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Friday, 25th January, 2013

Centro de Física Teórica de Partículas
Instituto Superior Técnico
Av. Rovisco Pais, P-1049-001 Lisboa, Portugal

Dear Profs Branco and Rebelo,

Re: Postdoc in Flavour Physics, LHC Physics and/or Neutrino Physics

I hereby submit for your consideration my application for postdoctoral appointment to the Centro de Física Teórica de Partículas of Instituto Superior Técnico, Lisboa.

As I have highlighted below, my strong background in many-body non-equilibrium quantum field theory and its relevance to flavour dynamics and neutrino physics make me an excellent candidate for the position. Having recently had the opportunity to attend the Discrete 2012 conference at the IST, I am incredibly keen to join a group whose interests marry so well with my own.

I am currently a research associate in the Astro-Particle Theory and Cosmology Group at the University of Sheffield, UK, working with Profs Carsten van de Bruck and Elizabeth Winstanley in aspects of inflationary cosmology, extra-dimensional models and statistical mechanics in non-inertial space-time backgrounds.

During my PhD at the University of Manchester, UK, I worked with Prof Apostolos Pilaftsis to develop a new perturbative approach to non-equilibrium thermal quantum field theory. This substantial work (arXiv: 1211.3152) is anticipated by many to become a classic reference on the subject. This new formulation is capable of describing both time-dependent and spatially-inhomogeneous backgrounds and provides solutions to a number of long-standing problems in the field. In particular, our approach is free of the mathematical pathologies thought to spoil such perturbative treatments. We provide an alternative framework in which to derive non-perturbative master time evolution equations for observables in ultra-relativistic many-body systems. Existing approaches rely on a method of quasi-particle approximation and gradient expansion, where one assumes slow evolution and expands to leading order in time derivatives in order to obtain tractable expressions. On the other hand, our perturbative framework is built from non-homogeneous Feynman rules, which explicitly break space-time translational invariance from tree-level. As a result, we are able to truncate these evolution equations in a loop-wise sense, keeping all orders in the time behaviour without assuming any separation of time-scales. The result is the systematic treatment of transient early-time dynamics. This prompt behaviour is dominated by energy-violating non-Markovian processes due to the uncertainty principle, since, for systems out of equilibrium, we necessarily make measurements of observables over finite intervals of time.

The foreseeable applications of this formalism are numerous and inter-disciplinary, ranging from the description of the evolution of the early Universe to the deconfined phase of QCD, the quark-gluon plasma, whose existence has been inferred from observations of jet quenching in heavy-ion collisions by the ALICE, ATLAS and CMS experiments at the LHC, CERN. This new approach is of particular relevance to systems in which processes occur over some characteristic time-scale, for instance, the finite formation time of QCD plasmas at experiments like the LHC and RHIC. Another example is the nucleation of the first-order electroweak phase transition in which the ratio of the bubble wall velocity and width set such a characteristic time-scale for processes taking place in the vicinity of the wall. Moreover, with the treatment of finite-time effects and the incorporation of time-dependent statistical effects from tree-level, this approach lends itself to a first-principles field-theoretic description of mixing phenomena and decoherence. This is especially interesting for flavour dynamics and time-dependent measurements of CP violation in the flavour sector, for instance those performed recently by the LHCb collaboration. Furthermore, this approach permits the derivation of improved flavoured transport equations, relevant to leptogenesis and the generation of the Baryon Asymmetry of the Universe or the formation of Dark Matter relic densities.

Aside from these research interests, I have maintained an enthusiasm for teaching and outreach throughout my career. I have worked with students of all ages to enrich science curricula and have appeared on discussions for BBC and local radio stations in the UK. Moreover, along with Prof Jeff Forshaw of the University of Manchester, I am collaborating with TED and the publisher, Wiley-Blackwell to produce teaching materials for a series of freely-available talks on aspects of theoretical physics that stretch from exceptional simple Lie groups to string theory.

I thank you for your time and any attention given to this application.

Yours sincerely,

Peter Millington

Publication List

Peter William Millington

Friday, 25th January, 2013

Perturbative Non-Equilibrium Thermal Field Theory
Peter Millington and Apostolos Pilaftsis
arXiv: 1211.3152

Dr Peter William Millington AMInstP

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Current Affiliation

Jun 2012– Jun 2013 *Astro-Particle Theory and Cosmology Group, University of Sheffield*
(Lancaster-Manchester-Sheffield Consortium for Fundamental Physics)
Research Associate

Education and Prizes

2008–2012 *University of Manchester* (November 2012)
PhD in Theoretical Particle Physics (STFC studentship)
Title Thermal Quantum Field Theory and Perturbative Non-Equilibrium Dynamics
Supervisor Prof Apostolos Pilaftsis
Working to develop a new perturbative approach to thermal quantum field theory, which systematically accounts for the time-dependence and spatial inhomogeneity of out-of-equilibrium macroscopic backgrounds at finite temperature and density.

Second Year Postgraduate Research Poster Prize Winner 2010

2004–2008 *University of Manchester*
Master in Physics, First Class with Honours 2008
Title Looking for Extra Dimensions
Supervisor Prof Apostolos Pilaftsis
Studying the phenomenology of Kaluza-Klein excitations in extra-dimensional quantum field theories with particular emphasis on the ADD and Randall-Sundrum models.

Platt Prize for Physics 2008 (for theoretical work)
Student Team Working Award (Second Place) 2008
(for the project: *Risk and Security in Personal Electronic Transactions*)
Moseley Prize for Physics 2006 (for academic performance)
Delta Travel Prize 2006 (for essay-writing)
Herbert Lloyd Tate Scholarship 2004 (for academic performance at A-level)

2003–2004 *University of Newcastle Upon Tyne*
Stage I Undergraduate MBBS Medicine

1996–2003 *William Brookes School and Sixth Form, Much Wenlock, Shropshire TF13 6NB*
A-level Chemistry (A), Mathematics (A), Physics (A)
AS-level General Studies (B), Music (A)
ASDAN (Award Scheme Development and Accreditation Network) (2002) in recognition of commitment to extra-curricular activities
GCSE 7A*, 3A including English and Mathematics

Other Qualifications

Oct 2009 **i-to-i 40 Hour Intensive Online** TEFL/ TESOL **Course**
(Teaching English as a Foreign Language/ as a Second or Other Language)
Oct 2009 **i-to-i 20 Hour Grammar Awareness Course**
Sep 2007 **i-to-i 20 Hour Intensive** TEFL/ TESOL **Course**

Other Research Experience

Sep 2012– IPPP, *University of Durham*
YETI 2013: Young Experimentalists and Theorists Institute
Member of the organizing committee for the 2013 annual YETI meeting on the Higgs boson.

6 Dec 2012 IST, *Lisbon*
Discrete 2012:
the third symposium on prospects in the physics of discrete symmetries
Parallel session talk on *Thermal field theory to all orders in gradient expansion*.

21 Nov 2012 *King's College London*
Conference: Non-Perturbative Aspects in Field Theory
Talk on *Thermal field theory to all orders in gradient expansion*.

11 Oct 2012 IPPP, *University of Durham*
Seminar on *Perturbative non-equilibrium thermal field theory*.

Sep 2012 *University of Sheffield*
Delivering a series of three seminars on *Thermal quantum field theory*.

Oct 2011 **Proof-reading and indexing** of *The Quantum Universe* by Brian Cox and Jeff Forshaw for Allen Lane, Penguin Books.

Sep 2010 RWTH *Aachen*
Workshop: Out-of-Equilibrium Quantum Fields in the Early Universe

Sep 2009 *University of Liverpool*
BUSSTEPP **British Universities' Summer School on Theoretical Elementary Particle Physics**

Jun 2009 *University of Manchester*
Seminar on *Quantum loop effects in the imaginary- and real- time formalisms of thermal field theory*.

2008 **Proof-reading** of *Introduction to Astronomy and Cosmology* by Ian Morison.

Jun – Aug 2006 *Pulsar Group, Jodrell Bank Observatory, University of Manchester*
Title Analysing Pulse Profiles in Pulsars Exhibiting Timing Noise
Supervisors Prof Andrew Lyne and Prof Michael Kramer

Teaching and Outreach

6 Nov 2012– *Collaboration with TED and Wiley-Blackwell*
Co-authoring teaching resources to accompany a series of online talks on modern theoretical physics.

5 Jul 2012 *Radio Appearance, XFM Manchester*
Discussion of the Higgs-like particle discovery at CERN.

4 Jul 2012 *Radio Appearance, BBC Radio Wales*
Invited to appear on a phone-in programme to answer the public's questions on the Higgs boson.

29 Mar 2012 *Physics Masterclass, University of Manchester*
Delivering a talk to 300 A-Level students on particle physics.

25–27 Mar 2012 *One Day Schools, University of Manchester*
Delivering three talks to 300 A-Level students at a time on particle physics.

2009– *University of Sheffield*
Facilitating undergraduate workshops in mathematics.

2009– STEM*net, Museum of Science and Industry, Manchester*
STEM **Ambassador**
Working with schools to enrich curricular programmes. Involvement has included astronomy, electricity and science-fiction projects as well as talks.

2008–2012 *University of Manchester*
Teaching Assistant: First Year Tutor
Facilitating undergraduate tutorials for 3 groups of 4 to 5 students in mathematics, mechanics, electromagnetism, astronomy, astrophysics and cosmology; marking mid-semester exams and completing progress reviews.

2008–2011 *Concord College Summer Course, Shropshire SY5 7PF*
Assistant Course Director
Responsible for the day-to-day running of an annual 3-week international summer school in English, mathematics and science for around 280 students aged 8–18. The role included pastoral care, health and safety, staff management, discipline and behaviour management as well as the organisation of excursions and the extra-curricular recreation programme.

Jun – Aug 2007 *Concord College Summer Course, Shropshire SY5 7PF*
Summer Course Tutor
Working at two consecutive international summer schools, teaching chemistry, mathematics and physics to students aged 11–17 and acting as houseparent to 2 groups of male students, aged 8–11 and 12–17. Further responsibilities included supervising excursions and organising extra-curricular activities as part of the recreation programme.

2003–2004 *MedSEX, University of Newcastle Upon Tyne*
Student Facilitator
Teaching sex education in secondary schools in Tyneside, working in small groups with the students and using activity-based teaching.

Administrative Roles and Positions of Responsibility

2008–2012 *School of Physics and Astronomy, University of Manchester*
Admissions Assistant
Giving a weekly presentation to parents and guardians of prospective undergraduates as part of the School of Physics and Astronomy's UCAS Visit Days. Other roles have included leading tours of the University and being on hand to meet and greet the visitors on their arrival.

2009 *Faculty of Engineering and Physical Sciences, University of Manchester*
New Academics Programme Seminar Speaker
Invited to give a seminar on student support to new academics.

2007–2008 CAOS*: the Choir and Orchestra Society, University of Manchester*
Chair
With overall responsibility to ensure the running of the choir and orchestra.

2006–2008 *School of Physics and Astronomy, University of Manchester*
Chair of Student Representatives and Student Representative (2004–2008)
Involved in organising the student representation structure within the School of Physics and Astronomy. This included personal involvement in discussions of teaching and programme development across School, Faculty and University level as well as involvement in the production of pastoral documentation for the undergraduate programme in the School of Physics and Astronomy.

2005–2007 *School of Physics and Astronomy and Students as Partners, University of Manchester*
Student Mentor Coordinator (2005–2006) **and Student Mentor**
Assigned to a group of 4 first year students to help them with the transition to University and to oversee a group project, helping in particular with group dynamics. Roles as Mentor Coordinator involved organising the mentoring programme within the School of Physics and Astronomy and general administration.

2005–2009 *Harmony Gospel Choir, University of Manchester*
Musical Director
Responsible for: selecting, transcribing and arranging music for the choir and band; rehearsing parts with the choir and band; auditioning soloists and conducting the choir in all performances.

2005 *Manchester Branch IoP and Nexus*
Student Representative
With a key role in organising the Manchester Institute of Physics Nexus Einstein Year Ball, one of three events held in the UK.

2004–2006 *PhysSOC: The Physics Society, University of Manchester*
President

2004–2005 *JCR, Dalton-Ellis Hall, University of Manchester*
Social Secretary

Other Experience and Achievements

Jul 2005–Sep 2005 / Dec 2005–Jan 2006 — *Windsor Life Assurance, Telford, Shropshire*
Purchase Ledger Clerk
Working in Management Accounts with responsibilities including the processing of purchase orders, invoices, transfers and payments.

Jun–Jul 2005 — *The Old Orleton Inn, Wellington, Shropshire*
Bar Staff

Jun 2004–Sep 2004 / Jul 2003–Sep 2003 — *The Horseshoe Inn, Uckington, Shropshire*
Bar and Restaurant Staff

Feb–May 2004 — *Fenwick Ltd., Newcastle Upon Tyne*
Catering Assistant

Sep 2001–Jun 2003 — *Partners the Stationer Ltd., Shrewsbury, Shropshire*
Senior Sales Assistant
Responsibilities included customer service, cash administration, supervising staff and running the store on Sundays and Bank Holidays.

2002 — *Engineering Education Scheme, Royal Academy of Engineering*
Working with industry on a group engineering project to design and build a prototype solution to a real industrial problem.

Aug 2002 — *Severndale School, Shrewsbury, Shropshire (1 week)*
Classroom Assistant
Volunteer at a school for children with severe learning difficulties.

Nov 2002 — *Medical Engineering Services, Royal Shrewsbury Hospital NHS Trust (1 week)*

Jul 2001 — *Christ Church C.E. Primary School, Cressage, Shropshire (2 weeks)*
Classroom Assistant

Sep 2001 — *Client Support, Electronic Date Systems Ltd., Telford, Shropshire (2 weeks)*

Other Interests

Throughout school, college and university, I have remained a keen musician. I am a singer and guitarist and dabble in a number of other instruments including the ukelele, banjo, piano and bodhrán. Whilst at the University of Manchester, I sang as a tenor and soloist with the Manchester University Chorus, Manchester Harmony Gospel Choir, the Burlington Singers and CAOS: the Choir and Orchestra Society. In 2009, I composed a choral setting of Psalm 61, which was subsequently performed by the Choir and Orchestra Society.

Referees

Prof Carsten van de Bruck
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