Norway grants

SCREAM Workshop: Schedule

Sunday	Arrival 14 - 16 Check-in starts at 15:00							RT Biology conference 16-18			Dinner 19-20
Monday	Breakfast 7 - 10	RT Biology conference 11 - 13			Lunch 13 - 15	PT Demiański 15 - 15:50	Integration 16 - 19				Workshop Dinner 19 - 20
Tuesday	Breakfast 7 - 10	MC Gover 10 - 10:50	PT Slovak 11 - 11:50	Lunch 12 - 14	Leisure 14 - 19						Dinner 19 - 20
Wednesday	Breakfast 7 - 10	MC Gover 10 - 10:50	RT Kryński 11 - 11:35	RT Šilhan 11:45 - 12:20	Lunch 12:30-14:30	RT Kamiński 14:30 - 15:05	Break ≥10 min	RT Kopiński 15:25 - 15:55	RT Schneider 16:05 - 16:35	DS Chair: Doubrov 17 - 18 Distinguished curves	Dinner 19 - 20
Thursday	Breakfast 7 - 10	MC Gover 10 - 10:50	RT Kruglikov 11 - 11:45	Lunch 12 - 14	RT Mason 14 - 14:45	Break ≥10 min	RT Doubrov 15:05 - 15:50	RT Makhmali 16:00 - 16:40	DS Chair: Mason 17 - 18 Integrable systems	Workshop Dinner 19 - 20	
Friday	Breakfast 7 - 10	RT Merker 10 - 10:45	MC Nurowski 11 - 11:50	Lunch 12 - 14	RT Brustenga 14 - 14:20	RT The 14:25 - 15:10	Break ≥10 min	RT Kessy 15:30 - 15:50	RT Melnick 15:55 - 16:40	DS Chair: The 17 - 18 Homogeneous models	Dinner 19 - 20
Saturday	Breakfast 7 - 10	RT Santi 10 - 10:40	RT Harrach 10:50 - 11:10	MC Nurowski 11:15 - 12	Lunch 12 - 14	No talks 14 - 19					Dinner 19 - 20
Sunday	Breakfast 7 - 10	Departure 10 - 13 Check-out until 13:00									

-PT: Public talk -MC: Minicourse -RT: Research talk -DS: Discussion session

-All times are CEST (Warsaw, Brno, Tromsø)

-If the speaker agrees, his or her talk will be recorded and later uploaded on YouTube. The discussion sessions will *not* be recorded.

-The discussion session can continue after 18:00 in a more informal way if there is interest. The chair decides when to end the session.

Titles and Abstracts

Monday

11:00 - 13:00 Research talks in the biology conference. The schedule can be downloaded from here. Talks are *not* broadcasted via Zoom. The following lectures can be of interest to a wider audience:

- Ewa Baczyńska (I Session at 16:00 - Sunday)
- Błażej Ruszczycki (II Session at 11:00 - Monday)
- Elise Tse (II Session at 11:30 - Monday)

Chair: Paweł Nurowski

15:00 - 15:50 Marek Demiański (University of Warsaw)

Expanding Universe

Tuesday

Chair: Katja Sagerschnig

10:00 - 10:50 Rod Gover (University of Auckland)

Conformal and projective techniques in general relativity
Content of Lecture 1: Basic pseudo-Riemannian geometry and space-time geometry, The motivation for, and classical approach to, conformal compactification. Conformal geometry and tractor calculus. The geometry of scale and it's use to understand and extend the theory of space-time compactification.

11:00 - 11:50 Jan Slovák (Masaryk University)

The Geometry of Diffusion Tensor Imaging
Several important medical imaging methods are based on the diffusion of water molecules, measured by MRI. We shall focus on imaging in brain research. For each small unit of space, the so called voxels, we interpret the data as speed of the diffusion in all direction. While the grey matter is very isotropic, the white matter is highly anisotropic and this is exploited for segmentation and fibre tracking. The Diffusion Tensor Imaging (DTI) modality assumes that the diffusion process is well approximated by a Gaussian distribution, which means the second order tensors are the relevant approximations for the data. Clearly, diffusion must be approximated by positive definite tensors. However, with the current available resolution, about 30% of the white matter voxels involve crossings, kissing or merging of more fibres. This invokes higher order tensors to be exploited.

Along our journey through several practical algorithms, we shall meet the mathematical background involving (conformal) Riemannian geometry, geodesics, some algebra related to quartic and quadratic forms, as well as variational and statistical methods.

Wednesday

Chair: Omid Makhmali

10:00 - 10:50 Rod Gover (University of Auckland)

Conformal and projective techniques in general relativity
Content of Lecture 2: Part 1. Applications of the conformal approach to understanding space-time boundary (at infinity) geometry, Applications of the conformal approach to boundary problems and scattering.
Part 2. A conceptual approach to geometric compactification. Examples and (space-time) models.

11:00 - 11:35 Wojciech Kryński (IM PAN)

On variational approach to conformal geodesics
Conformal geodesics are solutions to a system of third order equations, which makes a Lagrangian formulation problematic. We show how enlarging the class of allowed variations leads to a variational formulation for this system with a third order conformally invariant Lagrangian.

11:45 - 12:20 Josef Šilhan (Masaryk University)

Variational approach to conformal curves
First we review conformal theory of curves using the tractor calculus. This allows a setting rather similar to the classical Euclidean case. Then we formulate simplest conformally invariant variational problems and indicate how to characterize critical curves in terms of conformal invariants.

Chair: Andrea Santi

14:30 - 15:05 Wojciech Kamiński (University of Warsaw)

Conformal Einstein's equations
Vanishing of the Fefferman-Graham obstruction tensor was proposed by Anderson and Chrusciel as a tool for studying asymptotically simple solutions to Einstein's equations. It is a conformally covariant equation and a stronger condition: every lambda-vacuum solution in any even dimension has vanishing Fefferman-Graham tensor. The equation is an alternative for known Friedrich's construction of conformal version of Einstein's equations. The important property is well-posedness of this equation. It is nontrivial because the principal symbol has multiple characteristics. However, Fefferman-Graham tensor as well as conformal powers of Laplacians share a structure that imply some version of hyperbolicity. I will discuss this in my talk.

15:15 - 15:45 Jarosław Kopiński (CFT PAN)

On the conformal transformation between two anisotropic fluid spacetimes
Motivated by the recent results concerning conformally flat aeons in the conformal cyclic cosmology scenario, we investigate the necessary conditions for the existence of conformal class of metrics containing two anisotropic fluid metrics. The assumptions that are made on the matter fields serve as a way to consider the most direct generalization of the Friedmann–Lemaître–Robertson–Walker class of solutions of the Einstein field equations.

15:55 - 16:25 Eivind Schneider (University of Hradec Králové)

Differential invariants of Kundt spacetimes
We compute generators for the algebra of rational scalar differential invariants of general and degenerate Kundt metrics. Special attention is given to dimensions 3 and 4 since in those dimensions the degenerate Kundt metrics are known to be exactly the Lorentzian metrics that can not be distinguished by polynomial curvature invariants. The talk is based on joint work with Boris Kruglikov.

Thursday

Chair: Dennis The

10:00 - 10:50 Rod Gover (University of Auckland)

Conformal and projective techniques in general relativity
Content of Lecture 3. Projective geometry and metric-projective geometry. Compactification – the setup, and asymptotics. Applications to boundary problems and scattering.

11:00 - 11:45 Boris Kruglikov (UiT)

Second order PDEs in 4D with half-flat conformal structure on every solution.
It was demonstrated previously that for classes of translationally invariant second order PDEs in 4D integrability is equivalent to the self-duality property of the conformal symbol. Here integrability is meant both in hydrodynamic sense and as the existence of a dispersionless Lax pair (dLp). In the general context hydrodynamic integrability is not developed, but we relate the existence of a dLp to half-flatness of the conformal symbol and to the Monge-Ampere property of the equation. We show several examples of integrable deformations of PDEs based on this. Joint work with S.Berjawi, E.Ferapotov, V.Novikov (Proc Royal Soc A 2020).

Chair: Boris Kruglikov

14:00 - 14:45 Lionel Mason (University of Oxford)

A twistor sigma model for Plebanski generating functions and gravity scattering
Plebanski generating functions give a compact encoding of the geometry of self-dual Ricci-flat space-times or more generally hyper-Kahler spaces. They have applications as generating functions for BPS/DT/Gromov-Witten invariants. We first show that Plebanski's first fundamental form also provides a generating function for the gravitational MHV amplitude. We then explain how such Plebanski generating functions arise as the value of the action of new sigma models for holomorphic curves in corresponding twistor spaces. In 4d, perturbations of a self-dual metric correspond to positive helicity gravitons. The sigma model's perturbation theory gives rise to a sum of tree diagrams for the gravity MHV scattering amplitude observed previously in the literature, and their summation via a matrix tree theorem gives a first-principles derivation of Hodges' determinant formula directly from general relativity. We generalise the twistor sigma model to higher-degree (defined in the first instance with a cosmological constant), giving a new generating principle for the full tree-level graviton S-matrix in general with or without cosmological constant. This is joint work with Tim Adamo and Atul Sharma in https://arxiv.org/abs/2103.16984.

14:55 - 15:40 Boris Doubrov (Belarusian State University)

Non-holonomic generalization(s) of Cayley's ruled cubic
We discuss possible non-holonomic analogs of Cayley's ruled cubic based on (a) its characterization as the only non-degenerate projective surface in $\mathbf{P}^3$ with 3-dimensional symmetry algebra and (b) its relation with the solution space of the system of PDEs $u_{xx} = u_y, u_{yy} = 0$ and (c) algebraic properties of its double vibration by asymptotic curves.

15:50 - 16:30 Omid Makhmali (CFT PAN)

Einstein-Weyl-like conditions, ruled affine spheres, and causal structures in dimension three
We generalize Einstein-Weyl conditions for three dimensional conformal structures to causal structures using their twistorial characterization. We define a causal structure as a field of null cones that are not necessarily quadratic. By augmenting a causal structure with a two parameter family of null surfaces one obtains a path geometry, which is an analogue of the projective structure on an Einstein-Weyl manifold. The resulting structure is in one to one correspondence with point equivalence classes of scalar third order ODEs. As a result of further natural integrability conditions, such structures are reduced to either classical Lorentzian Einstein-Weyl structures or special classes of half-flat Kähler metrics on the 4-dimensional space of paths.

Friday

Chair: Jan Slovák

10:00 - 10:50 Joël Merker (Paris-Saclay University)

Differential Invariants, Recurrence Relations, and Homogeneous Models, in Branches and in Subbranches
Finite or infinite-dimensional group actions on submanifolds produce large collections of differential invariants. Explicit expressions rapidly become unwieldy. Fortunately, the Fels-Olver recurrence relations enable to reach the heart of the matter, without having to handle huge formulas. Naturally, branches and subbranches created by (relative) differential invariants carry their own recurrence relations. The Janet-Riquier theory then becomes concrete, motivated by geometric problems and various group actions. An alternative view can be developed by means of power series expansions at only one point, say the origin. This, again, lowers the computational complexity. In particular, the production of all homogeneous models of a given geometric structure can be reduced to linear algebra computations. Also, Cartan's method of equivalence can be enhanced accordingly.

11:00 - 11:50 Paweł Nurowski (CFT PAN)

TBA

Chair: Josef Šilhan

14:00 - 14:20 Andreu Llabrés i Brustenga (UiT)

Differential invariants of curves in G_2 flag varieties
Regular curves in $M = G_2/P$, where P is a parabolic subgroup, can be classified by the type of their 1-jet. I will show the Hilbert function that counts the number of differential invariants for curves of constant type. Integral curves correspond to minimal orbits of the action of G_2 on $J^1(M, 1)$, and the algebra of differential invariants of such curves was computed by Doubrov and Zelenko. I will discuss those invariants, and also invariants for generic curves, corresponding to maximal orbits of the said action. I will present a transformation between generic curves in G_2/P_1 and G_2/P_2 induced by the twistor correspondence via G_2/P_{12}. This allows us to reduce the computation of invariants to those of G_2/P_1 by relating the equivalence problems for all 3 choices of the parabolic subgroup P. This is a joint work with Boris Kruglikov.

14:25 - 15:10 Dennis The (UiT)

On uniqueness of submaximally symmetric parabolic geometries
Among (regular, normal) parabolic geometries of type (G, P), there is a locally unique maximally symmetric structure and it has symmetry dimension $\dim(G)$. The symmetry gap problem concerns the determination of the next realizable (submaximal) symmetry dimension. When G is a complex or split-real simple Lie group of rank at least three or when $(G, P) = (G_2, P_2)$, we establish a local classification result for all submaximally symmetric structures.

15:20 - 15:40 Johnson Allen Kessy (UiT)

Symmetry gaps for higher order ordinary differential equations
The maximal contact symmetry dimensions for scalar ODEs of order at least four and vector ODEs of order at least three are well known. We determine the next largest realizable (submaximal) symmetry dimensions for these ODE in a manner independent of classifications of contact vector fields (classically used in the scalar case). This is joint work with Dennis The.

15:45 - 16:30 Karin Melnick (University of Maryland)

Conformal groups of compact Lorentzian manifolds
The Lorentzian Lichnerowicz Conjecture is a Lorentzian analogue of the Ferrand-Obata Theorem on conformal transformation groups of Riemannian manifolds. I will discuss my verification of the conjecture in dimension three, for real-analytic metrics, in recent joint work with C. Frances.

Saturday

Chair: Joël Merker

10:00 - 10:40 Andrea Santi (UiT)

$G(3)$ supergeometry and a supersymmetric extension of the Hilbert–Cartan equation
I will report on the realization of the simple Lie superalgebra $G(3)$ as supersymmetry of various geometric structures – most importantly super-versions of the Hilbert–Cartan equation and Cartan's involutive PDE system that exhibit $G(2)$ symmetry – and compute, via Spencer cohomology groups, the Tanaka–Weisfeiler prolongation of the negatively graded Lie superalgebras associated with two particular choices of parabolics. I will then discuss non-holonomic superdistributions with growth vector $(2|4, 1|2, 2|0)$ obtained as super-deformations of rank 2 distributions in a 5-dimensional space, and show that the second Spencer cohomology group gives a binary quadric, thereby providing a "square-root" of Cartan's classical binary quartic invariant for (2, 3, 5)-distributions. If time allows, I will outline an extension of Tanaka's geometric prolongation scheme to the case of supermanifolds. This is a joint work with B. Kruglikov and D. The.

10:50 - 11:10 Christoph Harrach (University of Vienna)

Poisson transforms adapted to BGG-complexes
We consider intertwining operators for tractor bundle valued differential forms between homogeneous parabolic geometries G/P and their corresponding Riemannian symmetric spaces G/K which are compatible with the BGG-complex and relate this property to differential operators on G/K. Furthermore, we give an explicit construction of such operators in terms of Poisson transforms, which are integral operators with an invariant kernel. Explicitly, we translate existence and compatibility of Poisson transforms with several differential operators to computations in finite dimensional representations of reductive Lie groups.

11:15 - 12:00 Paweł Nurowski (CFT PAN)

TBA