GT02

Differential Geometry, Mathematical Physics and Control Theory

Geometría Diferencial, Física Matemática y Teoría de Control

Organizers **Organizadores** **Antolatzaileak**

Miguel Ángel Berbel López

(Universidad Pontificia de Comillas)

Asier López Gordón

(Institute of Mathematics of the Polish Academy of Sciences)

Silvia Souto Pérez

(Universidade de Santiago de Compostela)

Description **Descripción** **Deskribapena**

The goal of this session is to highlight various topics of current research in differential geometry and its applications to physics, dynamical systems, and control theory. It has a remarkable interdisciplinary character, aiming to encourage collaboration among geometers, applied mathematicians, physicists, and engineers. The proposal has the support of the Geometry, Dynamics, and Field Theory Network, which will cover the travel and accommodation expenses for several speakers.

Esta sesión temática tiene por objetivo dar a conocer diversos temas de investigación actual en geometría diferencial y sus aplicaciones a la física, los sistemas dinámicos y la teoría de control. Tiene un carácter fuertemente interdisciplinar, pretendiendo fomentar la colaboración entre geómetras, matemáticos aplicados, físicos e ingenieros. La propuesta cuenta con el respaldo de la Red Temática de Geometría, Dinámica y Teoría de Campos, la cual financiaría el alojamiento y los viajes de varios ponentes.

MSC Codes **Códigos MSC** **MSC Kodeak**

53Z05

(primary)

37J39; 37J60; 53D20; 53Z30; 70H06; 70H40; 70Q05; 81T20

(secondary)

Slots **Bloques** **Blokeak**

2.A (Aula 0.19S); 2.B (Aula 0.19S); 2.C (Aula 0.19S)

QR Code **Código QR** **QR Kodea**

Session Schedule **Horario de la Sesión** **Saioaren Ordutegia**

J16 | 11:00-11:20 | 0.19S
An invitation to the world of higher geometry
Arnau Mas (ICMAT)

J16 | 11:30-11:50 | 0.19S
Generalized Hamilton spaces: new developments and applications
Lucía Santamaría-Sanz (Universidad de Burgos)

J16 | 12:00-12:20 | 0.19S
Symmetry reduction for contact Lagrangian systems
Silvia Souto Pérez (Universidade de Santiago de Compostela)

J16 | 12:30-12:50 | 0.19S
Comments on the contact Marsden-Weinstein reduction
Bartosz M. Zawora (University of Warsaw)

J16 | 16:30-16:50 | 0.19S
Nonholonomic mechanics and virtual constraints on Riemannian homogeneous spaces
Efstratios Stratoglou (American College of Thessaloniki)

J16 | 17:00-17:20 | 0.19S
Global Stability
Jordi Gaset (CUNEF Universidad)

J16 | 17:30-17:50 | 0.19S
Contact Lie systems on three-dimensional Riemannian and Lorentzian spaces of constant curvature
Oscar Carballal (Universidad Complutense de Madrid)

J16 | 18:00-18:20 | 0.19S
k-contact geometry and its application
Tomasz Sobczak (University of Warsaw)

V17 | 9:30-9:50 | 0.19S
AdS Space: Hyperbolic Geometry and Diffusion
Valle Varo (Universidad de Deusto)

V17 | 10:00-10:20 | 0.19S
A graded aproach to brackets in classical field theory
Rubén Izquierdo-López (UNIR-ICMAT)

V17 | 10:30-10:50 | 0.19S
Hamilton-Jacobi theory for non-conservative field theories in the k-contact framework
Julia Lange (University of Warsaw)

Thursday 16 | **Jueves 16** | **Osteguna 16**
11:00-11:20 | **11:00-11:20** | **11:00-11:20**
[Room 0.19S] | **[Aula 0.19S]** | **[Gela 0.19S]**

An invitation to the world of higher geometry

Arnau Mas
(ICMAT)

Many of the objects of interest that appear in field theories are of infinite dimension, namely spaces of fields, spaces of solutions, moduli spaces, etc. Nevertheless, the standard machinery of differential geometry is ill equipped to deal with objects of this kind. I will attempt to make the case in this talk that ideas of category theory can be used to construct a context that generalises finite dimensional differential geometry while accomodating infinite dimensional objects.

Thursday 16 | **Jueves 16** | **Osteguna 16**
11:30-11:50 | **11:30-11:50** | **11:30-11:50**
[Room 0.19S] | **[Aula 0.19S]** | **[Gela 0.19S]**

Generalized Hamilton spaces: new developments and applications

Lucía Santamaría-Sanz
(Universidad de Burgos)

We make new developments in generic cotangent bundle geometries depending on all phase-space variables. We focus on the generalized Hamilton spaces, discussing how the main ingredients of this geometrical framework can be derived from a given metric. We study the spacetime and momentum isometries of the metric, and also discuss the possible applications of cotangent bundle geometries in quantum gravity, such as the construction of deformed relativistic kinematics and non-commutative spacetimes.

Joint work with Javier Relancio.

arXiv:2407.18819

Thursday 16 **Jueves 16** **Osteguna 16**
12:00-12:20 **12:00-12:20** **12:00-12:20**
[Room 0.19S] **[Aula 0.19S]** **[Gela 0.19S]**

Symmetry reduction for contact Lagrangian systems

Silvia Souto Pérez
(Universidade de Santiago de Compostela)

In this talk, we investigate the reduction process of a contact Lagrangian system whose Lagrangian is invariant under a group of symmetries. We will show that the resulting reduced differential equations, the so-called Lagrange-Poincaré-Herglotz equations, can be derived in a relatively straightforward fashion from the Herglotz equations, by choosing a suitable adapted frame, or equivalently by employing well-chosen quasi-velocities.

Joint work with A. Anahory Simoes, L. Colombo, M. de León and M. Salgado.

arXiv:2308.00990

Thursday 16 **Jueves 16** **Osteguna 16**
12:30-12:50 **12:30-12:50** **12:30-12:50**
[Room 0.19S] **[Aula 0.19S]** **[Gela 0.19S]**

Comments on the contact Marsden-Weinstein reduction

Bartosz M. Zawora
(University of Warsaw)

The first generalization of the Marsden-Weinstein reduction theorem to contact manifolds was proven by C. Albert in 1989. However, this result applies only to coorientable contact manifolds and depends on the choice of the contact form. I will review various approaches to the contact reduction theorem and focus on the technical condition introduced by C. Willett, demonstrating its necessity. I will then present a new version of the theorem, applying when Willett's condition fails.

Joint work with J. de Lucas, X. Rivas, S. Vilariño.

Thursday 16	**Jueves 16**	**Osteguna 16**
16:30-16:50	**16:30-16:50**	**16:30-16:50**
[Room 0.19S]	**[Aula 0.19S]**	**[Gela 0.19S]**

Nonholonomic mechanics and virtual constraints on Riemannian homogeneous spaces

Efstratios Stratoglou
(American College of Thessaloniki)

In this talk, we describe nonholonomic systems on Riemannian homogeneous spaces and introduce the notion of virtual nonholonomic constraint (VC) which is a controlled invariant distribution associated with an affine connection control system. Moreover, we show the existence and uniqueness of a control law preserving the VC and also give the closed-loop dynamics obtained using the unique control law in terms of an affine connection. Examples inspired by robotics will be presented.

Joint work with Alexandre Anahory Simoes, Anthony Bloch, and Leonardo J. Colombo.

Thursday 16	**Jueves 16**	**Osteguna 16**
17:00-17:20	**17:00-17:20**	**17:00-17:20**
[Room 0.19S]	**[Aula 0.19S]**	**[Gela 0.19S]**

Global Stability

Jordi Gaset
(CUNEF Universidad)

Global stability studies the asymptotic behaviour of all solutions, not only those around a critical point. This concept arises from theoretical physics as it is challenging to quantize systems that are not globally stable.
In this talk, we will see that global stability is a geometric property of the system. We will review methods to prove global stability and present new extensions. We will see how these concepts are related to integrable systems and explain the relevant challenges ahead.

Thursday 16 | **Jueves 16** | **Osteguna 16**
17:30-17:50 | **17:30-17:50** | **17:30-17:50**
[Room 0.19S] | **[Aula 0.19S]** | **[Gela 0.19S]**

Contact Lie systems on three-dimensional Riemannian and Lorentzian spaces of constant curvature

Oscar Carballal
(Universidad Complutense de Madrid)

In this talk we will show how four-dimensional Lie-Hamilton systems based the Lie algebra sp(4,R) can be reduced to contact Lie systems on the three-dimensional sphere. These systems also arise as particular case of a novel construction of contact Lie systems on the so-called three-dimensional Cayley-Klein spaces. Finally, under some topological assumptions, we will prove that some of these systems produce well-known two-dimensional Lie-Hamilton systems through a curvature-dependent reduction.

Joint work with R. Campoamor-Stursberg and F. J. Herranz.

arXiv:2406.17479

Thursday 16 | **Jueves 16** | **Osteguna 16**
18:00-18:20 | **18:00-18:20** | **18:00-18:20**
[Room 0.19S] | **[Aula 0.19S]** | **[Gela 0.19S]**

***k*-contact geometry and its application**

Tomasz Sobczak
(University of Warsaw)

This talk aims to introduce k-contact geometry, a generalization of contact geometry that has appeared when studying field theories and dissipative systems. I will present this extension and highlight its properties, such as conditions on k-contact distributions, which improve the analysis of differential equations. These results will be mainly applied to Lie systems, a class of ODEs whose general solutions can be expressed in terms of a family of particular solutions and a set of constants.

Joint work with J. de Lucas and X. Rivas.

arXiv:2409.11001

Friday 17	**Viernes 17**	**Ostirala 17**
9:30-9:50	**9:30-9:50**	**9:30-9:50**
[Room 0.19S]	**[Aula 0.19S]**	**[Gela 0.19S]**

AdS Space: Hyperbolic Geometry and Diffusion

Valle Varo
(Universidad de Deusto)

In this talk, we will explore Anti-de Sitter (AdS) manifolds by examining key models, such as the Poincaré one that provides a unique simply connected and geodesically complete Lorentzian manifold of constant curvature -1, up to isometries. We will focus on the (2+1)-dimensional case, where, through the PSL(2, R) model, the AdS-3 space may be endowed with a Lie group structure. This will allow us to analyze diffusion processes and define a Fokker-Planck equation in a geometric manner.

Friday 17	**Viernes 17**	**Ostirala 17**
10:00-10:20	**10:00-10:20**	**10:00-10:20**
[Room 0.19S]	**[Aula 0.19S]**	**[Gela 0.19S]**

A graded aproach to brackets in classical field theory

Rubén Izquierdo-López
(UNIR-ICMAT)

In this talk I will present some recent work where we generalized the notion of Poisson and Dirac structures to classical field theory, obtaining objects of graded nature. We will focus on explaining some results obtained in this recent work, specially those relating the obtained graded Poisson algebra and the graded Poisson tensor.

Joint work with Manuel de León.

arXiv:2410.06034

Friday 17	**Viernes 17**	**Ostirala 17**
10:30-10:50	**10:30-10:50**	**10:30-10:50**
[Room 0.19S]	**[Aula 0.19S]**	**[Gela 0.19S]**

Hamilton-Jacobi theory for non-conservative field theories in the k-contact framework

Julia Lange
(University of Warsaw)

The Hamilton-De Donder-Weyl (HDW) equations generalize Hamilton's equations to field theory, with HDW equations expressed geometrically via k-vector fields. This talk inspects the dynamics of classical field theories described via k-contact structures. A generalisation of the evolutionary contact vector field to the k-contact realm is provided and its HDW equations are defined and analysed. In particular, a Hamilton-Jacobi theory for non-conservative Hamiltonian field theories is developed.