Gerrit Farren

Curriculum Vitae

I am a theoretical cosmologist starting my PhD at the University of Cambridge in October 2020. I graduated from Haverford College with a Bachelor of Science in Physics in May of 2020. I am mainly interested in using the Cosmic Microwave Background (CMB) to understand fundamental physics. In particular I am working on using the CMB together with the large scale structure in the universe to test axion dark matter. During my PhD I will mainly focus on using gravitational lensing of the CMB to learn more about neutrinos.

Previous Employment

May 2019 – August 2019 **Summer Research Student**, *Durham University*, United Kingdom.

I worked with Professors Carlos Frenk and Cedric Lacey on understanding galaxy formation in low mass dark-matter haloes at high redshift. We were aiming to explore the minimum halo mass required to successfully cool the baryonic gas in a halo and form a galaxy. We used both semi-analytic and numerical methods to understand the physics that govern the formation of these first galaxies in the universe.

September 2018 – May 2019 **Course Assistant**, *Haverford College*, PA, United States.

During the 2018/19 academic year I worked as a course assistant for two second year physics course: Waves and Oscillations and Introductory Quantum Mechanics. My role was to reinforce students' understanding of the material by reviewing concepts and techniques learned in lecture and applying these to relevant problems. In past semesters, I also assisted with an introductory programming course with focus on physics and astronomy topics and an introductory linear algebra course.

June 2018 – August 2018 **Summer Research Student**, *Imperial College London*, United Kingdom.

I worked with Professor of Astrophysics Andrew Jaffe on models of the kinetic Sunyaev-Zeldovich effect in connection with dark matter models involving ultra light scalar particles called axions (see below for details). In addition to pursuing an independent research project, I was able to expand my view of astrophysics and to participate in a larger academic environment. I am continuing this research and hope to write my senior thesis on this topic.

May 2017 – July 2017 **Research Assistant**, *Institute for Nuclear Physics - Research Center Jülich*, Germany.

Over the summer of 2017, I continued my work at the Institute for Nuclear Physics rejoining the group examining spin polarization preservation in hydrogen atoms during recombination. We conducted measurements to determine the dependence of depolarization effects on surface interactions, in which I assisted in gathering data. As a supplement to this, I worked on an experiment studying interaction cross sections for hydrogen molecules in caesium vapour.

January 2017 – present **Research Assitant**, *Haverford College*, PA, United States.

I have been working with Emeritus Professor of Physics and Astronomy Bruce Partridge on transferring the Planck satellite's absolute calibration to ground based observatories like ACT and ALMA (see below for details).

January 2016 – July 2016 **Research Assitant**, *Institute for Nuclear Physics - Research Center Jülich*, Germany.

After initially completing a six month internship, I was offered the opportunity to join the Institute for Nuclear Physics for another six months. I was introduced to the physics of particle accelerators and independently conducted a simulation-based study of the particle beam features at injection of the accelerator COSY. I was also involved in a project examining the nuclear spin polarization preservation in hydrogen atoms during recombination, which posed my first exposure to quantum mechanics. My contribution consisted of calculations predicting a temperature dependence in depolarization effects.

Education

2016–2020 **Haverford College, Haverford, PA United States**, *Physics Major, Mathematics Minor, Scientific Computing Concentration*, Graduated *Summa Cum Laude* with BSc Physics (May 2020).

Relevant Coursework:

- Physics: Introductory Mechanics and E&M (Fall 2016 and Spring 2017), Waves and Oscillations (Fall 2017), Introduction to Quantum Mechanics (Spring 2018), Computational Physics (Spring 2018), Discrete and Continuous Mechanics (Fall 2018), Advanced Quantum Mechanics, Particle Physics (Spring 2019), Statistical Mechanics, General Relativity (Fall 2019), Advanced E&M (Spring 2020)
- Mathematics: Multivariable Calculus (Fall 2016), Introduction to Statistics (Spring 2017), Linear Algebra (Fall 2017), Abstract Algebra, Differential Equations (Fall 2018), Real Analysis (Fall 2019), Differential Geometry (Spring 2020)
- Other: Introductory Computer Science (Fall 2016)

2007–2015 **Hugo-Junkers-Gymnasium, Mönchengladbach**, Adavanced Courses (Leistungskurse): *Physics & Mathematics*, Basic Courses (Grundkurse): *Computer Science, English, etc.*, Graduated (Abitur): 12 June 2015.

Notable Projects

- **Astronomy Research:** *Transfer of the Planck satellite's absolute calibration to ALMA*

  In this project, we are attempting to transfer the absolute calibration of the Planck satellite to the Atacama Large Millimetre/submillimetre Array by using observations of compact radio sources. Since ALMA and Planck were not observing at the same time, we use observations made by the Atacama Cosmology Telescope as an intermediate "bridge". We are matching point source fluxes measured by the different observatories to determine agreement between calibration scales. I am tasked with developing and constantly improving the matching and analysis algorithm. The experience was helpful in learning how to computationally handle large data sets and drawing statistical conclusions. In connection with this work, I traveled to Chile in May 2018, where I collaborated with scientist at the ALMA headquarters in Santiago and visited the ALMA site in the Atacama desert. In addition, I worked at the ACT telescope and assisted among other things in taking beam profile measurements.

- **Cosmology Research:** *Constraining ultra light axion dark matter models using the kinetic Sunyaev-Zeldovich effect*

  Models proposing ultra light scalar particles as dark matter candidates have recently gathered increased attention. Working at Imperial College in London, I extended the formalism for the calculation of the power spectrum of secondary anisotropies induced by the Ostriker-Vishniac effect to models with peculiar growth features as they arise in the context of such theories. We are currently exploring the effect on non-linear scales using mean pairwise velocity spectra. Based on the numerical results of those calculations, we are working on forecasting the power of upcoming observations to constrain the axion mass and abundance. I presented this work at the January 2019 AAS meeting in Seattle.

Technical and Personal skills

- **Programming Languages:** Python, C, C++, C#
  Also basic ability in MatLab and Fortran.

- **Languages:** German (native language), English (fluent written and spoken, conversational, and scientific/technical)

Awards and Recognitions

2020 **American Physical Society LeRoy Apker Award finalist**, *Haverford College*.

2019 **Royal Astronomical Society Undergraduate Research Bursary**, *Durham University*.

2019 ***Phi Beta Kappa***, *Haverford College*, Inducted junior year.

2016 - 2019 **Recipent *Class of 1950 International Student Scholarship Fund***, *Haverford College*.

2016 - 2017 **Recipent *The Robert Maquinay 1948 Scholarship Fund* and *C.V. Star Scholarship***, *Haverford College*.

Publications

Rahul Datta, Simone Aiola, Steve K Choi, Mark Devlin, Joanna Dunkley, Rolando Dünner, Patricio A Gallardo, Megan Gralla, Mark Halpern, Matthew Hasselfield, Matt Hilton, Adam D Hincks, Shuay-Pwu P Ho, Johannes Hubmayr, Kevin M Huffenberger, John P Hughes, Arthur Kosowsky, Carlos H López-Caraballo, Thibaut Louis, Marius Lungu, Tobias Marriage, Loïc Maurin, Jeff McMahon, Kavilan Moodley, Sigurd K Naess, Federico Nati, Michael D Niemack, Lyman A Page, Bruce Partridge, Heather Prince, Suzanne T Staggs, Eric R Switzer, Edward J Wollack, and Gerrit Farren. The Atacama Cosmology Telescope: two-season ACTPol extragalactic point sources and their polarization properties. *Monthly Notices of the Royal Astronomical Society*, 486(4):5239–5262, 11 2018.

R. Engels, G. Farren, K. Grigoryev, M. Mikirtychiants, F. Rathmann, H. Seyfarth, H. Ströher, L. Kochenda, P. Kravtsov, V. Trofimov, et al. Hyper-polarized deuterium molecules: An option to produce and store polarized fuel for nuclear fusion? In *Nuclear Fusion with Polarized Fuel*, pages 45–54. Springer, 2016.

G. S. Farren, D. Grin, and A. H. Jaffe. Calculation of the Ostriker-Vishniac Effect for Cosmological Models with Ulta-light Axions. In *American Astronomical Society Meeting Abstracts #233*.