HGSFP

NEWSLETTER

Heidelberg Graduate School of Fundamental Physics

No. 10 / April 2014

Main Topics:

Editorial

In this edition of our newsletter we are pleased to be able to introduce you to all our new junior research group leaders. They cover our usual fields of research in high energy experimental physics, complex quantum systems, and astronomy, but in addition we have new junior research group leaders doing exciting experiments in environmental physics and (theoretical) research in mathematical physics. We've already had good experience with our new fields, which also include complex classical systems. All subjects were already incorporated into our students' organised winter school, which was well received. We look forward to their contributions in the future!

Do remember that you are always welcome to provide contributions and give feedback to us at any time.

Sandra Klevansky and Rüdiger Klingeler

Students report back

■ The last months saw the recurrence of two student events, which have become well-established traditions of the HGSFP over the last years: the HGSFP Soccer Cup in August 2013 won by the "Minions" of the ITP and the 7th HGSFP winter school in Obergurgl in January 2014.

With nearly 50 participants the HGSFP winter school again proved to be popular among the graduate students. Following the recent addition of three new branches to the HGSFP, lectures on string theory (mathematical physics), climate research (environmental physics) and neural networks (complex classical systems) were included. Together with lectures from the traditional branches and a poster session, the whole scientific research spectrum of the HGSFP was covered. Discussions during this year's winter school also sparked the idea of launching a "HGSFP-Stammtisch". It is open to all HGSFP students and has taken place for the first time on 18th February in the Marstallhof.

Recently, all students of the HGSFP were asked to participate in a student survey, monitoring important markers of their daily doctoral life. Nearly 100 graduate students, in other words one third of all HGSFP students, participated. A high level of satisfaction regarding the students' supervision and of the HGSFP in general could be observed. Detailed results of the survey are available in the student-wiki (http://wiki.kip.uni-heidelberg.de/hgsfp/).

As outgoing student representatives, we wish the new representatives Puneet Murthy (PI) and Walter Hahn (ITP) all the best. We want to thank all organizers of this year's events and the HGSFP directorate and secretariat for their support.

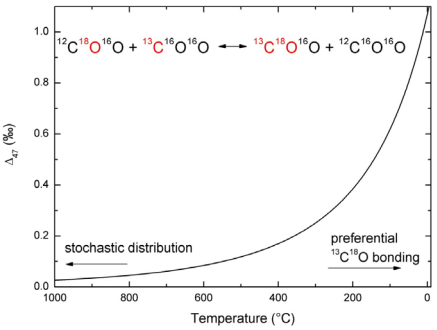
As always, any of your ideas, suggestions or questions are very welcome (studentreps@gsfp.uni-heidelberg.de). ◀

Participants of the 7th HGSFP winter school

Statistical Quantum Mechanics and Paleoclimate

■ Small differences in the zero-point energy and the vibrational and rotational modes of multiply-substituted isotopologues affect their abundance relative to single-substituted isotopologues. The bond between two rare, heavy isotopes has an increased stability and, therefore, leads to a higher abundance of multiply-substituted isotopologues at low temperature. This subtle effect on the order of ppm could only be measured recently benefiting from improved mass spectrometric technologies. CO^2 gas contains several multiply-substituted isotopologues whereof ^{13}C-^{18}O-^{16}O, with a temperature sensitivity of ~0.005 ‰ /K (at 25°C), is the most abundant. The isotopic ordering is also recorded in carbonates and reveals past climatic variations. Current research investigates the temperature relationship of the isotopologue distribution and examines the influence of mineral growth and kinetic effects.

This research is performed by Tobias Kluge (see overpage) whose group is located at the Institute of Environmental Physics, INF 229. ◀



Temperature-dependent abundance of the $^{13}C^{18}O^{16}O$ isotopologue of CO_2 relative to the high-temperature stochastic distribution (specified as Δ_{47} value).
Values are taken from Wang et al., Geochim. Cosmochim. Ac., 68, 4779-4797, 2004.

ATLAS and the Higgs Boson

■ Despite its enormous success, the latest step being the discovery of the Higgs boson, the Standard Model of elementary particle physics fails to answer the fundamental question about the constitution of dark matter.

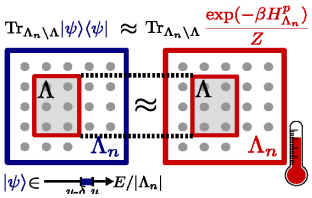
Oleg Brandt's (see overpage) research group utilises experimental signatures with pairs of massive electroweak gauge bosons and jets at the ATLAS experiment at CERN as a probe to search for a generic weakly coupling Dark Matter candidate, and to investigate the fundamental nature of the Higgs boson. The sensitivity of such a search increases dramatically with the centre-of-mass energy of the kinematic regime being probed.

The group utilises advanced data analysis techniques like multivariate and matrix element methods to scrutinise the experimentally challenging highest energy regime accessible at the Large Hadron Collider.

Dr. Brandt's office is located in the Kirchhoff Institute for Physics, INF 227. ◀

Thermalization of closed quantum systems

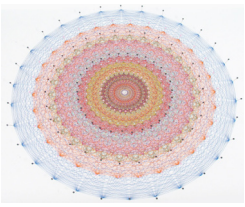
■ One current research project Markus Müller finds fascinating is on thermalization of closed quantum systems. Together with colleagues Lluis Masanes, Nathan Wiebe and Emily Adlam he published a paper (arXiv: 1312.7420) which shows mathematically how the canonical ensemble arises from entanglement in translation-invariant quantum many-body systems. The picture presents the statement that generic pure states on a lattice are locally close to thermal states, with thermodynamic entropy arising from entanglement entropy. In further research, he would like to prove some version of the "eigenstate thermalization hypothesis", a conjecture that has so far notoriously resisted all proof attempts. ◀



Thermodynamic entropy

Exploring symmetry group E8

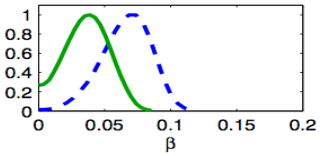
■ Eran Palti's current research is exploring the role that the exceptional symmetry group E8 plays in string theory and in particular in constraining the possible particle physics models that can emerge from it. E8 is the largest compact lie group and it emerges very naturally in string theory and its strongly coupled regime termed F-theory. It is possible that the symmetries of this group control the spectrum of particles that we observe in nature and also their interactions. The research centers on whether that is the case in string and F-theory and if so then how precisely this is realised. ◀



Thread representation of the root system of E8

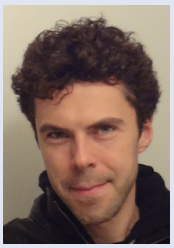
The case of coupled dark energy

■ Despite the good agreement of a cosmological constant with observations, several other scenarios are still very much allowed. Since most models in which General Relativity is modified include a fifth force, Valeria Pettorino has tested the case of coupled dark energy in which the fifth force is parametrized by a constant β. A value of β different from zero would indicate deviations from the standard model. As shown in the plot and described in detail in PRD 88 063519, data are still fully compatible with non zero values of β, with 2.2σ or 3.6σ tension from a zero value, depending on the datasets. ◀



Likelihoods for the cosmological parameters for coupled dark energy models; compared are runs from Planck+BAO (green, lighter) and Planck+HST (blue, darker); plot from http://journals.aps.org/prd/pdf/10.1103/PhysRevD.88.063519 (2013)


Oleg Brandt


Markus Müller


Eran Palti


Tobias Kluge


Valeria Pettorino

Personalia

■ In this edition of our newsletter we introduce our new junior research group leaders:

Oleg Brandt joined the Kirchhoff Institute for Physics in July 2013 to work on searches for new phenomena in pair-production of massive gauge bosons at highest energies with the ATLAS experiment at the Large Hadron Collider, CERN. Before coming to Heidelberg, he was a postdoctoral researcher at Göttingen University and an International Fellow at Fermilab. Oleg Brandt obtained his PhD from the University of Oxford in 2006, investigating signatures for Supersymmetry and the calibration of the ATLAS detector, and studied physics at the University of Bonn, working on the D0 experiment.

Markus Müller obtained his PhD in mathematical physics at TU Berlin, and subsequently worked for two years in the quantum information group of Prof. Jens Eisert in Potsdam. He then moved to the Perimeter Institute in Canada, spending his time freezing in the Canadian cold, snowboarding, and thinking about the foundations of quantum mechanics and thermodynamics. Since September he is a junior research group leader in mathematical physics at the HGSFP.

Eran Palti studied at undergraduate and Masters level at the University of Oxford, before completing his PhD at the University of Sussex. He went on to hold a Science and Technology Facilities Council Postdoctoral Fellowship at the University of Oxford and a Marie Curie Fellowship at the Ecole Polytechnique in Paris, before arriving at Heidelberg. He works in the general area of high energy theoretical physics and in particular string theory. His research ranges from mathematical aspects of string theory to extracting direct phenomenological implications.

Tobias Kluge graduated with a diploma in 2005 and obtained his doctorate in 2008 from Heidelberg University. He was awarded a two-year DFG research fellowship and worked at the Department of Geology and Geophysics at Yale University. In 2012 he joined the Department of Earth Science and Engineering at Imperial College, London, where he worked in the context of the Qatar Carbonates and Carbon Storage Research Centre. Since January 2014 Tobias Kluge is a member of the HGSFP and part of the Institute of Environmental Physics. His research activities focus on multiply-substituted isotopologues, isotope exchange reactions, and isotopic fractionations under equilibrium and non-equilibrium conditions.

Valeria Pettorino is a theoretical physicist working on cosmology. She has been working in Italy, Germany and Switzerland before coming to Heidelberg. She is in particular interested in the Dark Universe and works on theoretical models in which Dark Energy is dynamical, beyond the cosmological constant scenario, possibly connected to modifications of General Relativity at very large scales. Her research interests also include the cosmic microwave background, neutrinos and supernovae. Valeria is a Core Team member of the Planck collaboration, with focus on parameter estimation. She works for theory and forecasts for the Euclid mission, a satellite expected to be launched in 2020. ◀

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