Institute for Particle Physics Phenomenology

NEWSLETTER

September 2020

Welcome to the IPPP

Welcome to the first instalment of IPPP's bi-annual newsletter! We will use these newsletters as a forum to share our past and planned activities with the UK HEP community.

The past six months have been challenging for everybody, including the IPPP. Our usual workshops, conferences and visitors programs have stalled and are yet to resume. Without the possibility to have in-person meetings, just like all other groups in the UK, we had to resort to remote seminars and workshops.

However, challenges can become opportunities. Acknowledging the accelerated importance of online meetings and virtual conferences to shield from the pandemic and to limit the environmental impact of travel, which was echoed in the report of the European Strategy Group for Particle Physic, over the summer the IPPP implemented a few initiatives to strengthen its online presence and its digital engagement with the UK-HEP community.

In May we organised the first 'Remote Conference on New Concepts in Particle Theory', short RECONNECT. We thank the speakers

and more than 3000 participants for contributing to this online event.

Since March, more and more UK groups have made their seminar series accessible through an online platform. The IPPP now provides a website where we collate UK-based seminars, conferences and job announcements: https://www.ippp.dur.ac.uk/uk-hep-community

To introduce the IPPP to a wider audience, we have produced a 'showreel'. Please watch our animated video on our new youtube-channel: https://www.youtube.com/watch?v=v7Px_T1tetc

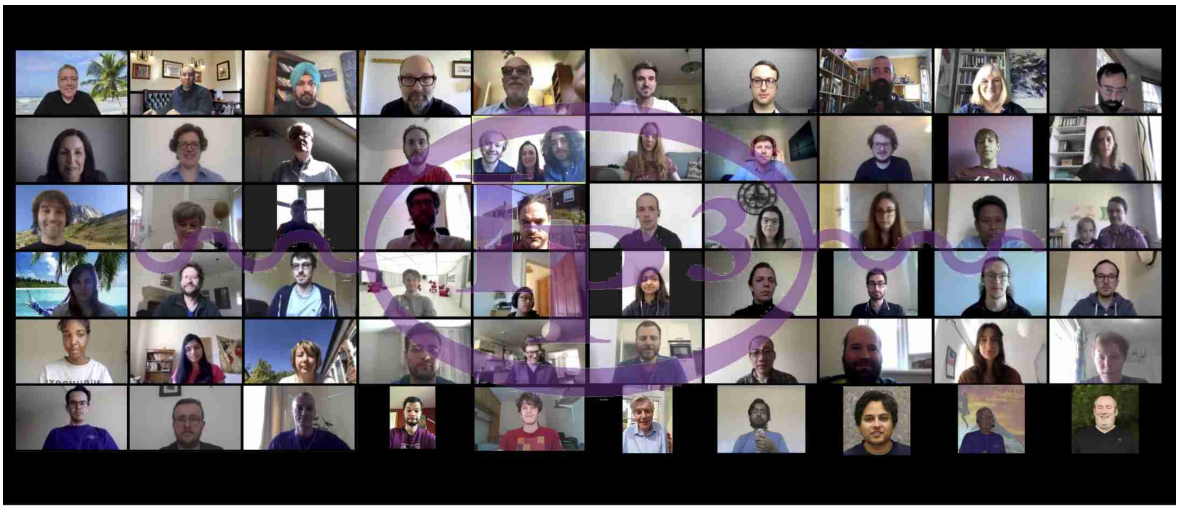
Just before the lockdown in April, we were fortunate to be able to welcome three new academic staff members: Francesca Chadha-Day, Djuna Croon and Jessica Turner.

Contents

Over the last six months, members of our group have ventured into novel and timely research areas, either in response to the pandemic or to broaden the research scope of the IPPP.

We hope you will enjoy reading this newsletter and we wish you a good start into the new academic year!

Michael Spannowsky
Director IPPP



New Academic Staff Members

The IPPP is very happy to announce the addition of Francesca Chadha-Day, Djuna Croon (from Sept. 2021), Stephen Jones and Jessica Turner to their academic staff.

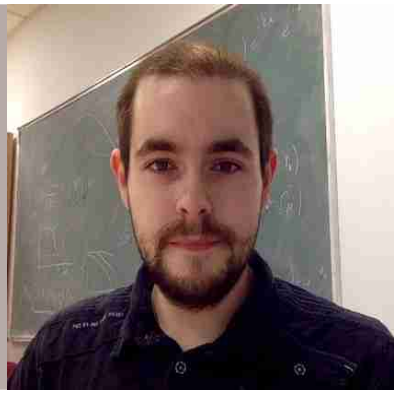
Francesca Chadha-Day

Fran works on axion phenomenology and particle astrophysics, with a particular focus on X-ray astronomy and superradiance. Before coming to Durham, she completed her PhD at Oxford, supervised by Joe Conlon, and was a research fellow at Peterhouse, Cambridge. Fran is also a science comedian and has taken her solo show, Physics Fan Fiction, to festivals around the UK. Fran will join Durham with a Stephen Hawking Fellowship and hopes to further her outreach and public engagement work as well as her research programme.

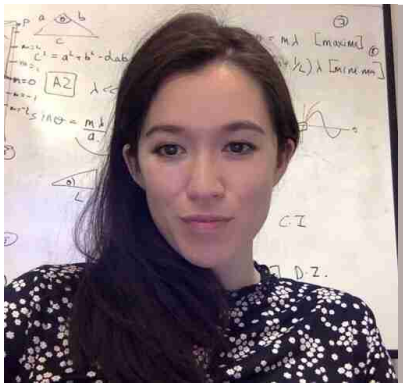
Djuna Croon

Djuna does research on the intersections of particle physics phenomenology, astrophysics, and cosmology. After a PhD at the University of Sussex, and post-doctoral positions at Dartmouth College and TRIUMF, she will start as an IPPP faculty member in 2021. Djuna's work includes articles on cosmic inflation, extended Higgs sectors, boson stars, phase transitions in the early Universe, dark matter, supernova explosions, black holes, gravitational microlensing, and gravitational waves. She is also an enthusiastic science communicator, and committed to making academia more inclusive.

Stephen Jones



Stephen will join the IPPP following a fellowship at CERN. His research has focused on precision tests of QCD and Electroweak Symmetry Breaking as well as methods for computing higher-order perturbative corrections. He is particularly interested in developing the tools and techniques required to undertake multi-loop computations. Recently, he was awarded a Royal Society University Research Fellowship for a project entitled "The Higgs Sector at the Precision Frontier", the goal of which is to provide the precise theoretical input required to interpret measurements of the Higgs.



Jessica Turner

Jessica is a researcher in theoretical particle and early universe physics. She is particularly interested in the interface between neutrino phenomenology and cosmology. She received her PhD from the University of Durham and is currently a postdoctoral researcher at Fermi National Accelerator Laboratory. She looks forward to starting her position as assistant professor at the University of Durham in October 2020.

Various Announcements

Workshops and Conferences

Fellowships and Associateships

Seminars and Research visits

Online and Offline Forums

- We wish farewell to our former academic staff members, **Simon Badger** (University of Turin), **David Cerdeno** (IFT Madrid), **Alexander Huss** (CERN) and **Alexander Lenz** (University of Siegen), and we hope to be able to welcome them back as visitors soon.
- Following advice from the HEP community, the **Annual Theory Meeting has been cancelled** for December 2020. We hope to be able to organise a regular meeting in December 2021.
- The Higgs-Maxwell Meeting in Edinburgh, originally planned for February 2021 has been deferred to July 2021.
- The Young Experimentalists and Theorists Institute (YETI) planned for January 2021 has been deferred to July 2021. This year's topic is “Future e+e- colliders”.
- The IPPP invites expressions of interest to become a member of our Steering Committee. Please message Joanne Bentham (joanne.bentham@durham.ac.uk).
- To support UK's HEP-community initiatives the IPPP provides an online forum where **UK-based seminars, conferences and jobs** are announced: https://www.ippp.dur.ac.uk/uk-hep-community
- The Associateship, Durham IPPP Visiting Award and Senior Experimental Fellowship programmes are continuing. We encourage applications for all three schemes and invite you to consult the following webpages for application deadlines:
  - IPPP Associateship: https://www.ippp.dur.ac.uk/ippp-associateships
  - DIVA: https://www.ippp.dur.ac.uk/diva
  - Senior Exp. Fellowship: https://www.ippp.dur.ac.uk/senior-experimental-fellowships

Workshop and Conference program

RECONNECT 2020

RECONNECT was the first 'Remote Conference on New Concepts in Particle Theory'. The aim of this conference was to reconnect the high-energy physics community in times when personal collaborative ties have been cut due to recent global events. With this first edition we aimed to provide a forum in which the whole theoretical community can share the latest ideas that drive our field.

Topics included gravity and string theory, physics of the early Universe, the geometry of scattering amplitudes, physics beyond the Standard Model and precision collider phenomenology.

While a remote conference cannot re-create the equivalent of a regular workshop or conference, such a meeting offers some interesting benefits since it does not suffer from the same restrictions due to limited budgets, political travel restrictions or personal commitments.

We are grateful to all the speakers who have made this an unique event:

Babis Anastasiou (ETH), Nima Arkani-Hamed(IAS),
Christine Davies (Glasgow), Andre de Gouvea (Northwestern),
John Ellis (KCL), Katherine Freese (Texas),
Yuval Grossman (Cornell), Lavinia Heisenberg (ETH),
Rocky Kolb (Chicago), Juan Maldacena (IAS),
John March-Russell (Oxford), Hitoshi Murayama (IPMU),
Gilad Perez (Weizmann), Serguey Petcov (SISSA),
Maxim Pospelov (Minnesota), Lisa Randall (Harvard),
Gavin Salam (Oxford), Gerard 't Hooft (Utrecht)

Truly global event:

- Attendees from allover the world
- More than 12k page views
- More than 3.5k individual IPs

Durham University

IP3

UKRI Science and Technology Facilities Council

Online events address global double-C challenges

- Corona Crisis
- Climate Change

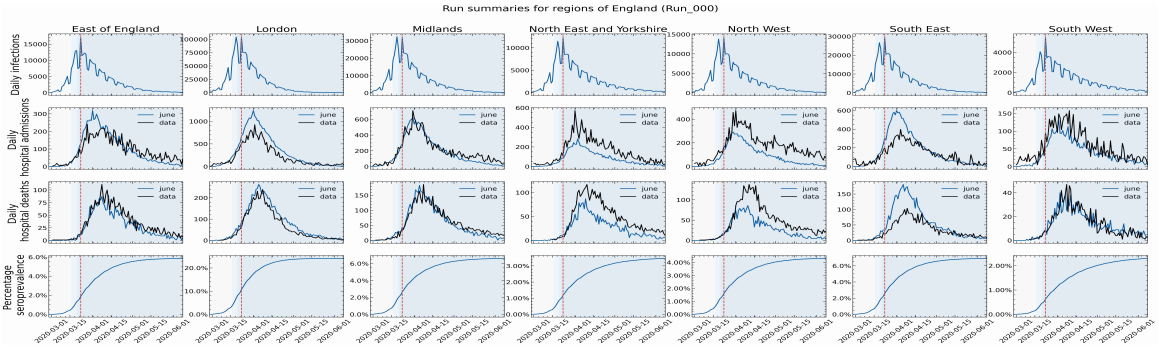
Research Snippet
JUNE - an open-source individual-based model to simulate the spread of epidemics

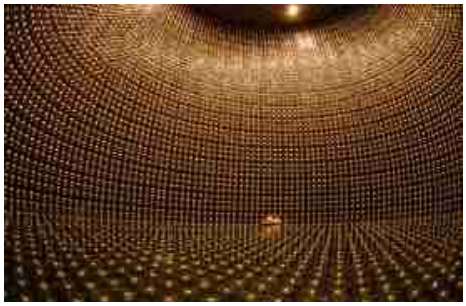
In the past months a team of members of the IPPP, Durham University and University College London have developed JUNE, an individual-based model to simulate the spread of epidemics. The project has been instigated and is led by Frank Krauss. JUNE creates nearly 55 million virtual residents of England based on the 2011 census data. Using demographic information in units of on average 200-300 people with similar socio-economic characteristics, and information about age, gender, and ethnicity distribution, the code populates households in about 20 different categories. Including the same source for regional and trans-regional commute patterns, this allows a detailed simulation of the population. Similarly, geo-locations and types of schools and information about Universities is used to describe the primary, secondary, and tertiary eduction sector. The simulation of further interactions of the virtual population is based on additional publicly available data and includes inter-regional travel between about a dozen capital railway stations and other behavioural patterns such as age-dependent frequencies of shopping or various leisure activities.

Since its inception, JUNE has matured with astonishing velocity to a level where it is able to describe in hitherto not available detail the progression of the epidemic through England, including daily hospitalisation and death rates at the level of regions, and in different age bins as well as the seroprevalence of the population. Some example results are depicted in the Figure below, stemming from one of the many runs with which we are currently fitting the about 15 parameters of the model to data.

Once this fit is successfully finalised, NHS England will use the code for operative planning: JUNE will provide insight supporting the national Covid-19 strategic response through Kevin Fong, National Clinical Advisor in the Emergency Preparedness Resilience and Response team (EPRR) at NHS England.

The team: Joe Bullock (IPPP, Durham), Richard Bower (ICC, Durham), Tristan Caulfield (UCL), Aoife Curran (ICC, Durham), Carolina Cuesta-Lazaro (ICC, Durham), Edward Elliott (ICC, Durham), Kevin Fong (UCL & NHS), Miguel Icaza-Lizaola (ICC, Durham), Frank Krauss (IPPP, Durham), James Nightingale (ICC, Durham), Arnau Quera-Bofarull (ICC, Durham), Aidan Sedgewick (ICC, Durham), Henry Truong (IPPP, Durham), Ian Vernon (Department for Mathematical Sciences), and Julian Willams (Institute for Hazard, Risk & Resilience, Durham)





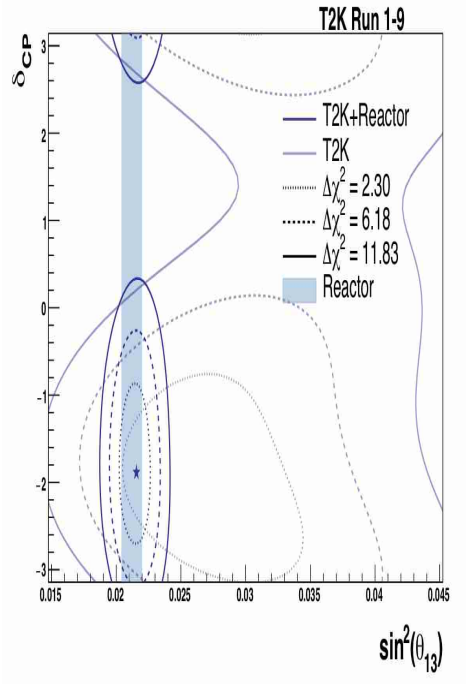
Research Snippet
CP-violation in neutrinos

Reporting in Nature (Nature 580 (2020) 7803, 323-324), Silvia Pascoli and Jessica Turner outlined the interesting recent findings of T2K on CP violation.

"The discovery of substantial CP-violation could be ground breaking"

The violation of the CP symmetry in the leptonic sector is still unknown. Leptonic CP violation plays a crucial role in unveiling the principle behind the observed mixing structure and it is a key ingredient to explain the origin of the baryon asymmetry of the Universe via the leptogenesis mechanism.

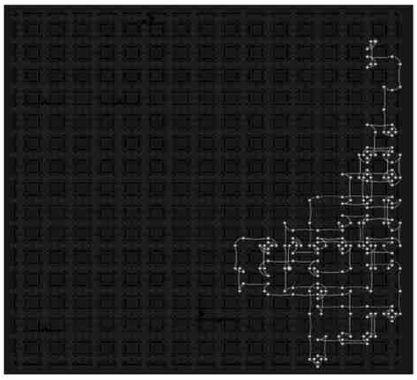
The T2K experiment, based in Japan, exploits a neutrino beam sourced at Tokai and the SuperKamiokande detector located 295 km away. The detector consists of 50 kilotons of ultrapure water surrounded by a vast array of light sensors. T2K can discriminate between muons and electrons, produced in the water by neutrino interactions, thereby identifying the flavour of the impinging neutrino and measuring the probability of muon-to-electron neutrino conversion.



The collaboration analysed data collected between 2009 and 2018, in neutrino and antineutrino mode. By combining it with input from reactor neutrino experiments, they have disentangled the dependence of this probability on various parameters and thus provided strong indications of CP violation. The results exclude CP conservation at 95% C.L., and show that the CP-violating parameter is likely to be large.

In an intriguing turn of events, NOVA, a neutrino experiment based in the USA, announced at Neutrino 2020 that they disagree with the T2K best-fit point at 90% confidence level. The DUNE and T2HK experiments, currently under construction, will tests these results and may discover leptonic CP violation.

"There is now tension between T2K and NOVA"



Research Snippet
Quantum Computing for Quantum Field Theories

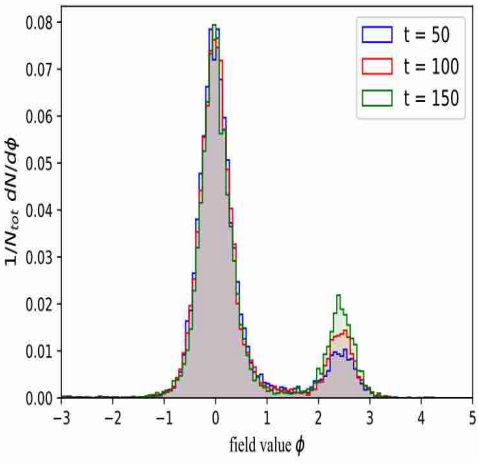
Quantum field theories are the theoretical framework underlying the most fundamental description of nature. Yet, studying the dynamics of those special classes of quantum field theories that occur in nature requires the use of either multi-body quantum systems, e.g. condensed matter systems, or the design of highly sophisticated high-energy experiments that probe the properties of quantum field theories when they manifest themselves as particles.

There are many interesting phenomena in physics, described by quantum field theories, that are difficult to analyse: these include tunnelling, baryogenesis and other non-perturbative processes.

In arXiv:2006.06003 Steve Abel and Micheal Spannowsky have shown that quantum annealers such as those provided by D-Wave are ideally suited to study such processes experimentally. The quantum field at each point is represented by an Ising spin chain of qubits, and it can be given an arbitrary potential.

One can then choose an energy profile, such that the quantum field starts in a false vacuum. It was then possible to observe instanton transitions for a scalar field theory in real-time and do a counting experiment to measure the probability for the field to tunnel from the false to the true vacuum for various tunnelling times, vacuum displacements and potential profiles. This provides an exciting quantum laboratory for future tests of intricate properties of quantum mechanics and arbitrary quantum field theories.

It is shown that a quantum annealer is a genuine quantum system and a laboratory for quantum field theories



Arbitrary quantum field theories can be encoded on a quantum annealer and their dynamics studied in real-time