LIV.DATA NEWS

Vacuum energy of non-supersymmetric S˜ heterotic string models

A team of researchers led by LIV.INNO student Luke Detraux at the University of Liverpool has made a significant breakthrough in string theory, a leading contender for a unified theory of physics. Their research, published in the journal [Physical Review D](#), introduces a new class of string models that could potentially explain the universe without requiring supersymmetry.

Supersymmetry, a theoretical concept that posits a symmetry between particles of matter and those of force, has long been a cornerstone of string theory. However, its absence in experimental observations has led to a growing scepticism among physicists. The new models, known as non-supersymmetric S˜ heterotic string models, offer a promising alternative.

The researchers constructed these models using a technique known as the free fermionic formalism, which is constructed at the free fermionic point. They found that unlike previous supersymmetric string models, which always have a vanishing vacuum energy, these new models can have a finite non-zero potential energy. In fact, most of these models result in a positive vacuum energy, which agrees with the vacuum energy measured in experiments. This means that the universe could exist in a stable state without the need for supersymmetric particles.

Data Drives Discovery

Two events highlight the growing importance of data science: the 2024 Nobel Prize in Physics and the AI Summit in Liverpool this week.

This year's Nobel winners helped lay the foundation for today's powerful machine learning, underscoring the critical role of data in modern physics.

At the Summit, one can earily see how AI is transforming industries from healthcare to energy and climate science.

To me, this is a clear indication of just important data science and AI is for shaping discovery and driving scientific and technological progress across disciplines. LIV.INNO is right at the centre of it all!

Prof Carsten P. Welsch
LIV.INNO Director

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Furthermore, the free fermionic point in these models is not necessarily a minimum of the potential energy landscape, and they show that the landscape around the free fermionic point can be explored without destabilising the potential. This suggests that there could be multiple possible stable or quasi-stable states for the universe, potentially explaining the existence of different cosmological phenomena.

The discovery of these new string models has significant implications for our understanding of the universe. If they prove to be correct, it could mean that supersymmetry is not a fundamental requirement for a unified theory of physics. This would open up new avenues of research and potentially lead to a more complete picture of the laws governing our universe.
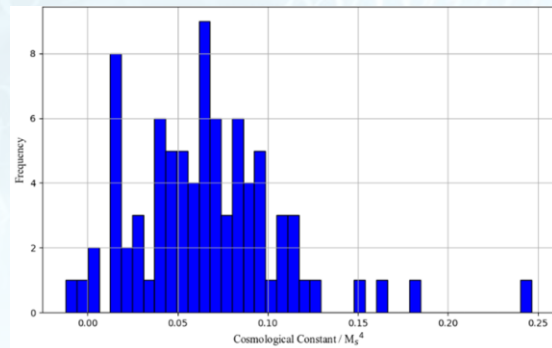
While further research is needed to fully explore the implications of these new models, their existence provides a tantalising glimpse into the possibilities of string theory and the mysteries of the cosmos.

Graph showing the vacuum energies of 84 S~ models that contain the Standard Mode. (Credit: Luke Detraux, Phys. Rev. D 110, 086006 CC BY 4.0)

Third cohort of LIV.INNO students begin their PhDs in Liverpool

The third cohort of LIV.INNO students have started studying for their PhDs at the University of Liverpool and Liverpool John Moores University. Another eleven students from across the world have come to Liverpool to study a wide range of topics which have Data Intensive Science at the core of them. While some of the students will remain in Liverpool for the duration of their studies others will spend time at other institutions such as CERN and FBK.

The students will commence their training in data science as well as subjects relevant to their projects such as accelerator physics, particle physics,

astrophysics and nuclear physics. As well as continuing their studies in these subjects the students will receive training in research skills and techniques, project management, networking, communication and presentation skills, with the aim to provide all students with the skill set required for a future career in academia or industry.

Each student is also required to undertake a six-month industrial placement as part of their PhD. This gives them the opportunity to apply their data science skills to real world challenges while gaining knowledge and experience working outside academia.

The new LIV.INNO students.

The projects the new students are working on are from across the three **LIV.INNO work packages**. The projects range from studies at FBK and CERN to modelling the Milky Way to a joint project with the School of Arts looking at modelling urban areas. More information about the students and their projects can be found **here**.

We wish all the students well in their studies and welcome them to the LIV.INNO centre!

Lattice conference takes place in Liverpool

The 41st Lattice Conference took place at the University of Liverpool, from 28 July to 3 August 2024, attracting 500 participants from around the world to Liverpool. Originally started as a forum for particle physicists to discuss recent developments in lattice gauge theory, especially lattice QCD describing the strong force between quarks and gluons, nowadays the conference is the largest of its type and has grown to include areas like algorithms and machine architectures, quantum computing, physics beyond the Standard Model, and strongly interacting phenomena in low-dimensional systems.

The conference was organised by a local organising committee which included LIV.INNO Management Board and Advisory Board member Simon Hands as its chair, and also Pavel Buividovich, John Gracey and David Schaich, who are all supervisors of LIV.INNO students, as members. Simon Hands said: "The conference is an important forum for both established experts and early career researchers alike to report recent progress, and the published proceedings will provide a valuable community resource. We've worked hard to ensure a welcoming and supportive environment for all our delegates."

The conference was also an opportunity for LIV.INNO students who are studying for PhDs in this area to engage with others in their field of study, as well as help with the running of both plenary and parallel talk sessions. LIV.INNO student Joseph Hadley attended the conference and found the Algorithms and Artificial Intelligence parallel session stream very useful and also had useful conversations with fellow machine learning researchers.

Joseph said "The highlights of this event for me were Christine Davies' talk on contributions from the lattice community in the Muon g-2 problem, and discussion which followed, hearing from influential authors in the field; Jan Smit, John Kogut, and Chris Michael, about the history of Lattice QCD, which matured as a field within living memory and an update on Glueballs delivered by Colin Morningstar"

Delegates at the 41st lattice conference including Local Organising Committee chair, Professor Simon Hands, on front row, second from right

LIV.INNO astrophysics students attend SWIFTcon meeting

Two LIV.INNO PhD students at the Astrophysics Research Institute at Liverpool John Moores University have recently attended SWIFTcon—the annual group meeting for the cosmological simulation code SWIFT—held at the University of Leiden in the Netherlands. SWIFTcon brought together computational astronomers from across the globe, providing a platform to share and discuss recent advancements in numerical models and methods within the context of the Swift astrophysical code.

LIV.INNO students Ryan Roberts and Emily Costello, along with their research group, attended the event which was focused on the ongoing development and implementation of SWIFT, a state-of-the-art code used in cosmological simulations. This gathering provided the students with

the opportunity to meet their collaborators in person, exchange ideas, and discuss future research directions.

Emily contributed to the conference further with a talk titled "Characterising Black Hole Populations in FLAMINGO." This research explores the mass distributions of black holes within the FLAMINGO cosmological simulation and investigates how these populations are influenced by different subgrid physics prescriptions, such as black hole repositioning algorithms and AGN feedback mechanisms. Her presentation stimulated conversations around the complexities of simulating black hole physics and advanced the collaborative efforts within the SWIFT community.

Emily said: "Attending SWIFTcon was a fantastic experience that allowed me to finally meet my collaborators in person, rather than just through a screen. Building those relationships has already been so essential to my research already, they've aided my understanding and sparked ideas that will be invaluable when writing my first paper. It was amazing to explore Leiden too, which was a beautiful city – I'm excited to return in the future."

Ryan added: "The opportunity to meet a team of people at the forefront of state-of-the-art cosmological simulation development was an extremely exciting and motivating one. I enjoyed being able to network face-to-face with not only the SWIFT team, but also other PhD students working on similar projects to my own. I left Leiden with a renewed appreciation for the research being carried out within my field, as well as having a plethora of new ideas to apply to my own research"

Delegates at the SWIFTcon meeting.

New Physics World Weekly podcast about LIV.INNO now available

The latest *Physics World Weekly* podcast is all about data and LIV.INNO. LIV.INNO Director Professor Carsten P Welsch and Deputy Director Dr Andreea Font are in conversation with Katherine Skipper from Physics World to discuss all things LIV.INNO.

In the podcast Professor Welsch and Dr Font discuss the purpose of PhDs and why data science is becoming increasingly important in the research world. They discuss the different areas of research where data science is used and some of the challenges which researchers face. They also discuss the increasing importance of data science in industry.

The training element of LIV.INNO is highlighted with the benefits of industrial placements to both students and the industrial partners discussed. Training in high-performance computing, data analysis, and machine learning and artificial intelligence which students receive is also included as well as training in project management, entrepreneurship and communication skills – preparing them for careers outside of academia.

Physics World Weekly Podcast
Data-intensive PhDs at LIV.INNO prepare students for careers outsi...

00:00 | 36:50

Future opportunities in LIV.INNO will include another cohort of students to start PhDs in 2025. Details of these opportunities will be published on the **LIV.INNO website** later in the year.

You can listen to the podcast **here**

Inaugural WoNDRS conference celebrates gender minorities in STEM at University of Liverpool

The inaugural Women and Non-Binary PhD Researchers in STEM (**WoNDRS**) conference was held on the 8th July 2024. Hosted in the Central Teaching Hub on the University of Liverpool campus, the event aimed to gather PhD researchers celebrate the work of gender minorities in STEM and build community for the PhD students in attendance.

The inspiration for WoNDRS came from the Conference for Undergraduate Women in Physics (CUWiP) that several of the WoNDRS organisers helped host in Liverpool in 2023. Following CUWiP, LIV.INNO student and WoNDRS organiser Katie Ferraby noticed the lack of equivalent events for postgraduate students and so, alongside physics PhD students Lauryn Eley and Beth Slater, built up an organising committee with representatives from multiple departments to help address this gap across STEM as a whole.

The format of the day-long agenda included six talks and a panel session, before moving to the Oliver Lodge building roof for a networking social event with drinks and ice cream. In total, there were 68 registered attendees and 18 contributors—with stands hosted by the Institute of Physics, the Royal Society of Chemistry, the School of Physical Science PGR Wellbeing Ambassadors, and local charity North West Women In STEM.

Participants at the WoNDRS conference (Image credit: Sudi Ravinthiran)

The speakers and panellists included a mix of academic and industry representatives, from companies including IBM and Rolls Royce, with a range of experiences and career stages. By showcasing and celebrating the fantastic research happening in these different environments, conference attendees were given opportunity to consider their own career paths and hear about the variety of options available following their PhD studies. In addition to careers and research, the sessions highlighted issues faced by gender minorities working in STEM and discussed strategies to manage these challenges. The panel discussion focussed on open conversation between the panellists and audience, drawing on both personal and professional topics.

In recognition of the impact of the event, organisers Katie, Lauryn, Beth and Jorge Romero on behalf of the WoNDRS 2024 Committee received the Leslie Green Prize from the Department of Physics, awarded for "outstanding contributions to improving the culture in and/or beyond the Department of Physics".

Katie Ferraby said: "We're extremely happy that WoNDRS brought together so many people and sparked critical conversations and community. So many people have approached us about getting involved with WoNDRS which highlights how rewarding and worthwhile bringing people together is and why events like these are needed."

The WoNDRS organisers would like to thank once again our sponsors, contributors and attendees for making the first WoNDRS conference so successful! The second WoNDRS conference will be hosted in 2025 with the intention of running as an annual event, so if you are interested in contributing or attending in future years, please get in touch – the organisers would love to discuss collaboration possibilities in all formats!

Event Website: **https://www.liverpool.ac.uk/science-and-engineering/outreach/WoNDRS/**

WoNDRS email:

WoNDRS_conference@proton.me

Lauryn Eley, Katie Ferraby, Jorge Romero and Beth Slater (from left to right) received the Leslie Green Prize. (Image credit: QUASAR Group)

LIV.INNO showcases its research at event in Liverpool

The LIV.INNO CDT has held a showcase event at the Hilton hotel in Liverpool. Students, staff and industry partners were all invited to this event to celebrate what has been achieved in the CDT so far and to discuss future collaborations with both new and existing partners. Over 60 people attended the event to hear presentations from a wide variety of speakers and discuss research with the current LIV.INNO students and industry representatives.

Innovations team at the University of Liverpool, who gave a talk on the mechanisms that exist to facilitate cross-sector collaborations.

LIV.INNO student Qiyuan Xu spoke about how work with industry has benefitted his research.

CDT Director Prof Carsten P Welsch gave an introduction to the LIV.INNO centre.

The day started with an introduction to the CDT from Director Professor Carsten P Welsch. This was followed by talks from current partners Adaptix and Mirion who both talked about the work they are currently undertaking with the CDT. This included the exciting announcement that the Adaptix-Liverpool collaboration has been awarded a £400,000 STFC grant to fund the OptiX project, a novel 3D chest X-ray device.

John Whaling, Lead Officer of Innovation and Commercialisation for the Liverpool City Region, discussed the vibrant research landscape across Liverpool and the opportunities that exist for academia and industry. This was followed by Lisa Carey from the Partnerships and

To showcase partnerships from a student's perspective, PhD candidates Beth Slater and Qiyuan Xu spoke about how collaboration with international research facilities and work with industry has benefitted their research, skill portfolio, and career progression. They also demonstrated the benefit that the structure their PhD studies has had on their partner organisations.

Following a lively lunch and networking session, LIV.DAT student Luana Parsons-Franca spoke about her industry placement at Silveray with her supervisor Lana Beck. Together, they showcased the benefit for industry in working with academia. Such fixed-term collaborations enable dedicated research time to spent addressing a promising area, which may otherwise not see sustained attention in the rapidly evolving world of a technology start-up. Luana commented on the many benefits to her, which included the ability to travel internationally to partner research organisations, and gain familiarity in a new field.

Steve Wells (Adaptix) explained how one can model systems that bring mobile, 3D X-ray imaging to patients' bedside.

In the next session, representatives from NHS England and the Home Office spoke about the many opportunities for challenging and rewarding data science internships that exist, as well as the arc of career progression a data scientist may expect to follow in the public sector.

Lively discussions at the poster session.

Having heard talks from a range of perspectives on collaborations between academics and industry, attendees next had the opportunity to engage directly with LIV.INNO's students and partners in a poster and display session. This session saw animated networking and discussion on areas of mutual interest and opportunities for further collaboration.

Industry displays at the CDT Showcase event.

The day was completed with a talk from Constantinos Astreos, Business Development Manager at the University of Liverpool who spoke about how we achieve knowledge exchange and innovation through industry collaboration. Any organisation who are interested in working with LIV.INNO should contact Constantinos for more information.

The full agenda for the day can be found on Indico here

LIV.INNO astrophysicists attend New Scientist Live outreach event

A team of researchers from Liverpool John Moores University, including staff and students from the LIV.INNO CDT, presented their work at "New Scientist Live" which took place at the ExCeL Centre in London. More than 3,000 people visited the LJMU stand over the course of the three-day event which was open to the public on first two days and was targeted at school groups on its final day.

The LIV.INNO team at New Scientist Live from L-R: Sakircan Beyazit, Dr Andreea Font, Khang Nguyen.

The team was led by LIV.INNO Deputy Director Dr Andreea Font and LIV.INNO was advertised at this event to potential future students. There were many students who were interested in discussing the work of the CDT with regard to their future careers. Dr Font said: "New Scientist Live is one of the greatest festivals of science in the world. We were amazed by the enthusiasm with which the public responded to our activities."

The team were bombarded with questions from curious visitors throughout the three-day event, wanting to know about everything from dark matter and black holes to exoplanets and aliens. As ever the young children who attended came up with the best questions and many went away from the event wanting to become astronomers!

The activities available to the visitors each day included a simulation of the Universe in Virtual Reality which LIV.INNO student Sakircan Beyazit is using as part of his PhD project. Computer apps where visitors could create their 'own Universes', and or could manoeuvre a 3D printed version of the Liverpool Telescope to make observations were also used.

Sakircan said: "Activities such VR provide us with a good medium to share our research with the public as it paints a simple general picture where people can see with their own eyes, interact with it and actually experience it first-hand. Sometimes our research can become a bit too abstract working with numbers and statistics, but such activities put it into a nice perspective which is more accessible to the public."

LIV.INNO student Khang Nguyen also attended and he said: "There were quite a few people who were on the verge of picking their GCSEs and A-levels and who would ask us about our journey in astrophysics and what careers are available, to which we would give them an insight on our own journeys, how things went for us and the myriad of things they could do with what they learn in astronomy. This is where I definitely recommended the LIV.INNO scheme and its support in industrial placements in data science to be a potential avenue in the careers of astrophysicists."

Next cohort of LIV.INNO students visit the Hartree Centre

Current first year LIV.INNO students at the STFC Hartree Centre.

In their first year LIV.INNO students are given the opportunity to visit our key partner, the STFC Hartree Centre, to find out about the work of the Centre and the collaborative research it is involved in.

This year's student visit to the Hartree Centre at Sci-Tech Daresbury proved to be quite enlightening. It began with a series of engaging presentations that introduced them to the cutting-edge work being done at the Centre. The team at the Hartree Centre showcased their application of data-intensive science in tackling real-world challenges, such as modelling viral proteins, designing new materials, and simulating plasma for fusion research using a generative model.

The students said that a highlight of their visit was the demonstration of the Hartree Centre's advanced data visualisation technologies. The students used 3-D glasses to explore a three-dimensional model of a UK field, generated using drone-collected data. This immersive experience was followed by a virtual tour of the high-performance computing server room, where they had the opportunity to ask detailed questions about the technologies and infrastructure.

In a cinema-style setting with a large ring screen, the students were introduced to the Virtual Wind Tunnel, demonstrating cutting-edge approaches in computational fluid dynamics used in aerospace and automotive prototyping. They were also given the opportunity to watch a captivating video on plasma simulation.

The students found the visit was inspiring, underscoring the potential of integrating artificial intelligence with data science to solve complex scientific problems.

Data Science Fellow Interview

In each edition of this newsletter, we will interview one of our Data Science Fellows from the LIV.DAT CDT, which recruited students from 2017 to 2020. In this edition, we speak to Conor McPartland who has been studying *"A search for charged lepton-flavour violating tau decays to 3 muons with the ATLAS Experiment"* during his time at the University of Liverpool.

Can you explain in a few words what your project was about and what you have achieved?

I am working in the area of experimental particle physics. Using data collected by the ATLAS experiment at the LHC, I am looking for whether the tau lepton can decay into 3 muons, which would be an example of charged lepton flavour violation. Violation of flavour has so far been observed in neutral leptons and quarks; but so far, not charged leptons. An observation of such a decay would be unambiguous evidence of new physics.

I am currently in the final year of my PhD. I have completed most of the data analysis now and I am in the process of finishing off more detailed aspects, such as looking at the effects of systematic errors.

What has the CDT provided you professionally?

The CDT has heled me develop skills in machine learning and data analysis. This has given me a greater understanding of the tools I use for data analysis.

The regular seminars have given me a window into other areas of physics that I might not have otherwise been exposed to. It's also been useful to see how these techniques have been applied in other areas.

Can you say something about your next career move?

I have really enjoyed my PhD and would love to continue doing further research. Once I have completed my thesis, I will apply for post doc positions in experimental particle physics within the North West.

What is your favourite memory from your time as part of the CDT?

I recently attended a CV and grant writing workshop as part of the CDT which I found both enjoyable and useful. It was really positive to reflect back on what I have achieved throughout my PhD.

Meet the LIV.INNO students

In each edition of this newsletter, we will introduce some of the students who are studying as part of LIV.INNO CDT

Andrea Sante (3rd year PhD student)

Project title:

Reconstructing the assembly history of our Galaxy using neural networks

Where are you from?

Brindisi, Italy

What degree did you study?

I have graduated with a First Class Honours MPhys Physics with Astrophysics degree at the University of Manchester.

What do you do in your free time?

In my spare time I like playing basketball, reading classics, and go thrift shopping.

Ana Costa Pereira (2nd year PhD student)

Project title

Data intense large order Feynmann graph evaluation

Where are you from?

Coimbra, Portugal

What degree did you study?

I studied Physics as an undergrad, followed by a Master's in Nuclear and Particle Physics.

What do you do in your free time?

In my free time I enjoy going on long walks in nature, do yoga and try new food

Sam Godwood (2nd year PhD student)

Project title:

Quantum computing for neutrino scattering

Where are you from?

Oxford, United Kingdom

What degree did you study?

I graduated with an MPhys in theoretical physics from the University of Liverpool

What do you do in your free time?

In my free time I like to watch (and play) football, reading, exercising and playing chess

Sinead Eley (2nd Year PhD student)

Project title

Search for new physics on the FASER experiment at the LHC

Where are you from?

Leeds, England

What degree did you study?

MPhys Physics, University of Liverpool

What do you do in your free time?

Outside of physics I like to bake and crochet, as well as go bouldering with friends.

Dates for your Diary

10 December 2024	15:00 GMT	Virtual Seminar Series: Bioinformatics and the curse of Dimensionality	Euan McDonnell (University of Liverpool)
14 January 2025	15:00 GMT	Virtual Seminar Series: tbc	Ioana Ciuca (Stanford University)
11 February 2025	15:00 GMT	Virtual Seminar Series: Explainable artificial intelligence for scientific discovery: trends and challenges	Simone Scardapane (University of Rome)

Notice Board

Liverpool Virtual Seminar Series on Data Intensive Science

The seminars in this series cover R&D outside of the LIV.INNO centre's core research areas and give an insight into cutting edge research data intensive science.

To register to attend these seminars please visit
https://indico.ph.liv.ac.uk/e/data_science_seminars

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