John **Gargalionis**

PhD Student · Particle Phenomenology

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Education

University of Melbourne

Melbourne, Australia

Doctor of Philosophy (Theoretical Particle Physics) — *2016 — 2019*

- *Prospective thesis title:* Studies in particle and collider phenomenology
- *Primary supervisor:* Prof. Raymond Volkas
- *Research topics:* Models of lepton-flavour non-universality to explain the anomalies in $R_{K^{(*)}}$ and $R_{D^{(*)}}$, GUT model building, radiative neutrino mass, effective field theories for model building, machine learning and data analysis in high-energy physics
- *Main outcomes:*
  - Developed an algorithm to find the UV-completions of effective operators, used to enumerate all possible, minimal radiative models of Majorana neutrino mass. The algorithm and computational framework can be extended to other EFTs
  - Developed phenomenological models to explain the recent anomalies in charged- and neutral-current B decays. An emphasis of our work is the natural connection these models have with radiative neutrino mass models
  - Applied unsupervised machine-learning techniques to quark/gluon identification with the CMS Open Data. To undertake our analysis we built a new data-analysis pipeline for working with the open data
- *Expected graduation:* Late 2019

Master of Science (with Distinction) — *2014 — 2016*

- *Thesis title:* Neutrino mass through leptoquarks: a new radiative model and its experimental prospects
- *Supervisors:* Prof. Raymond Volkas and Prof. Elisabetta Barberio
- *Coursework:* General Relativity, Non-equilibrium Statistical Mechanics, Particle Physics, Quantum Field Theory, Quantum Mechanics, Science Communication, String Theory
- *Research outcomes:*
  - Research project split between experiment and theory
  - Developed a new model of radiative neutrino mass involving two scalar leptoquarks. Explored the 13 TeV reach of this model at the LHC.
- *Average mark:* 87%

Bachelor of Science — *2010 — 2014*

- *Specialisations:* Physics, Neuroscience, Ancient Languages
- *Average mark:* 80%

Publications

Research publications

Training on data: quark/gluon discrimination with the CMS Open Data — *2019*

Noel Dawe, Matthew J. Dolan & John Gargalionis — *Manuscript in preparation*

`arXiv:19xx.xxxxx`

- Unsupervised learning techniques used to train directly on real data provided by CMS
- Built a computational framework for processing and analysing the data

Exploding operators for Majorana neutrino masses — *2019*

John Gargalionis & Raymond R. Volkas — *Manuscript in preparation*

`arXiv:19xx.xxxxx`

- Wrote an algorithm to automate the procedure of generating models of Majorana neutrino mass from $\Delta L = 2$ effective operators
- Wrote smaller modules implementing methods from tensor calculus and group theory in Python
- Technique can be expanded to other EFTs

A scalar model of neutrino mass derived from a dimension-11 effective operator — *2019*

John Gargalionis, Iulia Popa-Mateiu & Raymond R. Volkas — *Manuscript in preparation*

`arXiv:19xx.xxxxx`

- Explores the phenomenology of the first model derived from a dimension-11 operator, found using the algorithm and code I wrote for 'Exploding operators for Majorana neutrino masses'

A near-minimal leptoquark model for reconciling flavour anomalies and generating radiative neutrino mass — *2019*

Innes Bigaran, John Gargalionis & Raymond R. Volkas — *Submitted to JHEP*

`arXiv:1906.01870`

- Addresses the shortcomings of the model developed in our paper arXiv:1704.05849 by adding another scalar leptoquark

Reconsidering the One Leptoquark solution: flavour anomalies and neutrino mass — *2017*

Yi Cai, John Gargalionis, Michael A. Schmidt & Raymond R. Volkas — *JHEP*

`arXiv:1704.05849, https://doi.org/10.1007/JHEP10(2017)047`

- Explored the extent to which a popular one-leptoquark model could explain the recent B-meson anomalies
- Results showed varied ability of the model to explain the discrepancies in different regions of its parameter space
- We highlighted a previously overlooked contribution of this model to the charged-current anomaly that has come to be favoured in light of recent measurements

Explaining the 750 GeV diphoton excess with a coloured scalar charged under a new confining gauge interaction — *2016*

Robert Foot & John Gargalionis — *PRD*

`arXiv:1604.06180, https://doi.org/10.1103/PhysRevD.94.011703`

- Built a simple model to explain the 2015/2016 750 GeV diphoton excess
- The model involved a new, confining $\mathrm{SU}(N)$ bound state of scalars decaying to two photons

Other publications

Solutions to Problems at Les Houches Summer School on EFT — *2019*

Marcel Balsiger, Marios Bounakis, Medhi Drissi, John Gargalionis, Erik Gustafson, Greg Jackson, Matthew Leak, Christopher Lepenik, Scott Melville, Daniel Moreno, Michele Tommaro, Selim Touati & Timothy Trott — *Chapter in preparation*

`arXiv:19xx.xxxxx`

- Worked solutions to high-level problem sets given throughout the Les Houches 2017 Summer School on Effective Field Theories, solved and written voluntarily by subset of students
- Will be published as a chapter in the book 'Lecture Notes of the Les Houches School on Effective Field Theories' by the Oxford University Press
- Will be uploaded to the arXiv

General Skills

Programming

Python, Mathematica (Wolfram Language), C/C++, Clojure(Script), Scheme (and Racket), Haskell, Elm

- Familiar with the use of scripting languages like Python and Racket for large-scale (thousands of lines) package development
- Practised in test-driven software development
- Have taught scientific computation in both C/C++ (to undergraduates) and Python (to graduate students)
- Confident in the use of the SciPy suite (SciPy, NumPy, SymPy, Jupyter, etc.) for high-performance and scientific computation
- Experience with common algorithms, data structures and computational methods
- Limited experience in web-application development with ClojureScript and Elm
- Hobbyist interest in functional and logic programming

Data analysis

ROOT, SciPy, Pandas, Dask, h5py, SQLite

- Extensive experience with R-style data-frame objects in Pandas and Mathematica for data analysis and analytics
- ROOT objects and their Pythonic interface through rootpy
- Use of scalable data structures from Dask and h5py
- SQL database management including cross-table references and complex queries

Machine learning

TensorFlow, Keras, (Un)supervised learning, Image classification

- Experience with Keras' functional API for defining complex machine-learning models with TensorFlow backend
- Have used unsupervised and supervised learning techniques in image classification problems
- Understanding of common machine-learning architectures including feed-forward, convolutional and max-out

Communication

Public speaking, scientific writing, science communication

- Confident public speaker (see invited and contributed talks, scientific outreach and teaching)
- Published year-12 study guide for writing English essays 'How to write that A+ English Language essay' (2010)

Visualisation
Matplotlib, Seaborn, pgf-plots, TikZ, gnu-plot, quil
- Confident with many scientific plotting libraries
- Vector graphics and visual arts in TikZ and quil

Management
Git, Cluster computing, GNU Make, FTP, Unix command line
- Confident with git for version control
- Proficient in common Unix tools and bash for shell scripting
- Working knowledge of make for writing Makefiles

Markup
TEX, HTML, Markdown, org
- Typesetting of academic texts with mathematical content in LATEX
- Preparation of high-quality slides with beamer and reveal.js
- Translation between various markup languages with pandoc

Academic Skills

Model building and model exploration
Radiative neutrino mass, group theory, flavour phenomenology, GUTs
- Constructing and analysing extensions of the Standard Model, experience mostly in models of radiative neutrino mass
- Expertise in the group theory of $\mathrm{SU}(N)$ and $\mathrm{SO}(N)$ in the context of GUT model building
- Knowledgable about new-physics explanations of the B-meson anomalies and their connection to other topics in flavour
- Confident in analysing the viability of BSM models, especially in the context of flavour and collider constraints

Effective Field Theory
SMEFT, WET, $\Delta L = 2$ EFT
- Worked extensively with the Standard Model EFT at mass-dimension 6 and higher
- On top of current developments in operator-basis generation (i.e. Hilbert series and computational techniques)

Collider phenomenology
ROOT, CMSSW, MadGraph, Pythia, Fastjet, Delphes
- Confident in the generation of Monte-Carlo data starting from a Lagrangian
- Experience with the CMS analysis framework through the use of their publicly available data
- Well acquainted with concepts in experimental analysis, experience with a range of physics objects and signatures

Calculation and fitting
LieArt, Package-X, FeynRules, FeynArts, FormCalc, LoopTools, Flavio
- Calculating loop-level amplitudes by hand and with Mathematica packages (both analytically and numerically)
- Confident with the use of Flavio for flavour calculations and fits

Invited Seminars

Oct 2018	**Belle II Theory Interface Platform,** Leptoquarks and flavour	*KEK, Japan*
May 2018	**Monash University,** Radiative neutrino mass and the flavour anomalies: a circumstantial case	*Melbourne, Australia*
May 2017	**Instant workshop on B-meson anomalies,** Reconsidering the 'one leptoquark' solution: flavour anomalies and neutrino mass, https://cds.cern.ch/record/2265323	*CERN, Switzerland*

Contributed Seminars

Sep 2017	**Geoff Opat Seminar Series,** Radiative neutrino mass and the flavour anomalies: a circumstantial case	*Melbourne, Australia*
Aug 2017	**Technische Universität Dortmund,** Radiative neutrino mass and the flavour anomalies: a circumstantial case	*Dortmund, Germany*
Aug 2017	**Technische Universität München,** Radiative neutrino mass and the flavour anomalies: a circumstantial case	*Garching, Germany*
Dec 2016	**APPC-AIP Congress,** Reconsidering the 'one leptoquark' solution: flavour anomalies and neutrino mass	*Brisbane, Australia*
Jun 2016	**University of Melbourne,** Light leptoquarks at the LHC: neutrino mass and flavour physics	*Melbourne, Australia*
Nov 2015	**MSc completion seminar,** Radiative neutrino mass through leptoquarks	*Melbourne, Australia*

Training

Summer schools

Aug 2017	**Joint Challenges for Cosmology and Colliders**, MITP	*Mainz, Germany*
Jul 2017	**EFT in Particle Physics and Cosmology**, Ecole de Physique des Houches	*Les Houches, France*
Jul 2016	**Pre-SUSY School**, University of Melbourne	*Melbourne, Australia*

Summer research projects

Dark matter and heavy-flavoured quarks *Melbourne, Australia*

ATLAS EXOTICS GROUP *Jan 2016*

- *Supervisor:* Dr. Francesca UNGARO
- *Main outcomes:*
  - Suggested a more stringent criterion for the identification of b-quark jets in the analysis
  - Explored the potential of various kinematic variables to improve the reach of the search

Honours & Awards

2018	**Science Abroad Travel Scholarship**, University of Melbourne	*Melbourne, Australia*
2017	**Research poster award**, CoEPP	*Adelaide, Australia*
2016 – 2019	**Australian Postgraduate Award (APA)**, Australian Research Council	*Melbourne, Australia*
2015	**Prof. Kernot Research Scholarship in Physics**, University of Melbourne	*Melbourne, Austria*
2014	**N. D. Goldsworthy Scholarship**, University of Melbourne	*Melbourne, Austria*

Teaching

2018	**Tutor**, 1st year Physics	*University of Melbourne*
2018, 2019	**Grader**, 3rd year Quantum Mechanics	*University of Melbourne*
2018	**Tutor**, Advanced Scientific Programming in Python (Asia–Pacific)	*Melbourne Bioinformatics*
2016 – 2019	**Teaching assistant and course content creator**, 3rd year Subatomic Physics	*University of Melbourne*
2014 – 2016	**Curriculum designer and language teacher**, Modern and Ancient Greek	*Centre for Adult Education*
2014 – 2018	**Laboratory demonstrator**, 1st year Physics Lab, 3rd year Particle Lab, 2nd year Computational Physics	*University of Melbourne*
2010 – 2019	**Private Tutor**, Physics, Mathematics, Greek	

Scientific Outreach

2018, 2019	**CoEPP Work Experience Program**, Introductory talk: The Standard Model	*University of Melbourne*
2017	**Physics Workshops**, Project coordinator	*Hume Central Secondary*
2016	**Undergraduate Seminar Series**, Research talk targeted at undergraduate physics students	*University of Melbourne*
2015, 2016	**International Masterclass in Particle Physics**	*South Oakleigh Grammar*
2015	**CoEPP Work Experience Program**, Organising committee	*University of Melbourne*
2015	**International Masterclass in Particle Physics**	*University of Melbourne*

Other

Citizenship Australian (in the process of also acquiring Greek citizenship)
Birth year 1991
Languages English (native), Greek (fluent)