Geometric structures in physics

1-day workshop in Tromsø, 27.10.2023

THE ARCTIC UNIVERSITY OF NORWAY • UIT •

TROND MOHN STIFTELSE

TROMSØ RESEARCH FOUNDATION

Timetable

Friday, 27 of October

9:15-9:30	**Registration**		
9:30–9:35	**Welcome**		
9:35–10:20		**Jerzy Lewandowski** University of Warsaw	Extreme Horizons
10:20–11:05	**Discussion + Coffee**		
11:05–11:50		**Mikael Normann** University of South-Eastern Norway	On a field tensor for gravity and electromagnetism
11:55–12:40		**Eirik Eik Svanes** University of Stavanger	A Heterotic Kodaira-Spencer Theory at One-Loop
12:40–14:00	**Lunch**		
14:00–14:45		**Manuel Hohmann** University of Tartu	Cartan geometric structures in gravity and their symmetries
14:50–15:35		**Anna Pachol** University of South-Eastern Norway	Noncommutative Geometry in an approach to Quantum Gravity
15:35–16:15	**Discussion + Coffee**		
16:15–17:00		**Matthew Terje Aadne** Norwegian Defence Research Establishment	Curvature and the geometry of null-congruences

List of Abstracts – Talks

Extreme Horizons

Jerzy Lewandowski

University of Warsaw

The extremality condition for an isolated horizon (or the Killing horizon) combined with Einstein's vacuum equations (with or without a cosmological constant) induces an equation for the geometry of the horizon. The study of this equation has led to a number of results. For a 4-dimensional space-time and a horizon admitting a global section, the equation was completely solved for all compact topologies of the section. All solutions are immersible in the space-time of an exact solution of Einstein's equations. The admission of horizons that do not have a global cut leads to new solutions. They are immersible in NUT-type Einstein spacetimes. A purely local result concerning the extremal equation is the existence of an additional symmetry of static (non-rotating) solutions. These results also apply to non-extremal horizons foliating the Kundt spacetimes. The extremality equations provide arguments for the uniqueness of extreme horizons and their surroundings.

On a field tensor for gravity and electromagnetism

Mikael Normann

University of South-Eastern Norway

We show that a three rank Lanczos type tensor field is an appropriate choice to describe relativistic electromagnetic and gravitational effects. More precisely, we identify the irreducible field-decompositions of this tensor as gravitational and electromagnetic fields. A set of divergence equations are proposed as field equations.

A Heterotic Kodaira-Spencer Theory at One-Loop

Eirik Eik Svanes

University of Stavanger

Taking extrema of the six-dimensional heterotic superpotential gives the so-called F-term constraints of the Hull-Strominger system. Starting at a solution, one can consider "off-shell" fluctuations of the structure in the superpotential. This gives rise to a theory with similar features to Kodaira-Spencer gravity and holomorphic Chern-Simons theory. A natural next step is then to quantise this theory. Mathematically, correlation functions in such a theory should give rise to (quasi-)topological invariants of the geometry, similar to using holomorphic Chern-Simons theory to derive Donaldson-Thomas invariants. I will discuss a first step towards such a program to derive invariants for heterotic geometries, in the quadratic approximation. This gives the one-loop partition function of the theory. Modulo complications from anomalies, this is a (quasi-)topological invariant. The anomalies are interesting in their own right, and I will discuss their resolution and implications for understanding the quantum theory.

Cartan geometric structures in gravity and their symmetries

Manuel Hohmann[1,2]

[1] University of Tartu
[2] University of Oldenburg

The most common description of gravity is given by general relativity (GR), which makes use of a pseudo-Riemannian metric as the sole mediator of the gravitational interaction. The metric gives rise to an orthonormal frame bundle, which is equipped with a unique torsion-free Cartan connection, originating from the Levi-Civita connection. Modified gravity theories may employ different geometric frameworks, such as the metric-affine, teleparallel and Finsler geometries. A common property of these geometries is that also these give rise to particular Cartan geometries, and can therefore be studied using similar methods. In my presentation I will show how these geometries can be cast into a common framework based on Cartan geometry. As a particular example, I will show how this framework can be used to derive a notion of spacetime symmetries of each of these geometries from the Cartan geometry.

Noncommutative Geometry in an approach to Quantum Gravity

Anna Pachol

University of South-Eastern Norway

Noncommutative geometry, as the generalised notion of geometry, allows us to model the quantum gravity effects in an effective description without full knowledge of quantum gravity itself. On a curved space one must use the methods of Riemannian geometry - but in their quantum version, including quantum differentials and quantum connections.

In my talk I will provide the introduction to the quantum version of the Riemannian geometry involving noncommutative differential graded algebra and bimodule connections framework and illustrate the main concepts on some examples.

Curvature and the geometry of null-congruences

Matthew Terje Aadne

Norwegian Defence Research Establishment

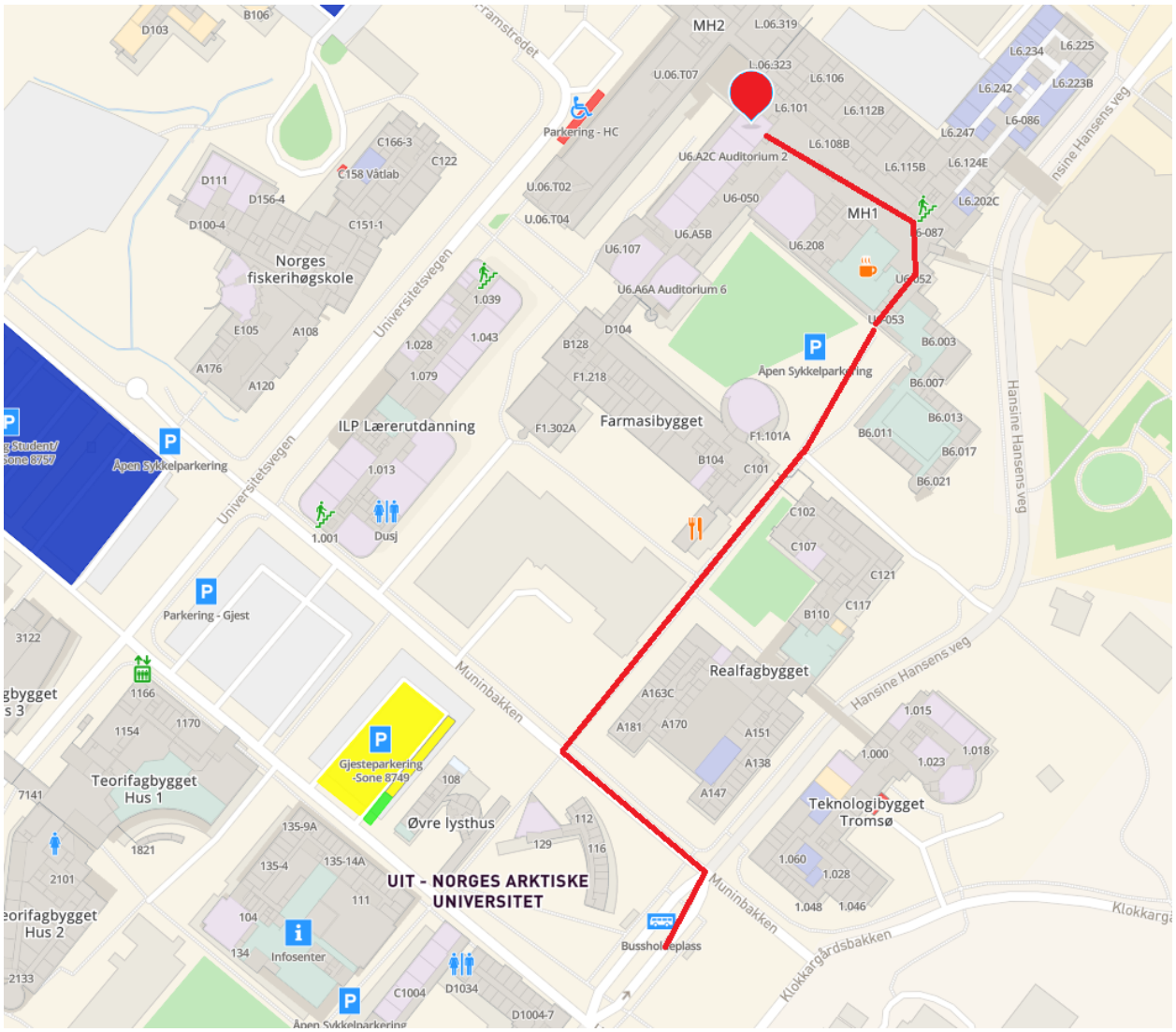
In this talk we present some techniques for studying the geometry of null-congruences directly from the curvature tensors. In addition we report on the progress of resolution to the following question: Do all algebraically special spacetimes admit local foliations by totally geodesic null-hypersurfaces, i.e., by local Kundt null-congruences.

List of Participants

Matthew Terje Aadne	Norwegian Defence Research Establishment
Zaryab Ahmed	University of Stavanger
Evgueny Dinvay	UiT The Arctic University of Norway
Tor Flå	UiT The Arctic University of Norway
Gabriel Gerez	UiT The Arctic University of Norway
Manuel Hohmann	University of Tartu
Boris Kruglikov	UiT The Arctic University of Norway
Jerzy Lewandowski	University of Warsaw
Arne Lien	UiT The Arctic University of Norway
David McNutt	UiT The Arctic University of Norway
Anders Samuelsen Nordli	UiT The Arctic University of Norway
Ben David Normann	NTNU
Mikael Normann	University of South-Eastern Norway
Anna Pachol	University of South-Eastern Norway
Quentin Pitteloud	UiT The Arctic University of Norway
Rodolfo Antonio Rios-Zertuche	UiT The Arctic University of Norway
Eivind Schneider	UiT The Arctic University of Norway
Wijnand Steneker	UiT The Arctic University of Norway
Eirik Eik Svanes	University of Stavanger
Dennis The	UiT The Arctic University of Norway
Vegard Undheim	University of Stavanger

Useful Information

The workshop takes place at UiT The Arctic University of Norway. Talks will be held in **Auditorium 1 in the MH1 building (MHU6.A1C).**



From the city center, take buss 20 or 34 (for example from 'Smørtorget') to 'UiT' which is the stop after 'UiT/Planetariet'. The red line on the map shows the way to the auditorium.

Tickets for the **city bus** are most easily bought through the 'Troms Billett' phone application. Alternatively, there are ticket machines only a few places in the city center, and one at the university.

Tickets and timetables for the **Airport Express** can be found here: https://www.bussring.no/bussring-airport-express/.