associate, Princeton University Observatory, Princeton University; and Investigador Asociado, Depto. de Astronomía, P. Universidad Católica de Chile
- 1/98-9/00     Post-Doctoral Fellow, Department of Astronomy, University of Toronto
- 6/94-12/97     Graduate Research Assistant, Department of Astronomy, University of Arizona
- 9/93-5/94     Graduate Teaching Assistant, Department of Astronomy, University of Arizona
- 9/90-8/93     Graduate Research Assistant, Department of Astronomy, University of Arizona
- 6/89-8/89     Summer Undergraduate Research Assistant, Department of Physics and Astronomy, University of Wyoming

### **Awards, Academic Honours, and Other Recognition**

- York University Faculty of Science & Engineering Established Researcher Award, 2011
- York University Merit Award Recipient (\$2,000 in 2007, 2008, 2009, and 2012)
- Asteroid 153686 Pathall (discovered in 2001) named after me
- National Science Foundation Graduate Fellowship (1991-1993, 1995-1996)
- University of Arizona Graduate Fellowship (1990-1991)
- High Distinction in General Scholarship (summa cum laude) at U.C. Berkeley (1990)
- Regents' and Chancellors' Scholar, University of California, Berkeley (1986-1990)

### **External Research Funding**

9/18-2/19	NSERC Engage Grant <i>Integrating an Analytical Business Intelligence Module into the Medical Confidence Machine Learning System</i> (\$24,977)
<b>5/17-4/22</b>	<b>NSERC Discovery Grant</b> <i>Constraining the Properties of Quasars and their Outflows Using Variability</i> (\$125,000)
5/12-4/17	NSERC Discovery Grant <i>Understanding Quasar Outflows</i> (\$160,000)
7/09-6/14	Ontario Early Researcher Award <i>Outflows from disks of matter orbiting supermassive black holes</i> (\$100,000, matched with \$50,000 from York University)
5/07-4/12	NSERC Discovery Grant <i>Connections Between Active Galactic Nuclei and Galaxy Bulges</i> (\$121,400)

### **Internal Research Funding**

3/19-8/19	York University Faculty of Science Minor Research Grant, 2019 (\$4,190)
4/18-4/18	York University Faculty of Science Minor Research Grant, 2018 (\$200,000 for membership in the Sloan Digital Sky Survey V)
10/11-9/12	York University Faculty of Science and Engineering Established Researcher Award (\$3,000)

## Research Activities

- **Broad Absorption Line Quasars and Their Time Variability:** I study quasars, which are accretion disks around supermassive black holes at the centres of galaxies. Much of my research focuses on outflows of matter from those accretion disks which are seen as absorption troughs in the spectra of some quasars, known as Broad Absorption Line (BAL) quasars. I am an external participant for studies of BAL quasars in the Sloan Digital Sky Survey, and have contributed to the SDSS quasar catalogs.

Absorption troughs in BAL quasars are sometimes remarkably variable. In Hall et al. (2011) and Rafiee et al. (2016) we reported quasars whose very strong BALs from singly-ionized iron essentially vanished over a few years. The distance of the absorbing gas from the black hole was constrained to be relatively small, showing that not all BAL outflows of its type are galaxy-wide outflows, contrary to previous suggestions. In Rafiee et al. (2016), my research group published a paper following up on this object and presenting two new cases of vanishing iron absorption. Our understanding of this phenomenon is being improved by space-based X-ray observations being led by my former postdoc Dr. P. Rodriguez Hidalgo.

Key collaborators in this work include N. Filiz Ak (Erciyes University, Turkey) and N. Brandt & C. Grier (Penn State). We have conducted large statistical studies of BAL quasar variability (Filiz Ak et al. 2012, 2014) as well as a targeted study of the most rapidly varying BAL trough yet seen (Grier et al. 2015). Unexpectedly, we found (Filiz Ak et al. 2013) that quasars' varying ionizing flux is responsible for at least 50% of BAL quasar trough variability. In such cases, the absorbing gas clouds do not move into or out of our line of sight to a quasar, but varying ionizing flux from the quasar changes the absorbing gas' ionization state and results in more or less absorption from a given ion.

My former PhD student J. Rogerson and postdoc P. Rodriguez Hidalgo conducted a statistical study of emergent BAL troughs, including some that appeared in previously non-BAL quasars (Rogerson et al. 2018; see also McGraw et al. 2017). Discoveries in this work include the highest-velocity BAL trough ever seen in ultraviolet light ( $v = 0.2c$ ; Rogerson et al. 2016) and investigative work (Rogerson et al. 2012) on using future short-exposure photometric monitoring observations of BAL quasars to detect trough variability and trigger long-exposure spectroscopic observations.

- **Blind Source Separation of Quasar Emission Components:** Quasar spectra can be considered as a sum of a few emission components affected by wavelength-dependent dust extinction. Given a large set of quasar spectra, those emission components can be inferred statistically. My Mitacs Globalink Intern S. Pandey and I extended previous approaches to, for the first time, attempt to statistically infer each quasar's dust extinction as well. We have been foiled so far by degeneracies between inferred parameters, but have ideas for future progress and have in the meantime produced fits to all quasar spectra from the latest release of the SDSS, which we will make available to the community.

- **Quasars with Redshifted BAL Troughs:** In Hall et al. (2013), I reported the unexpected discovery of BAL quasars with absorption from gas apparently *infalling* at up to  $13,000 \text{ km s}^{-1}$ . Whether they are failed winds or rotating outflows, they challenge models of quasar outflows. X-ray data on a subset reveal total absorption columns similar to those of normal BAL quasars (Zhang et al. 2017), favoring a rotating disk wind explanation but not ruling out a fallback scenario. My former MSc student N. Ahmed has analyzed new spectroscopic observations to check for variability and to measure inflow velocities more accurately, inputs which will be used for future modeling to compare to disk wind models.

- **Black Hole Mass Estimates:** Quasar broad emission line widths reflect the orbital velocity of the emitting gas. A quasar's black hole mass can thus be found from its linewidths, given an estimate of the orbital distance of the gas. The latter can be measured through 'reverberation mapping' (RM)

monitoring campaigns measuring the time delay between continuum and emission-line variations, or extrapolated from such studies via an observed scaling with luminosity. My first work in this area was supervising A. Rafiee's PhD thesis, which led to two papers. More recently I have participated in a Hubble Space Telescope RM campaign, have led the Canada-France-Hawaii Telescope imaging for the groundbreaking multi-object SDSS-RM campaign.

- **MSE:** I am involved with developing the design of, and advancing the case for, the proposed 11.25-m diameter Maunakea Spectroscopic Explorer (MSE) telescope. MSE will obtain 3000 low-resolution spectra and 1000 high-resolution spectra simultaneously, enabling large statistical studies of galaxy and quasar populations and the unravelling of the formation history of the Milky Way through the the distribution and dynamics of stars as a function of chemical abundance.
- **Weak-Lined Quasars:** A small subset of quasars have very weak, highly blueshifted, emission from ionized or neutral gas. With N. Brandt (Penn State) and collaborators, I have been studying these objects at X-ray wavelengths. A substantial fraction of them are strikingly X-ray weak. Our working hypothesis is that the accretion disk in these objects is puffed up, directing X-rays and EUV photons away from the broad-line gas. That would reduce the strength of the broad emission lines and produce stronger winds. We are continuing our X-ray observations to increase our sample size, and hope in future to analyze the small number of weak-lined BAL quasars known to determine how those characteristics are related.
- **Modelling Accretion Disks and Winds:** A long-term goal of mine is to connect quasar observables with fundamental quasar properties. In Chajet & Hall (2013) we compared models of emission arising at the base of quasar winds and observed emission-line width distributions and constrained the viewing angle distribution of quasars to be  $<45^\circ$  from the disk normal. Further models (Chajet & Hall 2017) formed the second part of L. Chajet's York PhD thesis, but there are many other areas of parameter space which remain to be studied. I hope to continue work in this area with a future student, possibly by linking to accretion disk models with inhomogeneous temperature gradients. In Hall, Sarrouh, & Horne (2018), we pointed out that a sufficiently low-density scattering atmosphere above a disk can alter its spectrum in a way that might help explain observations of AGN with larger than expected sizes and steeper than expected temperature gradients without altering the underlying accretion physics. One such case is NGC 5548, studied in detail in the AGN STORM campaign with which I am involved.
- **Educational:** To date I have overseen two first-author papers by York undergraduates in Physics education journals. The first was a simulation of the Moon's phases and angular size and speed during a hypothesized early phase of its existence in which it had a very eccentric orbit. The second described a demonstration of Martian gravity on Earth using a lightweight vinyl bag. Next up is a study of the offset of Earth's oceanic tidal bulge from the Earth-Moon line; astronomy textbooks may have it wrong.
- **Unusual Astrophysical Objects:** My determination to understand why unusual objects have the properties they do, and particularly my expertise at identifying broad absorption and emission in the spectra of quasars and stars, has led to the discovery and initial characterization of numerous such objects that continue to be the focus of further research (including my own, as detailed elsewhere in this section). These objects include: an optical transient (probably a flaring dwarf star) that was visible to the naked eye (Zhao et al. 2013), the most distant gravitationally lensed quasar yet reported (McGreer et al. 2010), a previously unknown fast-moving white dwarf star only  $\sim 100$  light-years from Earth (Hall et al. 2008), and a study of the sizes of absorbing structures in distant galaxies using even more distant quasars (Rogerson & Hall 2012) as a precursor to resolved studies of such structures which will be possible using the Thirty Meter Telescope and gravitationally lensed galaxies.

## Scholarly Activities and Service

- **Principal Investigator, approved Canada-France-Hawaii Telescope proposal** *Photometric Monitoring for a Multi-Object AGN Reverberation Mapping Campaign in SDSS-V*
- **Co-Investigator, Hubble Space Telescope Cycle 28 approved observing program** *Understanding the offset in the broad-line region size-luminosity relation with UV spectroscopy, May 2020 (PI: Dr. Yue Shen)*
- Invited Speaker, Astronomy Long Range Plan Town Hall, University of Toronto, Nov. 12, 2019
- Invited Speaker, *The Future of Astronomy* Meeting, University of Waterloo Centre for Astrophysics, Oct. 4, 2019
- Lead Author, Canadian Astronomy Long Range Plan 2020 White Paper, *The Maunakea Spectroscopic Explorer*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *Science, Technical and Strategic benefits of Canadian partnership with Subaru*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *Science with the Large Synoptic Survey Telescope*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *Canadian Participation in the LSST*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *The next decade of optical wide field astronomy in Canada*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *Revealing the Origin and Cosmic Evolution of Supermassive Black Holes*
- Co-signer, Canadian Astronomy Long Range Plan 2020 White Paper, *CASTOR: A Flagship Canadian Space Telescope*
- Co-Investigator, Hobby-Eberly telescope approved observing program *Checking for deceleration in a quasar outflow*, July 2019
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- **Principal Investigator, Gemini approved observing program** *Checking for deceleration in a quasar outflow, June 2019*
- Ad Hoc Program Member, Faculty of Graduate Studies Appeals and Academic Honesty Committee, June 2019
- **York University representative to the Association of Canadian Universities for Research in Astronomy (ACURA) Institutional Council, Jun. 1, 2019 - present**
- **Co-Investigator, NAO approved observing survey program** *DECam Early Imaging of AGN Reverberation Mapping Fields in SDSS-V, January 2019 (PI: Dr. Yue Shen)*

- **Co-Investigator, Gemini approved observing survey program *Mapping the Accretion Disk and Broad Line Region of the Super-Eddington Active Galactic Nucleus Mrk 142*, December 2018 (PI: Ms. Viraja Khatu)**
- **Co-Investigator, Hubble Space Telescope Cycle 26 approved observing program *Ultraviolet Echoes of Quasar Accretion Disks*, November 2018 (PI: Ms. Yasaman Homayouni)**
- External Referee, application for promotion for a professor at a Canadian university, Oct. 2018
- Invited Participant, *Wide Field Astronomy in Canada* meeting in Waterloo, ON, Oct. 2018
- **Member, Sloan Digital Sky Survey V (SDSS-V), June 2018 - present; featured in YFile Nov. 4, 2020**
- Accepted talk on ‘Canada and the Maunakea Spectroscopic Explorer’ at the Canadian Astronomical Society annual meeting, Victoria, BC, May 2018
- **Collaborator, Ultraviolet Near-Infrared Optical Northern Survey (UNIONS), Apr. 2018 - present**, and Canada-France Imaging Survey (CFIS), Feb. 2017 - Apr. 2018. UNIONS is a merger of CFIS and Pan-STARRS.
- Accepted talk on ‘Maunakea Spectroscopic Explorer: Key Science Drivers for a Wide Field Spectroscopic Survey Facility’ at the *SnowPAC Particle Astrophysics And Cosmology* meeting, Snowbird, UT, USA, March 2018
- Accepted talk on ‘The Maunakea Spectroscopic Explorer’ at the *Exploiting Extra-galactic Synergies between WFIRST and Future Facilities* workshop, Pasadena, CA, USA, February 2018
- Accepted talk on ‘MSE: Maunakea Spectroscopic Explorer’ at the *Decadal Survey Planning Community Workshop*, Tucson, AZ, USA, February 2018
- Chair, Maunakea Spectroscopic Explorer Management Group, December 2017 - December 2018
- Co-Investigator, XMM-Newton X-ray satellite approved observing program *Deciphering the Remarkable X-ray Spectrum of the Weak-Line Quasar SDSSJ1521+5202*, November 2017 (PI: Dr. Niel Brandt)
- Accepted talk on ‘MSE: Maunakea Spectroscopic Explorer’ at the *Cosmic Visions: Dark Energy* workshop, Berkeley, CA, November 2017
- Contractor for Essential Analysis and Design Services to Maunakea Spectroscopic Explorer Project Office, August - December 2017
- **Member, Thirty-Meter Telescope International Science Development Team for Time Domain Science, August 2017 - present**
- Volunteer Visitor, National Research Council Herzberg Astronomy & Astrophysics, Victoria, BC, July 2017 - June 2018
- **Co-Investigator, Hubble Space Telescope Cycle 25 approved observing program *Ultraviolet Echoes of Quasar Accretion Disks*, June 2017 (PI: Dr. Jonathan Trump)**

- Accepted talk on “Updates on Emergent and Redshifted BAL Quasars” at the *Active Galactic Nuclei Winds on the Georgia Coast* meeting, Georgia, USA, June 2017
- Invited Participant, *AGN Driven Winds* conference at Technion, Haifa, Israel, May 2017
- Participant, *Disks, Dynamos, and Data: Confronting MHD Accretion Theory with Observations* conference at Kavli Institute for Theoretical Physics, Santa Barbara, California, Feb. 2017
- Principal Investigator, approved Canada-France-Hawaii Telescope proposal *A Transformative Multi-Object AGN Reverberation Mapping Campaign: Continued Photometric Monitoring in 2017A*
- **Maunakea Spectroscopic Explorer Management Group Member, November 2016 - present**
- Collaborator, After SDSS-IV white paper proposal ‘New Dimensions in Black Hole Accretion from Repeat Spectroscopy of Quasars’
- Co-signer, “The Astropy Problem” white paper, (arXiv:1610.03159)
- Invited Participant, *Astronomy 8* conference at the University of Oxford, UK, June 2016
- **Member, Canadian Large Synoptic Survey Telescope Consortium, April 2016 - present**
- Local Organizing Committee Member, 2016 Great Lakes Quasar Symposium, August 2015 - May 2016
- Speaker, Maunakea Spectroscopic Explorer Collaboration Meeting, Madrid, April 27-29, 2016
- Principal Investigator, approved Canada-France-Hawaii Telescope proposal *A Transformative Multi-Object AGN Reverberation Mapping Campaign: Continued Photometric Monitoring in 2016A*
- Co-signer, After SDSS-IV white paper ‘All-Sky Multi-Epoch Spectroscopy of Quasars’
- Co-Investigator, Chandra X-ray Observatory approved observing programs *Constraining X-ray Absorption in Emergent BAL Quasars* and *Bridging the Gap Between Weak-Line and Typical Quasars*, 2015-2016
- Principal Investigator, approved Canada-France-Hawaii Telescope proposal *A Transformative Multi-Object AGN Reverberation Mapping Campaign: Continued Photometric Monitoring in 2015A*
- Local Organizing Committee Member, 2015 Gemini Science Meeting, July 2014 - June 2015
- Invited Speaker, *The Inner Regions of Quasars* Symposium, University of Texas at Austin, Sept. 12-14, 2014
- **Maunakea Spectroscopic Explorer Science Team member, August 2014 - present**
- **External Collaborator in the Sloan Digital Sky Survey IV Collaboration for research on Broad Absorption Line Quasars, July 2014 - present**

- Co-Investigator, Chandra X-ray Observatory approved observing programs *The Nature of Quasars with Redshifted Broad Absorption Lines* and *Shielding Gas Variations in Transforming Broad Absorption Line Quasars*, 2014-2015
- Maunakea Spectroscopic Explorer Advisory Group Member, June 2014 - October 2016
- **External Collaborator in the Sloan Digital Sky Survey IV Collaboration for research on Quasar Reverberation Mapping, Feb. 2014 - present**
- York University representative to the Association of Canadian Universities for Research in Astronomy (ACURA) Institutional Council, Jan. 1, 2014 - Dec. 31, 2016
- Principal Investigator, approved Canada-France-Hawaii Telescope proposal *A Transformative Multi-Object AGN Reverberation Mapping Campaign: Photometric Component*, 81.4 hours in semester 2014A
- Principal Investigator, approved Gemini Observatory observing program *Monitoring Emergent Absorption Troughs in Quasars*, semesters 2013A, 2013B, 2014A, 2014B
- Co-Investigator, Sloan Digital Sky Survey approved extra time program *Multi-Object Reverberation Mapping with SDSS*, semester 2014A
- Co-Investigator, European Southern Observatory approved observing program *Constraining the Causes of Dramatic Variability in Newly Emerged Quasar Outflows*, Fall 2013
- Collaborator (with York graduate student J. Rogerson and postdoc P. Rodríguez Hidalgo) on approved Gemini Observatory proposal *Spectroscopy of Photometrically Varying BAL Quasars*, semester 2013B [One result featured in *Gemini Focus* magazine, April 2016 and January 2017 '2016 Year in Review' issues]
- Co-Investigator, Hubble Space Telescope approved observing program *Mapping the AGN Broad Line Region by Reverberation*, May 2013
- Co-Investigator, Hubble Space Telescope approved observing program *Unveiling the X-ray/UV Connection in AGN Winds: the PG 1126-041 Case Study*, May 2013
- Invited Participant, ngCFHT workshop "The Next Generation of the CFHT: A wide field spectroscopic facility for the coming decade," March 2013
- Collaborator (with York graduate student J. Rogerson and postdoc P. Rodríguez Hidalgo) on approved Canada-France-Hawaii Telescope proposal *Monitoring Quasar Colour Variability in Stripe 82*, semesters 2012B and 2013B

### Scientific Papers, Proposals, and Funding Applications Refereed

- One proposal for the Canada-France-Hawaii Telescope, October 2020
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- One proposal for the Gemini International Telescopes, May 2020



- Paper for the Monthly Notices of the Royal Astronomical Society, October 2019 - December 2019
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- Paper for Nature Astronomy, July 2018 - August 2018
- Paper for The Astrophysical Journal, January 2018 - April 2018
- Paper for The Astrophysical Journal, August 2017 - September 2017
- One proposal for the Gemini International Telescopes, April 2017
- One proposal for the Gemini International Telescopes, November 2016
- Two proposals for the China Telescope Access Program, October 2015
- Paper for Astronomy & Astrophysics, August 2015 - September 2015
- Paper for The Astrophysical Journal, July 2015 - February 2016
- Paper for The Astronomical Journal, May 2015 - October 2015
- Paper for The Astrophysical Journal Letters, August 2014 - January 2015
- Two proposals for the Gemini International Telescopes, October 2013
- One proposal for the Gemini International Telescopes, April 2013
- One proposal for the Canada-France-Hawaii Telescope, April 2013

#### **Invited Colloquia and Seminars (28 as of January 2018)**

- Queen's University, Physics & Astronomy Dept. Seminar, November 2019: 'Quasar Reverberation Mapping and the Maunakea Spectroscopic Explorer'
- York University, Physics & Astronomy Dept. Colloquium, October 2019: 'How to Learn About Quasars From Quite A Long Way Away'
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- Virginia Polytechnic University, Physics & Astronomy Dept. Seminar, April 2019: 'Quasar Reverberation Mapping and the Maunakea Spectroscopic Explorer'
- University of British Columbia, Dept. of Physics & Astronomy Cosmo-Pizza Seminar, March 2018: 'Quasar Reverberation Mapping and the Maunakea Spectroscopic Explorer'
- University of Victoria, Dept. of Physics & Astronomy Seminar, January 2018: 'Quasar Outflows: the Fast and the Furious'
- Western University, Dept. of Physics & Astronomy Colloquium, January 2016: 'Quasar Outflows: the Fast and the Furious'

- Bucknell University, Dept. of Physics & Astronomy Seminar, October 2013: ‘Gas Falling Into Black Holes: A Surprising Discovery’

### **Memberships in Professional and Related Societies**

- Canadian Association of Physicists (2014-present)
- International Astronomical Union (2003-present)
- Canadian Astronomical Society (1998-present)
- American Astronomical Society (1991-present)

### **Graduate Supervisions (3 PhD completed; 5 MSc completed)**

- Courtney Mulholland, York University Astronomy Thesis Master’s program *Quasar Wind Deceleration* (September 2018 - May 2020).
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- Nabeel Ahmed, York University Astronomy Project Master’s program *Redshifted Broad Absorption-Line Quasars: Variability, Infall, and Rotating Outflows* (September 2015 - May 2017). Currently Anti Money Laundering QA Analyst at CIBC in Toronto, ON.
- Jesse Rogerson, York University Astronomy PhD program *Monitoring Broad Absorption-Line Quasar Variability* (January 2011-May 2016) and York University Astronomy Thesis Master’s program, *Investigating Mg II Absorption in Quasar Pair Sight Lines* (September 2007-December 2010). Currently Science Advisor at the Canada Aviation and Space Museum, Ottawa, ON.
- Laura Chajet, York University Astronomy PhD program, *Disk Winds and Line-Width Distributions* (December 2007-December 2015) and York University Astronomy Thesis Master’s program, *Infrared Confirmation of  $z > 5.5$  Quasar Candidates* (May 2005-November 2007).

### **Graduate Supervisory and Examining Committee Memberships**

- York University Department of Physics and Astronomy internal PhD supervisory committee member for Mr. Richard Bloch (program: Physics and Astronomy, supervisor: Dr. Matthew Johnson), April 2019 - April 2020
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- York University Department of Physics and Astronomy internal MSc supervisory committee member for Mr. Chris Rampersad (program: Physics and Astronomy, supervisor: Dr. Adam Muzzin), April 2019
- York University Faculty of Graduate Studies Master’s examining committee member for Ms. Elisabeth Smith (program: Earth and Space Sciences and Engineering, supervisor: Dr. John Moores), September 2018

- University of Waterloo Faculty of Science PhD examining committee external examiner for Mr. Mansour Karami (program: Astronomy, supervisors: Dr. Niayesh Afshordi and Dr. Avery Broderick), September 2018
- York University Faculty of Graduate Studies Master's examining committee member for Mr. Jacob Kloos (program: Earth and Space Sciences and Engineering, supervisor: Dr. John Moores), September 2016
- York University Faculty of Graduate Studies PhD examining committee member for Ms. Laura Chajet (program: Physics and Astronomy, supervisor: Dr. Patrick Hall), December 2015
- York University Faculty of Graduate Studies Master's examining committee member for Mr. Hugh Podmore (program: Earth and Space Science and Engineering, supervisor: Dr. Regina Lee), August 2015
- York University Faculty of Graduate Studies Master's examining committee member for Mr. Ryan Denault (program: Physics and Astronomy, supervisor: Dr. Marshall McCall), June 2015
- York University Department of Physics and Astronomy internal MSc supervisory committee member for Ms. Athary Alfayez (program: Physics and Astronomy, supervisor: Dr. Michael De Robertis), May 2015
- York University Faculty of Graduate Studies Master's examining committee member for Mr. Calvin Midwinter (program: Earth and Space Science and Engineering, supervisor: Dr. Mike Daly), March 2015
- York University Faculty of Graduate Studies Master's examining committee chair for Ms. Neda Hejazi (program: Physics and Astronomy, supervisor: Dr. Michael De Robertis), October 2014
- York University Department of Physics and Astronomy internal PhD supervisory committee member for Mr. George Conidis (program: Physics and Astronomy, supervisor: Dr. Marshall McCall), 2014-2016
- York University Department of Physics and Astronomy internal MSc supervisory committee member for Ms. Neda Hejazi (program: Physics and Astronomy, supervisor: Dr. Michael De Robertis), May 2013
- York University Department of Physics and Astronomy internal MSc supervisory committee member for Mr. George Conidis (program: Physics and Astronomy, supervisor: Dr. Marshall McCall), March 2013

### **Postdoctoral Fellow Research Mentoring**

- March 2015-May 2015: supervised Dr. Alireza Rafiee in his role as lead author on a peer-reviewed paper investigating three 'disappearing FeLoBAL' quasars whose broad absorption has greatly decreased in the recent past.
- January 2012-July 2015: supervised York postdoctoral researcher Dr. Paola Rodríguez Hidalgo on numerous projects involving broad absorption line quasars. During her work with me, Dr.

Rodríguez Hidalgo presented her work at several targeted scientific meetings, including an Aspen Center for Physics workshop, and at one meeting of the American Astronomical Society. Dr. Rodríguez Hidalgo is currently a professor at Humboldt State University in California.

### **Graduate Student Research Mentoring**

- September 2018-May 2020: supervising York Master's student Courtney Mulholland on a project to study deceleration of BAL quasar outflows as they sweep up gas in the surrounding galaxy.
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- September 2015-May 2017: supervised York Master's student Nabeel Ahmed on projects to study and model the absorption-line and variability properties of redshifted BAL quasars and the emission-line and variability properties of weak-lined quasars.
- January 2011-May 2016: supervised York graduate student Jesse Rogerson on a PhD project to study BAL quasar variability. Mr. Rogerson has presented on aspects of this work with posters at two targeted scientific meetings and one meeting of the Canadian Astronomical Society, and with a talk at the National Optical Astronomy Observatory's Friday Scientific Lunch Talk series in Tucson, Arizona.
- January 2011-May 2016: supervised York graduate student Jesse Rogerson on a PhD project to study BAL quasar variability. Mr. Rogerson has presented on aspects of this work with posters at two targeted scientific meetings and one meeting of the Canadian Astronomical Society, and with a talk at the National Optical Astronomy Observatory's Friday Scientific Lunch Talk series in Tucson, Arizona.
- December 2007-December 2015: supervised York graduate student Laura Chajet on a PhD project to predict quasar broad emission line profiles for a variety of disk wind outflow scenarios (published as Chajet & Hall 2013). Ms. Chajet has presented on aspects of this work with posters at two targeted scientific meetings and two meetings of the Canadian Astronomical Society, and with a talk at the Women In Physics Conference 2015 in Toronto.

### **Undergraduate Student Research Mentoring**

- May 2020-August 2020: supervised recent York graduate Dyuman Bhattacharya (as an NSERC USRA recipient) on a project to derive the fundamental emission components of quasars, including deriving matrix derivative updates accounting for multiplicative wavelength-dependent attenuation.
- **May 2019-August 2019, May 2020-present:** supervised York undergraduate Ghassan Sarrouh (first as a Dean's Undergraduate Research Award recipient) on a project to derive the fundamental emission components of quasars using advanced statistical techniques.
- May 2019-July 2019: supervised York undergraduate Romina Bahrami on a 12-week project to derive the fundamental emission components of quasars using advanced statistical techniques, specifically Complex Nonnegative Matrix Factorization.

- November 2016-April 2017: supervised York undergraduate Ghassan Sarrouh on visualization of the offset of Earth's oceanic tidal bulge from the Earth-Moon line and on calculation of the radial temperature structure of accretion disks.
- May 2015-July 2015: co-supervised (with York postdoctoral researcher Dr. Paola Rodríguez Hidalgo) U. of Toronto undergraduates Abdul Khatri and Viraja Khatu on searches for, and studies of, high-velocity broad absorption lines in distant and nearby quasars. Mr. Khatri and Ms. Khatu will be co-authors on the resulting paper(s).
- May 2015-July 2015: supervised Indian Institute of Technology Delhi undergraduate student and Mitacs Globalink Intern Shivam Pandey on a project to derive the fundamental emission components of quasars using Blind Source Separation statistical techniques, and to use those components to reconstruct observed quasar spectra free of absorption and with reduced noise. Mr. Pandey will be a co-author on the resulting paper(s), and is now a graduate student at U. Penn.
- March 2015-July 2015: co-supervised (with York lecturer Dr. Alireza Rafiee) York undergraduate Patrik Pirkola on analyzing and interpreting observations of 'disappearing FeLoBAL' quasars; Mr. Pirkola is a co-author on the resulting paper.
- March 2015-July 2015: co-supervised (with York lecturer Dr. Alireza Rafiee) York undergraduate Natalee Galati on constructing and plotting light curves and spectral energy distributions for quasars as part of a study of 'disappearing FeLoBAL' quasars; Ms. Galati is a co-author on the resulting paper.
- August 2014-August 2015: supervised York undergraduate student Nabeel Ahmed on projects involving reduction and analysis of spectroscopic data from the Gemini telescopes.
- June 2013-September 2013: supervised Yanzhou University undergraduate student and Mitacs Globalink Intern Yue (Cory) Zhao (now a graduate student at the University of Alberta) to work on projects on an optical transient (published as Zhao et al. 2013) and on quasar spectroscopic and photometric variability.
- May 2013-August 2013: supervised York undergraduate student (and NSERC USRA recipient) Emil Noordeh on projects animating the early orbit of the Moon (Noordeh, Hall & Cuk 2014), modelling quasar accretion disks (Hall et al. 2014), and reducing near-infrared spectra of quasars.
- October 2012-May 2015: supervised York undergraduate Patrik Pirkola on a project to describe a demonstration of Martian gravity on Earth; Mr. Pirkola is first author on the resulting paper.

### **High School Student Research Mentoring**

- July 2015: supervised Toronto high school student (and Ontario Association of Physics Teachers Grade 11 Physics Contest 2nd-place finisher) Abtin Ameri on projects to search for variable quasars by comparing spectra from the SDSS and BOSS databases, and to measure unexpected emission-line shifts in certain quasars; he is a co-author on the paper reporting the latter.
- March 2015-May 2015: co-supervised (with York postdoctoral researcher Dr. Alireza Rafiee) high school student Shruthi Sailesh in updating the Scale Model of the Solar System at York website: <http://solarsystem.blog.yorku.ca/>

### Course Directorships

- **Physics 2030 ‘Computational Methods for Physicists and Engineers’**: W2020, W2019
- Natural Sciences 1570 ‘Exploring the Solar System’: F2020, W2019
- \_\_\_\_\_
- Physics 1070 ‘Fundamentals of Astronomy’: W2017, F2015, F2014, F2007, W2005
- Physics 4070/5090 ‘Stars and Nebulae’: W2016, W2014, W2012, W2010, W2008, W2006
- Physics 4270/5390 ‘Astronomical Techniques’: Y2008-09, Y2006-07
- Physics 5290 ‘Extragalactic Astronomy’: F2012, F2018
- Natural Sciences 1740 ‘Astronomy’: F2016, W2015, Y2013-14, Y2012-13, Y2011-12, Y2009-10, Y2008-09, W2008, Y2006-07, Y2005-06, F2004

### Graduate Teaching

- Fall 2018: York University Physics 5290 ‘Extragalactic Astronomy’
- Winter 2016: York University Physics 4070/5090 ‘Stars and Nebulae’
- Winter 2014: York University Physics 4070/5090 ‘Stars and Nebulae’
- Fall 2012: York University Physics 5290 ‘Extragalactic Astronomy’
- Winter 2012: York University Physics 4070/5090 ‘Stars and Nebulae’

### Undergraduate Teaching

- **Winter 2020: Physics 2030 ‘Computational Methods for Physicists and Engineers’ (one-term course open required for most majors in the Department), including creation of a few new in-class conceptual programming exercises and homework and exam problems**
- Fall 2020: Natural Sciences 1570 ‘Exploring the Solar System’ (one-term introductory course for students outside the Faculty of Science), including clicker quizzes and in-class activities
- \_\_\_\_\_
- Winter 2019: Physics 2030 ‘Computational Methods for Physicists and Engineers’ (one-term course open required for most majors in the Department), including creation of in-class conceptual programming exercises and homework and exam problems
- Winter 2019: Natural Sciences 1570 ‘Exploring the Solar System’ (one-term introductory course for students outside the Faculty of Science), including clicker quizzes and in-class activities
- Winter 2017: Physics 1070 ‘Fundamentals of Astronomy’ (one-term introductory course open to any qualifying student; required for astronomy stream physics majors), including introduction of online telescope network usage to obtain images for interpretation by students

- Fall 2016: Natural Sciences 1740 'Astronomy' (fall term of two-term introductory course for students outside the Faculty of Science), including re-introduction of clicker quizzes and design and testing of a few new in-class activities
- Fall 2015: Physics 1070 'Fundamentals of Astronomy' (one-term introductory course open to any qualifying student; required for astronomy stream physics majors)
- Winter 2015: Natural Sciences 1740 'Astronomy' (second term of a two-term introductory course for students outside the Faculty of Science), including continued design and testing of new in-class activities
- Fall 2014: Physics 1070 'Fundamentals of Astronomy' (one-term introductory course open to any qualifying student; required for astronomy stream physics majors), including application of various active learning approaches and development of some in-class activities
- Fall 2013 - Winter 2014: Natural Sciences 1740 'Astronomy' (two-term introductory course for students outside the Faculty of Science), including continued design and testing of new in-class activities
- Fall 2012 - Winter 2013: Natural Sciences 1740 'Astronomy' (two-term introductory course for students outside the Faculty of Science), including continued design and testing of new in-class activities

### **Public Outreach, Education, and Media Coverage**

- Public Talk to University of Toronto Astronomy and Space Exploration club: 'Quasars: Black Holes You Can "See"', October 24, 2018
- Public Talk for Science Literacy Week at York University 'Our Weird Universe!', September 19, 2018
- Public Talk to RASC Victoria Centre 'Quasars: Black Holes You Can "See"', January 10, 2018
- Public Talk 'Quasar, Quasar, Burning Bright' (Chronicles of a Peculiar Universe #1) at Toronto Public Library Coxwell Branch, October 11, 2017
- Public Talk on 'Gas Falling into Black Holes: A Surprising Discovery' at a Dominion Astrophysical Observatory Summer Star Party evening, August 26, 2017
- Performer at Science Slam for Science Rendezvous After Dark: Hard-Boiled Astronomy, May 13, 2017
- In Search Of... Planet Nine public talk to York University Astronomy Club, Mar. 22, 2017
- Actor, Dark Energy Infomercial parody at .Astronomy 2016 conference
- Nucleosynthesis - The Musical! public talk to York University Astronomy Club, Mar. 23, 2016
- Press release on ultra-fast winds near supermassive black holes, reporting the discovery of record high-speed UV absorption in collaboration with my grad student Jesse Rogerson, March 21, 2016

- Subject of 'Galactic Appetite' profile on discovery of quasars with gas apparently falling into black holes in the View section of The York University Magazine, Fall 2015
- Public Q&A Session (with Prof. John Moores) at York University Astronomy Club event 'Plutopalooza' celebrating the New Horizons mission flyby of Pluto, July 14, 2015
- Consulted for New model of sun's cycles predicts 'mini ice age' in 2030s CTV News online news story, July 13, 2015
- Nucleosynthesis public talk to York University Astronomy Club, Jan. 28, 2015
- Talk on 'State of the Universe 2014' at Science Teachers' Association of Ontario (STAO) annual conference, Nov. 15, 2014
- Developer and Co-Instructor, Helix Summer Science Institute senior high school student course *Our Weird Universe*, July 14-18, 2014
- Talk on 'Gas Falling Into Black Holes: A Surprising Discovery' to the Royal Astronomical Society of Canada, Mississauga Centre, May 23, 2014
- 'Imagine Relativity' talk at TEDx St. Mary's Catholic Secondary School, May 8, 2014
- 'Our Weird Universe' talks to two groups of 9th grade students, May 5, 2014
- Skype interview by 1st and 2nd grade students at Edgewood P.S., Apr. 24, 2014
- Subject of York University Press Release Gas falling into black holes? York U researcher discovers unusual type of quasar, November 5, 2013, picked up by discovery.com, phys.org, weather.com, etc.
- Redshifted BAL Quasars public talk to York University Astronomy Club, Oct. 16, 2013
- Monthly guest on York's Astronomy.fm internet radio show *YorkUniverse!*, September 2012 - March 2015

#### Academic Activities and Service

- **Member, York University Department of Physics & Astronomy Adjudicating Committee for the tenure and promotion of Prof. O. Mermut, November 2020 - present**
- **Member, York University Department of Physics & Astronomy Adjudicating Committee for the tenure and promotion of Prof. A. Muzzin, October 2020 - present**
- **Member of the CRESS Executive (Centre for Research in Earth and Space Science), York University, September 2020 - present**
- **Member, York University Faculty of Science Research-Stream Black Faculty Search Committee, August 2020 - present**
- \_\_\_\_\_



- Trainee, York University Unconscious Bias Affirmative Action Workshop, April 27, 2020
- Member, York University Faculty of Science Major Awards Advisory Committee, April 2020
- Teaching referee for the promotion to Full Professor of Prof. M. Armour, February 2020 - May 2020
- Teaching referee for the tenure and promotion of Prof. A. Muzzin, January 2020 - May 2020
- **Chair, York University Department of Physics & Astronomy File Preparation committee for the tenure and promotion of Prof. A. Muzzin, January 2019 - present**
- Member, York University Faculty of Science Curriculum committee, Summer 2019 - Summer 2020
- Member, York University Department of Physics & Astronomy Curriculum committee, Summer 2019 - Summer 2020
- \_\_\_\_\_
- Ad Hoc Program Member, Faculty of Graduate Studies Appeals and Academic Honesty Committee, June 2019
- Member, York University Division of Natural Science Advisory Committee, April 2019 - June 2020
- Dean's Representative, York University Physics & Astronomy / Fermilab Joint Research-Stream Faculty Search Committee, December 2018 - May 2019
- Affirmative Action Representative, York University Physics & Astronomy Alternate-Stream Faculty Search Committee, August 2018 - December 2018 (recused due to conflict of interest)
- Chair, York University Observational Astrophysics Faculty Search Committee, August 2015 - April 2016
- Attended Ontario Association of Physics Teachers 2015 Conference *Bridging the Gap: Strengthening Ties Between K-12 and Postsecondary Educators*, Guelph, ON, May 7-9, 2015
- Attended Physics Teacher Education Coalition Conference *Building a Thriving Undergraduate Physics Program*, Seattle, WA, February 6-8, 2015
- Undergraduate Program Director, Physics & Astronomy Department, July 1, 2014 - June 30, 2017
- Chair, Physics & Astronomy Department Adjudicating Committee for the promotion of Prof. W. Taylor to Full Professor, December 2013
- Chair, Physics & Astronomy Department ad hoc committee on teaching relief for Prof. A. Kumarakrishnan, November-December 2013
- Faculty of Science Committee on Tenure and Promotions Alternate Member, Fall 2013 - Winter 2016

- Drafted successful course proposal for new course NATS 1585 3.0 'Exploring the Universe', adapted from 2nd semester of NATS 1740 6.0 'Astronomy', Fall 2013
- Chair of Council, York University Faculty of Science, Fall 2013-Winter 2014
- Featured in the Faculty of Science Annual Report 2013
- York University Faculty of Science Committee on Examinations and Academic Standards member, Summer 2013
- York University Faculty of Science & Engineering Library committee member, Fall 2012-Summer 2013
- York University Dept. of Physics & Astronomy Graduate Executive committee member, Fall 2012-Summer 2013

### **Research Skills**

- Very experienced with longslit, multislit, and multifiber optical spectroscopy.
- Experienced with deep and wide-field optical and infrared imaging and reductions
- Experienced with optical/IR observing and 1-2m class telescope operation.
- Experienced with adaptive-optics infrared imaging and reductions.
- Experienced with acquisition and reduction of polarimetric data.
- Experienced with analysis of X-ray imaging data.
- Experienced with acquisition and reduction of SCUBA sub-millimeter data.
- Very experienced with IRAF as both software and programming language.
- Also experienced with SM, UNIX,  $\LaTeX$ , MATLAB, SQL, Python, HTML, IDL, Perl, and FORTRAN.

## Publications (Lifetime Summary)

ORCID: 0000-0002-1763-5825

Books: 3 (partial authorship/editorship)  
 Chapters in books: 0  
 Papers in refereed journals: 232 (First author: 28)  
 Papers in refereed conference proceedings: 52 (First author: 10)  
 Technical reports: 0  
 Abstracts & other unrefereed contributions: 98 (First author: 20)  
 Other: 1  
 Independent Papers by Research Group Members: 4

## Publications (Details, Current and Past 6 Calendar Years)

### Books

- “Solar System Activities Manual,” **Patrick Hall**, 2018 (Kendall Hunt: Des Moines)  
*Includes three new in-class activities for introductory astronomy courses, plus material from my 2012 workbook.*
- “Astronomy Activities Manual,” **Patrick Hall**, 2012 (Kendall Hunt: Des Moines)  
*I created almost 20 activities (laboratory and in-class) for this workbook for introductory astronomy courses, which includes activities previously published by other Kendall Hunt authors.*

### Papers in Refereed Journals

(Key: AAS - American Astronomical Society; AJ - The Astronomical Journal; ApJ - The Astrophysical Journal; ApJL - The Astrophysical Journal Letters; ApJS - The Astrophysical Journal Supplement Series; A&A - Astronomy & Astrophysics; A&AL - Astronomy & Astrophysics Letters; BAAS - Bulletin of the American Astronomical Society; JAAVSO - Journal of the American Association of Variable Star Observers; MNRAS - Monthly Notices of the Royal Astronomical Society; PASJ - Proceedings of the Astronomical Society of Japan; PASP - Proceedings of the Astronomical Society of the Pacific)

### Submitted

(Key to paper title fonts: **First Author**; *Heavy Involvement*; Some Contribution)  
 (Key to author fonts: Highly Qualified Personnel collaborators at York are underlined)

- “Space Telescope and Optical Reverberation Mapping Project. XII. Broad-Line Region Modeling of NGC 5548,” Williams, et al. 2020, in press  
*I am a member of the AGN STORM project.*

### In Press

- “Space Telescope and Optical Reverberation Mapping Project. IX. Velocity-Delay Maps for Broad Emission Lines in NGC 5548,” Horne, et al. 2020, ApJ, in press (arXiv:2003.01448)  
*I provided feedback on the presentation of results.*

### Published

- 
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Estimating Masses of Black Holes in Quasars with Single-Epoch Spectroscopy,” Dalla Bontà, et al. 2020, ApJ, 903:112 (28pp) (arXiv:2007.02963)  
*I provided feedback on the presentation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: How Broad Emission Line Widths Change When Luminosity Changes,” Wang, et al. 2020, ApJ, 903:51 (30pp) (arXiv:2006.06178)  
*I am a member of the SDSS-RM collaboration.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Mg II Lag Results from Four Years of Monitoring,” Homayouni et al. 2020, ApJ, 901:55 (14pp) (arXiv:2005.03663)  
*I provided feedback on the presentation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Photometric *g* and *i* Light Curves,” Kinemuchi, **Hall**, et al. 2020, AAS Journals, in press (arXiv:2007.05160)  
*I was the PI of the CFHT proposal which provided much of the data in this paper, was involved in the analysis, and was heavily involved in the writeup.*
- “Survey of Extremely-High-Velocity Outflows in Quasars,” Paola Rodríguez Hidalgo, Abdul Moiz Khatri, **Patrick B. Hall**, Sean Haas, Carla Quintero, Viraja Khatu, Griern Kowash, & Norm Murray 2020, ApJ, 896, 151 (arXiv:2006.05633)  
*I was heavily involved in all aspects of this research.*
- “An Extreme X-ray Variability Event of a Weak-Line Quasar,” Ni, Brandt, Yi, Luo, Timlin, **Hall**, Liu, Plotkin, Shemmer, Vito, & Wu 2020, ApJL, 889, L37 (arXiv:2001.08216)  
*I contributed to the interpretation of the results reported in this paper.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Initial C IV Lag Results from Four Years of Data,” Grier, Shen, Horne, Brandt, Trump, **Hall**, et al. 2019, ApJ, 887:1 (38pp) (arXiv:1904.03199)  
*I provided feedback and clarification on the presentation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Accretion and Broad Emission Line Physics from a Hypervariable Quasar,” Dexter, Xin, Shen, Grier, Liu, Gezari, McGreer, Brandt, **Hall**, Horne, Simm, Merloni, Green, Vivek, Trump, Homayouni, Peterson, Schneider, Kinemuchi, Pan, & Bizyaev 2019, ApJ, 885:44 (11pp) (arXiv:1906.10138)  
*I provided feedback and clarification on the interpretation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Comparison of Lag Measurement Methods with Simulated Observations,” Li, Shen, Brandt, Grier, **Hall**, Ho, Homayouni, Horne, Schneider, Trump, Starkey et al. 2019, ApJ, 884:119 (21pp) (arXiv:1909.03092)  
*I provided feedback on the presentation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Improving Lag Detection with an Extended Multi-Year Baseline,” Shen, Grier, Horne, Brandt, Trump, **Hall** et al. 2019, ApJL, 883, L14 (arXiv:1908.00027)  
*I provided feedback and clarification on the presentation and interpretation of results.*

- “Space Telescope and Optical Reverberation Mapping Project. VIII. Time Variability of Emission and Absorption in NGC 5548 Based on Modeling the Ultraviolet Spectrum,” Kriss et al. 2019, ApJ, 881, 153 (arXiv:1907.03874)  
*I provided feedback and clarification on the presentation of results.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Accretion-Disk Sizes From Continuum Lags,” Homayouni, Trump, Grier, Shen, Brandt, Starkey, **Hall**, Horne, Kinemuchi, Li, McGreer, Sun, Ho, & Schneider 2018, ApJ, 880, 126 (arXiv:1806.08360)  
*I contributed to the analysis, understanding, and presentation of these results.*
- “The Extremely Luminous Quasar Survey in the Pan-STARRS 1 Footprint (PS-ELQS),” Schindler, Fan, Huang, Yue, Yang, **Hall**, Wenzl, Hughes, Litke, & Rees 2019, ApJS, 243, 5 (arXiv:1905.04069)  
*I provided human-expert identification of BAL quasars and their redshifts.*
- \_\_\_\_\_
- “Variability Of Low-Ionization Broad Absorption Line Quasars Based On Multi-Epoch Spectra From The Sloan Digital Sky Survey,” Yi, Brandt, **Hall**, Vivek, Grier, Filiz Ak, Schneider, & McGraw 2019, ApJS, 242, 28 (arXiv:1905.01573)  
*I provided extensive feedback to modeling approaches and interpretation of results in this paper.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Sample Characterization,” Shen, **Hall**, Horne, Zhu, McGreer, Simm, Trump, Kinemuchi, Brandt, Green, Grier, Guo, Ho, Homayouni, Jiang, Li, Morganson, Petitjean, Richards, Schneider, Starkey, Wang, Chambers, Kaiser, Kudritzki, Magnier, & Waters 2019, ApJS, 241, 34 (1tp) (arXiv:1810.01447)  
*I am a founding member of this project and led the CFHT imaging observations for it.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Systematic Investigations of Short-Timescale CIV Broad Absorption Line Variability,” Hemler, Grier, Brandt, **Hall**, Horne, Shen, Trump, Schneider, Vivek, Bizyaev, Oravetz, Oravetz, & Pan 2019, ApJ, 872, 21 (21pp) (arXiv:1811.00010)  
*I contributed greatly to the analysis of these spectra and the interpretation of the observed variability.*
- “X-ray and multi-epoch optical/UV investigations of BAL to non-BAL quasar transformations,” Sameer, Brandt, Anderson, Filiz Ak, Grier, **Hall**, Vivek, Ahmed, Luo, Myers, Rodríguez Hidalgo, Ruan, & Schneider 2019, MNRAS, 482, 1121 (14pp) (arXiv:1810.03625)  
*I analysed optical spectra for this project and contributed to the interpretation of the results.*
- “Connecting the X-ray properties of weak-line and typical quasars: testing for a geometrically thick accretion disk,” Ni, Brandt, Luo, **Hall**, Shen, Anderson, Plotkin, Richards, Schneider, Shemmer & Wu 2018, MNRAS, 480, 5184 (19pp) (arXiv:1807.08757)  
*I analysed optical spectra for this project and contributed to the interpretation of the results.*
- “Redshifted broad absorption line quasars found via machine-learned spectral similarity,” Reis, Poznanski, & **Hall** 2018, MNRAS, 480, 3889 (9pp) (arXiv:1805.09829)  
*I provided human-expert identification of redshifted BAL quasars and interlopers to refine the accuracy of the machine learning algorithm used herein.*

- “The Sloan Digital Sky Survey Reverberation Mapping Project: Quasar Host Galaxies at  $z < 0.8$  from Image Decomposition,” Yue, Jiang, Shen, **Hall**, Yu, Schneider, Ho, Horne, Petitjean, & Trump 2018, ApJ, 863, 21 (17pp) (arXiv:1806.09083)  
*I was PI of the CFHT proposal which obtained the data used in this project.*
- “Emergence and Variability of Broad Absorption Line Quasar Outflows,” Rogerson, **Hall**, Ahmed, Rodríguez Hidalgo, Brandt, & Filiz Ak 2018, ApJ, 862, 1 (22p) (arXiv:1807.07594)  
*I guided and supervised this work, which was a part of Dr. Rogerson’s PhD thesis at York.*
- “The Sloan Digital Sky Survey Quasar Catalog: fourteenth data release,” Pâris et al. 2018 (40 authors), A&A, 613, A51 (17pp) (arXiv:1712.05029)  
*I contributed to the identification of some quasars in this publication.*
- “The Fourteenth Data Release Of The Sloan Digital Sky Survey: First Spectroscopic Data From The Extended Baryon Oscillation Spectroscopic Survey And From The Second Phase Of The Apache Point Observatory Galactic Evolution Experiment,” Abolfathi et al. 2018, ApJS, 235:42 (19pp) (arXiv:1707.09322)  
*I am an External Collaborator in the SDSS-IV collaboration.*
- “Spectroscopic characterization of galaxy clusters in RCS-1: spectroscopic confirmation, redshift accuracy, and dynamical mass-richness relation,” Gilbank et al. 2018, MNRAS, 476, 1991-2012  
*I contributed to obtaining the observations for this paper.*
- “Non-Blackbody Disks Can Help Explain Inferred AGN Accretion Disk Sizes,” **Hall**, Sarrouh & Horne 2018, ApJ, 854:93 (10pp) (arXiv:1705.05467)
- “The Time-Domain Spectroscopic Survey: Target Selection for Repeat Spectroscopy,” MacLeod et al. 2017, AJ, 155:6 (17pp) (arXiv:1706.04240)  
*I contributed heavily to the target selection for a subset of objects in this paper.*
- “The Sloan Digital Sky Survey reverberation mapping project: H-alpha and H-beta reverberation measurements from first-year spectroscopy and photometry,” Grier et al. 2017, ApJ, 851:21 (22pp) [Erratum: ApJ, 868, 76 (2018)] (arXiv:1711.03114)  
*I contributed to obtaining and verifying data used in this paper.*
- “Optical linear polarization measurements of quasars obtained with the 3.6 m telescope at the La Silla Observatory,” Hutsemékers, **Hall** & Sluse 2017, A&A, 606, A101 (4pp) (arXiv:1709.01309)  
*I contributed to gathering the data presented in this paper.*
- “Space Telescope and Optical Reverberation Mapping Project. VII. Understanding the UV anomaly in NGC 5548 with X-Ray Spectroscopy,” Mathur et al. 2017, ApJ, 846:55 (9pp) (arXiv:1704.06345)  
*I contributed to the discussion of the results of this paper.*
- “Broad absorption line disappearance and emergence using multiple-epoch spectroscopy from the Sloan Digital Sky Survey,” McGraw, Brandt, Grier, Filiz Ak, **Hall**, et al. 2017, MNRAS, 469, 3163-3184 (arXiv:1705.03019)  
*I contributed to the discussion of the results of this paper.*

- “X-ray Insights into the Nature of Quasars with Redshifted Broad Absorption Lines,” Zhang, Brandt, Ahmed, **Hall**, et al. 2017, ApJ, 839, 101 (arXiv:1703.08180)  
*I contributed to the interpretation and discussion of the results of this paper.*
- “Space Telescope and Optical Reverberation Mapping Project. V. Optical Spectroscopic Campaign and Emission-Line Analysis for NGC 5548,” Pei et al. 2017, ApJ, 837, 131 (arXiv:1702.01177)  
*I am a member of the AGN STORM project.*
- “Magnetohydrodynamic Disc Winds and Line Width Distributions II,” Chajet & **Hall** 2017, MNRAS, 465, 1741 (arXiv:1611.01067)  
*I guided and supervised this work, which was a part of Dr. Chajet’s PhD thesis at York.*
- “Space Telescope and Optical Reverberation Mapping Project. VI. Reverberating Disk Models for NGC 5548,” Starkey et al. 2017, ApJ, 836, 65 (arXiv:1611.06051)  
*I contributed some clarification and discussion to the text of the paper.*
- “The Sloan Digital Sky Survey Quasar Catalog: twelfth data release,” Pâris et al. 2017 (46 authors), A&A, 597, A79 (25pp) (arXiv:1608.06483)  
*I contributed to the identification of some quasars in this publication.*
- “C IV Broad Absorption Line Acceleration in Sloan Digital Sky Survey Quasars,” Grier, Brandt, **Hall**, Trump, Filiz Ak, Anderson, Green, Schneider, Sun, Vivek, Beatty, Brownstein & Roman-Lopes 2016, ApJ, 824, 130 (22pp) (arXiv:1604.07410)  
*I contributed derivations, text, analysis, and interpretation to this publication.*
- “Space Telescope and Optical Reverberation Mapping Project. IV. Anomalous Behavior of the Broad Ultraviolet Emission Lines in NGC 5548,” Goad et al. 2016, ApJ, 824, 11 (10pp) (arXiv:1603.08741)  
*I helped revise the proposal that yielded the Hubble Space Telescope data studied herein.*
- “Vanishing Absorption and Blueshifted Emission in FeLoBAL Quasars,” Rafiee, Pirkola, **Hall**, Galati, Rogerson, & Ameri 2016, MNRAS, 459, 2472-2485 (arXiv:1604.06977)  
*I contributed figures, text, analysis, and interpretation to this publication.*
- “Space Telescope and Optical Reverberation Mapping Project. III. Optical Continuum Emission and Broad-Band Time Delays in NGC 5548,” Fausnaugh et al. 2016, ApJ, 821, 56 (25pp) (arXiv:1510.05648)  
*I helped revise the proposal that yielded the Hubble Space Telescope data studied herein.*
- “Multi-Epoch Observations of Extremely High-Velocity Emergent Broad Absorption,” Rogerson, **Hall**, Rodríguez Hidalgo, Pirkola, Brandt & Filiz Ak 2016, MNRAS 457 (1): 405-420 (arXiv:1509.02842)  
*I contributed to the analysis and interpretation of the results in this publication.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: First Broad-Line  $H\beta$  and Mg II Lags at  $z \geq 0.3$  from Six-Month Spectroscopy,” Shen et al. 2016, ApJ, 818, 30 (17pp) (arXiv:1510.02802)  
*I contributed comments on the paper text and content.*

- “*Demonstrating Martian Gravity*,” Pirkola & Hall 2015, *Physics Education*, 50 (6), 643-645 (arXiv:1602.06858)  
*I guided Mr. Pirkola in the outline and development of this publication.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Ensemble Spectroscopic Variability of Quasar Broad Emission Lines,” Sun, Trump, Shen, Brandt, Dawson, Denney, Hall, Ho, Horne, Jiang, Richards, Schneider, Bizyaev, Kinemuchi, Oravetz, Pan, & Simmons 2015, *ApJ*, 811, 42 [19pp] (arXiv:1506.07886)  
*I contributed to the refinement of the analysis methods used in this paper.*
- “Space telescope and optical reverberation mapping project. II. Swift and HST Reverberation Mapping of the Accretion Disk of NGC 5548,” Edelson et al. (50 authors) 2015, *ApJ*, 806, 129 (14pp) (arXiv:1501.05951)  
*I contributed comments on the paper text and the interpretation of one of the key results.*
- “Space telescope and optical reverberation mapping project. I. ultraviolet observations of the seyfert 1 galaxy NGC 5548 with the cosmic origins spectrograph on hubble space telescope,” De Rosa et al. (50 authors) 2015, *ApJ*, 806, 128 (15pp) (arXiv:1501.05954)  
*I contributed comments on the paper text and content.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Rapid C IV Broad Absorption Line Variability,” Grier, Hall, Brandt, Trump, Shen, Vivek, Filiz Ak, Chen, Dawson, Denney, Green, Jiang, Kochanek, McGreer, Pâris, Peterson, Schneider, Tao, Wood-Vasey, Bizyaev, Ge, Kinemuchi, Oravetz, Pan, & Simmons 2015, *ApJ*, 806, 111 (15pp) (arXiv:1503.03076)  
*I contributed heavily to all aspects of this publication.*
- “Mining for Dust in Type 1 Quasars,” Krawczyk, Richards, Gallagher, Leighly, Hewett, Ross, & Hall 2015, *AJ*, 149, 203 (20pp) [Erratum: *AJ*, 151, 20 (2016)] (arXiv:1412.7039)  
*I contributed some minor comments to this publication.*
- “X-ray insights into the nature of PHL 1811 analogs and weak emission-line quasars: unification with a geometrically thick accretion disk?,” Luo, Brandt, Hall, Wu, Anderson, Garmire, Gibson, Plotkin, Richards, Schneider, Shemmer, & Shen 2015, *ApJ*, 805, 122 (25p) (arXiv:1503.02085)  
*I contributed heavily to the spectroscopic analysis in this paper and also contributed to the interpretation and discussion of results.*
- “Spectroscopic Needs for Imaging Dark Energy Experiments,” Newman et al. (62 additional authors listed alphabetically) 2015, *Astroparticle Physics* 63, 81-100 [Corrigendum: *Astroparticle Physics* 65, 112]  
*I read, commented on, and signed my name to the white paper which became this publication.*
- “The Sloan Digital Sky Survey Reverberation Mapping Project: Technical Overview,” Shen, Brandt, Dawson, Hall, McGreer, et al. (34 additional authors listed alphabetically) 2015, *ApJS*, 216:4 (25pp) (arXiv:1408.5970)  
*I wrote the Canada-France-Hawaii telescope photometry section of this paper, and contributed general comments elsewhere in the paper.*
- “The Dependence of C IV Broad Absorption Line Properties on Accompanying Si IV and Al III Absorption: Relating Quasar-Wind Ionization Levels, Kinematics, and Column Densities,” Filiz



Ak, Brandt, **Hall**, Schneider, Trump, Anderson, Hamann, Myers, Pâris, Petitjean, Ross, Shen, & York 2014, ApJ, 791, 88 (22pp)

*I contributed to the direction of the analysis and to the interpretation of the results.*

- **“Modeling spikes in quasar accretion disc temperature”**, **Hall**, Noordeh, Chajet, Weiss & Nixon 2014, MNRAS, 442, 1090-1109
- *“The Sloan Digital Sky Survey quasar catalog: tenth data release”*, Pâris, Petitjean, Aubourg, Ross, Myers, Streblyanska, Bailey, **Hall**, Strauss, et al. (41 additional authors listed alphabetically) 2014, A&A, 563, A54 (15pp)  
*I contributed to the identification of some quasars presented in this study.*
- *“Simulating the Phases of the Moon Shortly After Its Formation,”* Noordeh, **Hall** & Cuk 2014, The Physics Teacher, 52, 239-240  
*I guided and supervised this work by a summer student of mine.*
- *“The Naked-eye Optical Transient OT 120926”*, Zhao, **Hall**, Delaney & Sandal 2013, JAAVSO, 41, 338-347  
*I guided and supervised this work by a summer student of mine.*
- *“The X-ray Spectrum and Spectral Energy Distribution of FIRST J155633.8+351758: a LoBAL Quasar with a Probable Polar Outflow,”* Berrington, Brotherton, Gallagher, Ganguly, Shang, DiPompeo, Chatterjee, Lacy, Gregg, **Hall**, & Laurent-Muehleisen 2013, MNRAS, 436, 3321-3330  
*I contributed to the initial analysis in this study.*
- *“Broad Absorption Line Variability on Multi-Year Timescales in a Large Quasar Sample,”* Filiz Ak, Brandt, **Hall**, Schneider, Anderson, Hamann, Lundgren, Myers, Pâris, Petitjean, Ross, Shen, & York 2013, ApJ, 777, 168 (29pp)  
*I contributed heavily to the direction of the analysis and to the interpretation of the results.*
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