	Tue 13 Sep	Wed 14 Sep	Thu 15 Sep	Fri 16 Sep
	Chair: Theisen	*Chair: Cederwall*	*Chair: Bachas*	*Chair: Fredenhagen*
10:00 – 10:30	Welcome	Meissner	Perry	Lechtenfeld
10:30 – 11:00	Damour	Ananth*	Pope	Fischbacher
11:00 – 11:30	–Coffee–	–Coffee–	–Coffee–	–Coffee–
11:30 – 12:00	Restuccia	Chamseddine*	Stelle	Lerche
12:00 – 12:30	Font	Loll	Bossard	Warner
12:30 – 13:30	—Lunch—	—Lunch—	—Lunch—	END
	Chair: Arutyunov	*Chair: Beisert*	*Chair: Plefka*	
13:30 – 14:30	Discussion	Discussion	Disucssion	
14:30 – 15:00	de Wit	Julia	Kleinschmidt	
15:00 – 15:30	Dall'Agata	Samtleben	Köhl	
15:30 – 16:00	–Coffee–	–Coffee–	–Coffee–	
16:00 – 16:30	Buras*	Alonso-Serrano	Ramond*	
16:30 – 17:00	Persson	Feingold	Schmidt	
17:00 – 17:30			Shankaranarayanan	
19:00			—Dinner @AEI—	
20:00			Townsend	

*online talk

Titles and abstracts

- Damour: Hidden Hyperbolic Kac-Moody Structures in Supergravity
  A brief review will be presented of the various indications of the presence of hyperbolic Kac-Moody structures in supergravity. The recent results (obtained with Philippe Spindel) concerning the presence of $K(G_2^{++})$ *in the Fermionic sector of* $D = 5$ *supergravity will be summarized.*

- Restuccia: D=11 Supermembrane: spectral properties, monodromy and gauge symmetry
  We first discuss the spectrum of the regularized D=11 Supermembrane, the existence of its ground state. We then formulate the M2 brane action on a torus bundle, with base manifold Σ *a closed compact torus, fiber a flat torus* T^2 *and structure group* G *the area preserving diffeomorphisms (APD). The group* $\Pi_0(G)$ *of isotopy classes of* APD *is* $SL(2, Z)$*. There are natural homomorphisms from* $\Pi_1(\Sigma) \to \Pi_0(G) = SL(2, Z)$ *. Each homomorphism defines a linear representation on the first homology group* $H_1(T^2)$*, which we identify with the KK charges of the Supermembrane. The subgroup of* $SL(2, Z)$ *determined by the homomorphism define the monodromy subgroup* H*. The inequivalent torus bundles for a given monodromy* H *are classified by the associated coinvariant classes. It turns out that the Hamiltonian of the Supermembrane is also defined on the space of coinvariant classes. Consequently, the symmetry leaving invariant each coinvariant ,* $SL(2, Q)$ *for the parabolic monodromy (Q the rational numbers), can be interpreted as a "gauge symmetry"of the formulation. The Supermembrane with monodromy is then naturally associated to the gauge Supergravities. We discuss some aspects of the construction.*

- Font: Variations on heterotic strings and lattices
  The internal momenta of heterotic strings compactified on a d-dimensional torus live on the even self-dual Narain lattice. In the first part of this talk we will explain how lattice embeddings allow to determine the maximally enhanced gauge groups of rank (16+d) that can occur. Toroidal orbifolds that realize theories with gauge groups of reduced rank (d+8) are also analyzed. In the second part of the talk we consider heterotic strings compactified on 3-dimensional toroidal orbifolds in which supersymmetry is broken by an asymmetric action on the Narain lattice.

- de Wit: Just a knock on the door

- Dall'Agata: Supergravity and the Swampland
  I will show how supergravity can be used to make clear statements about the Swampland criteria, especially by using the algebraic structure underlying gauged supergravity theories.

- Buras: BSM Flavour Expedition (From the Attouniverse to the Zeptouniverse)
  After the completion of the Standard Model (SM) through the Higgs discovery in 2012 particle physicists are waiting for the discovery of new particles either directly with the help of the Large Hadron Collider (LHC) at CERN or indirectly through quantum fluctuations causing certain rare processes with the change of quark flavour to occur at different rates than predicted by the SM. While the latter route is very challenging, requiring very precise theory and experiment, it allows a much higher resolution of short distance scales than it is possible with the help of the LHC. In fact in the coming flavour precision era, in which the accuracy of the measurements of rare processes and of the relevant theory calculations will be significantly increased, there is a good chance that we

may get an insight into the scales as short as 10^{-21} *m (Zeptouniverse) corresponding to energy scale of 200 TeV or even shorter distance scales. The main strategies for reaching this goal including the most recent developments will be presented. We will also summarize the present status of deviations from SM predictions for a number of flavour observables and list prime candidates for new particles responsible for these so-called anomalies. A short outlook for coming years will be given.*

- Persson: Geometric deep learning: from gauge theory to AI
  Despite the overwhelming success of deep neural networks we are still at a loss for explaining exactly how deep learning works, and why it works so well. What is the mathematical framework underlying deep learning? One promising direction is to consider symmetries as an underlying design principle for network architectures. This can be implemented by constructing deep neural networks on a group G that acts transitively on the input data. This is directly relevant for instance in the case of spherical signals where G is a rotation group. Even more generally, it is natural to consider the question of how to train neural networks in the case of "non-flat" data. Relevant applications include omnidirectional computer vision, biomedicine, and climate observations, just to mention a few situations where data is naturally "curved". Mathematically, this calls for developing a theory of deep learning on manifolds, or even more exotic structures, like graphs or algebraic varieties. A special class consists of homogeneous spaces G/H, where H is a subgroup. I will describe the mathematical framework for convolutional neural networks which are globally equivariant with respect to G and locally with respect to H. The formalism is closely similar to gauge theory and exploring this connection is an active area of research.

- Meissner: Observational consequences of charged Planck mass gravitini
  A proposal of charged Planck mass gravitini, motivated by N=8 supergravity, E(10) and the Standard Model charge assignments for quarks and leptons, leads to several observational consequences. They include an explanation of the nuclei as the cosmic rays of the highest energy, predicting a gap in masses of gigantic black holes observed in the early Universe and the proposal that the gravitini, being stable, can be dark matter candidates.

- Ananth: Aspects of N=8 supergravity
  I will discuss various aspects of N=8 supergravity with the common theme being an improved understanding of its ultraviolet properties.

- Chamseddine: Discrete Gravity
  We assume that the points in volumes smaller than an elementary volume (which may have a Planck size) are indistinguishable in any physical experiment. This naturally leads to a picture of a discrete space with a finite number of degrees of freedom per elementary volume. In such discrete spaces, each elementary cell is completely characterized by displacement operators connecting a cell to the neighboring cells and by the spin connection. We define the torsion and curvature of the discrete spaces and show that in the limiting case of vanishing elementary volume the standard results for the continuous curved differentiable manifolds are completely reproduced.

- Loll: Quantum Gravity Demystified
  Quantum theory and general relativity are not fundamentally incompatible: we must "only" adapt

quantum field theory to the situation where spacetime geometry is dynamical and implement diffeomorphism symmetry in a way that is compatible with regularization and renormalization. It has taken a while to address the underlying technical and conceptual challenges and to chart a path toward a theory of quantum gravity that is unitary, essentially unique and can produce "numbers" beyond perturbation theory. In this context, Causal Dynamical Triangulations (CDT) is to quantum gravity what lattice QCD is to nonabelian gauge theory, providing a nonperturbative toolbox to where other approaches cannot reach (yet). It has allowed us to extract quantitative results on the spectra of invariant quantum observables at or near the Planck scale. A breakthrough result of CDT quantum gravity in four dimensions is the emergence, from first principles, of a nonperturbative vacuum state with properties of a de Sitter universe. I will summarize these findings, highlighting the nonlocal character of observables and the structural challenges of relating Planckian and (semi-)classical gravity.

- Julia: Physical symmetries, group actions and group presentations
  After a very brief review of the E8 families program we shall introduce the McBeath-Thurston-Conway "orbifold" classification. On positive curvature surfaces it belongs to the ADE systematics but on flat surfaces 2d crystallography is recovered. We shall discuss other occurrences of a flat (affine) ADE list extracted from the latter: First order Painlevé classification, Star-shaped quivers, Composition Hall algebras, Quantized Del Pezzo surfaces... Time permitting a conjectured (affine) extension of the MacKay correspondence will be presented.

- Samtleben: Kaluza-Klein spectrometry from exceptional field theory
  I review new tools for the computation of Kaluza-Klein mass spectra associated with compactifications around various background geometries. Applications include the identification of non-supersymmetric AdS_4 vacua which are perturbatively stable at all Kaluza-Klein levels.

- Alonso-Serrano: Quantum Gravity Phenomenology from the Thermodynamics of Spacetime
  I present a formalism to analyze low-energy quantum gravity modifications in a completely general framework based on the thermodynamics of spacetime. I first discuss the connection between thermodynamics and gravitational dynamics in the light of the derivation of Einstein equations of motion from the proportionality of entropy with an area, and analyze the entropies involved in the process. Then, quantum gravity effects are considered via modification of entropy by an extra logarithmic term in the area. This modification is predicted by several approaches to quantum gravity, including loop quantum gravity, string theory, AdS/CFT correspondence and phenomenological models, giving our result a general character but allowing a parametrization in terms on the underlying theory. I show the derivation of the quantum modified gravitational dynamics from this modified entropy expression and discuss its main features. These results provide a general expression of quantum phenomenological equations of gravitational dynamics. Furthermore, I outline the application of the modified dynamics to particular models, such as cosmology, suggesting the replacement of the Big Bang singularity with a regular bounce.

- Feingold: A Lightcone Embedding of the Building For the Split Real Form of a Hyperbolic Kac-Moody Group
  Let $G_{\mathbb{C}}$ be the complex minimal adjoint Kac-Moody (KM) group associated with a hyperbolic KM

Lie algebra, $\mathfrak{g} = \mathfrak{g}(C)$, with $n \times n$ Cartan matrix $C = [c_{ij}]$. In [CFF], Carbone, Feingold and Freyn constructed an embedding of the twin building for $G_{\mathbb{C}}$ into the compact real form $\mathfrak{k}$ of $\mathfrak{g}$ which is generated by the subalgebras $\mathfrak{su}_2^i$, $1 \le i \le n$. The corresponding subgroups SU_2^i generate the compact real form K of $G_{\mathbb{C}}$, and their embedding map was only equivariant under the action of K.
Here we present a similar result embedding the twin building for the split real form $G_{\mathbb{R}}$ into $\mathfrak{p}$, where the split real form of the KM Lie algebra, $\mathfrak{g}_{\mathbb{R}} = \mathfrak{k} \oplus \mathfrak{p}$, is decomposed into the ± 1 eigenspaces for the Cartan involution on $\mathfrak{g}_{\mathbb{R}}$. If $\mathfrak{g}$ is E_{10} then $G_{\mathbb{R}}/K_{\mathbb{R}}$ is of interest in physics, and $\mathfrak{p}$ can be viewed as its tangent space, reflecting its geometry.

- Perry: A little progress on billiards
  A different approach to billiards is provided by using twistorial methods. Some explicit calculations for four-dimensional pure gravity will be presented. An extension to M-theory will be outlined and the brief appearance of octonions speculated on.

- Pope: Mode Stability and Black Holes in Supergravity
  An important question for black hole solutions in theories of gravity or supergravity concerns their stability under the influence of small perturbations. This has been very extensively studied in four dimensions, and also in higher dimensions. Here, we discuss an approach that was developed first for the four-dimensional Kerr black hole by Bernard Whiting in 1989. This started from the Teukolsky equation that gives a gauge-invariant description of the gravitational perturbations around the Kerr background, separating variables, and then studying the separated modes in order to establish that no exponentially growing perturbations could arise. Whiting's technique involved finding a transformation that mapped the difficult problem of studying modes in a spacetime with an ergo-region and its associated super-radiant phenomena into a simpler problem in a geometry with no ergo-region. This can in fact be studied already for the simpler case of a massless Klein-Gordon field. Here, we examine the analogous problem in a higher dimension, for the five-dimensional Myers-Perry black hole, and the charged rotating black holes of five-dimensional supergravity.

- Stelle: Gravity Concentrating Branes
  Brane solutions in supergravities, with noncompact spaces transverse to the brane, can have a taxonomy of two types of worldvolume subtheories for fluctuations around the original static brane. One is a consistent Kaluza-Klein reduction to a braneworld supergravity with the original static brane solution as a structural "skeleton". The other, which exists in special cases, genuinely concentrates supergravity modes around the brane surface. The two are distinguished by the details of boundary conditions on field limits towards the brane surface.

- Bossard: Generalized Scherk-Schwarz reduction to two dimensions
  Exceptional field theory provides a very powerful tool to obtain explicit consistent truncations of eleven-dimensional and type II supergravity down to gauged supergravity in lower dimensions. In this talk I will introduce the E_9 exceptional field theory that we have recently constructed with Ciceri, Inverso, Kleinschmidt and Samtleben and will describe its generalized Scherk-Schwarz reductions to two dimensions. This permitted us in particular to prove that SO(9) gauged supergravity is a consistent truncation of eleven-dimensional supergravity with the supersymmetric Nicolai–Samtleben vacuum that can be interpreted as the near horizon geometry of a stack of D0 branes

and should allow to shed light on the conjectured correspondence between the de Wit–Hoppe–Nicolai M-theory matrix model and M-theory on $AdS_2 \times S^8 \times S^1$.

- Kleinschmidt: On the Wheeler–DeWitt equation and chaos
The BKL paradigm states that approaching a classical spacelike singularity generically entails chaos. Seminal work of Damour, Henneaux and Nicolai extended this picture to the E_{10} *conjecture in maximal supergravity, according to which there is a correspondence between classical dynamics in spacetime and geodesics on an infinite-dimensional space carrying* E_{10} *Kac–Moody isometries. I will discuss quantum aspects of this conjecture and possible physical implications that is based on collaborations with Hermann Nicolai.*

- Köhl: Towards Kostant convexity and a mathematical confirmation of cosmological billiards

- Ramond: Nambu and the Ising Model
I discuss in some detail Nambu's remarkable simplification of Onsager's solution. Finished in 1947, Nambu's submission was delayed by news of the Lamb Shift in the September 29 issue of "Time Magazine". He spent the next year in computing the Lamb Shift using methods of the Tomonaga's school. Both are part of a book that Lars Brink and I are writing on Nambu's Greatest (known and unknown) Insights.

- Schmidt: The Albert Einstein Institute: Pre- and Early History

- Shankaranarayanan:Baryogenesis and Magnetogenesis: Two sides of the same coin?
The origin of primordial magnetic fields and baryon asymmetry of the Universe are still unresolved issues and require physics beyond the standard models of cosmology and particle physics. Since both require physics beyond the standard model, there is a possibility that the same new physics can solve both. In this talk, I will discuss a model, where non-minimal coupling to the Riemann tensor generates sufficient primordial helical magnetic fields at all observable scales during inflation. Interestingly, the generation of helical magnetic fields leads to baryogenesis, and the model predicts the observed amount of baryon a symmetry of the Universe for a range of reheating temperatures consistent with the observations.

- Townsend: A brief history of supergravity

- Lechtenfeld: Nicolai rules in supersymmetry - a legacy from the 1980s
In 1980 Hermann proposed a characterization of supersymmetric theories that became known as the Nicolai map. After initial promise and excitement (fuelling my own PhD work), the subject all but fell dormant for 35 years. Recently however, technical progress in the construction as well as a deeper insight into the nature of the map have been achieved, from quantum mechanics to super Yang-Mills in various dimensions. I will present the Nicolai map from this modern perspective and touch on some of the current developments. When the inverse map is employed for a diagrammatical perturbation expansion of quantum correlators, Feynman rules are replaced by 'Nicolai rules' - hence the title.

- Fischbacher: On the symmetry breaking structure of maximal gauged supergravities
Back in 2001, Hermann Nicolai suggested to me (as a PhD project) to look into the symmetry

breaking structure of the maximal gauged 2+1-dimensional Chern Simons supergravity models he had constructed with Henning Samtleben shortly before. Over the past 20 years, I left M theory research behind, came back to this problem, left supersymmetry behind again, and was pulled back again by this exact same problem, each time armed with substantially more powerful tools that rendered previous approaches obsolete. Nowadays, as an outcrop of these efforts, we think we mostly know the full symmetry breaking structure of not only four-dimensional N=8 de Wit-Nicolai supergravity, but also quite a few relevant related models.
In this talk, I want to tell the curious story of a problem that decided to be ripe to be solved, but since it required tools from the world outside M theory research, it apparently had to pick an adventurer as its avatar and send him on a journey.

- Lerche: On some Mathematics underlying the Stringy Landscape
  We review two aspects of Weak Gravity Conjectures in string compactifications. One posits the existence of certain superextremal states that must exist for the quantum consistency of black holes, the other one is the Emergent String Conjecture. We show that, as is so often with string theory, consistency is a consequence of certain non-trivial mathematical properties. In our context, these are the modularity of Jacobi forms and the degeneration geometry of Calabi-Yau manifolds.

- Warner: Gauged Supergravity and Black-Hole Microstructure
  I review some of the history of gauged supergravity, and show how three-dimensional gauged supergravity have found some remarkable new applications in describing the microstructure of BPS and non-BPS black holes.