BOOK OF ABSTRACTS

SS39 - Hamiltonian Systems: Theory and Applications

2nd Joint Meeting Brazil-Italy in Mathematics

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Organizers:

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Almost global existence for Hamiltonian PDEs on boundaryless compact manifolds

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Taking the nonlinear Klein Gordon equation as a model problem, I will present a result on the qualitative behaviour of solutions of Hamiltonian PDEs on compact boundaryless Riemannian manifolds. Precisely, one has that solutions corresponding to smooth and small initial data remain small and smooth for times of order ϵ^{-r}, $\forall r$. Here ϵ is the size of the initial datum. The proofs is based on variants of Birkhoff normal form.

I will start by reviewing the classical method of Birkhoff normal form for finite dimensional Hamiltonian systems, then I will recall the theory for equations in one space dimensions and finally I will present the ideas leading to the theory in higher space dimension.

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On the Birkhoff conjecture for Kepler billiards - I

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We investigate the integrability of Kepler billiards-mechanical billiard systems in which a particle moves under the influence of a Keplerian potential and reflects elastically at the boundary of a strictly convex planar domain. Our main result establishes that, except possibly for one location of the gravitational center, analytic integrability at high energies occurs only when the domain is an ellipse and the center is placed at one of its foci. This provides a partial affirmative answer to a Keplerian analogue of the classical Birkhoff-Poritsky Conjecture. Our approach is based on the construction of symbolic dynamics arising from chaotic subsystems that emerge in the high-energy regime.

References

[1] S. Baranzini, V. Barutello, I. De Blasi, S. Terracini, *On the Birkhoff conjecture for Kepler billiards*, preprint, 2025

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On the Birkhoff conjecture for Kepler billiards - II

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We investigate the integrability of Kepler billiards, that is, mechanical billiard systems in which a particle moves under the influence of a gravitational center and reflects elastically at the boundary of a strictly convex planar domain. Our main result establishes that, except possibly for one location of the gravitational center, analytic integrability at high energies occurs only when the domain is an ellipse and the center is placed at one of its foci. This provides a partial affirmative answer to a Keplerian analogue of the classical Birkhoff-Poritsky Conjecture. Our approach is based on the construction of symbolic dynamics at high energies, whose existence is ensured provided suitable conditions on the boundary are satisfied, and implies positive topological entropy.

References

[1] S. Baranzini, V. Barutello, I. De Blasi, S. Terracini, *On the Birkhoff conjecture for Kepler billiards*, preprint, 2025

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Invariant Manifolds near L_1 and L_2 in the Planar Elliptic Restricted Three-Body Problem

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In this work we investigate the connections between the stable and unstable manifolds of tori around the points L_1 and L_2 of the Planar Elliptic Restricted Three-Body Problem (PERTBP).

The study of connections between the invariant manifolds of the periodic orbits around these points, in the Planar Circular RTBP, and the creation of bridges between different types of orbits was already done in [1].

In the case of considering an elliptical movement, we investigate how the analysis of the orbit of comet 39P/Oterma can be improved in a more quantitative way. We compute the dynamical objects that interact with this comet (mixing the tools presented in [2] and the parallel shooting technique), and use some temporal+spatial sections in the phase space to better visualize these objects together with Oterma, when fitting its data into this model.

References

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[2] Jorba, À.: Numerical Computation of the Normal Behaviour of Invariant Curves of n-Dimensional Maps, *Nonlinearity* 14: 943-976, 2001.

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Bifurcation of periodic solutions for central force problems

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We discuss the existence of periodic solutions bifurcating from manifolds of periodic solutions for central force problems in classical and relativistic mechanics, both in two- and three-dimensional Euclidean space.

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On the set of asymptotic homologies of orbits on invariant Lagrangian graphs

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Given a smooth Tonelli Hamiltonian on the torus $\mathbb{T}^n$ and a C^2 Lagrangian graph $W \subset T^*\mathbb{T}^n$ that is invariant under the Hamiltonian flow and contained within a Mañé supercritical energy level, we demonstrate the existence of a proper cone in the first real homology group $H_1(\mathbb{T}^n, \mathbb{R})$ that contains the asymptotic homologies of the canonical projections of recurrent orbits in W. Additionally, for invariant Lagrangian graphs on $\mathbb{T}^3$, drawing on Franks' theory of the rotation set of homeomorphisms of $\mathbb{T}^2$ homotopic to the identity, we show that under certain assumptions for an invariant Lagrangian graph on $\mathbb{T}^3$, if there exists a rational vector in homology contained in the set of asymptotic homologies of orbits on the Lagrangian graph, then the graph contains a Mather measure supported on a periodic orbit. This result generalizes a well-known fact for Lagrangian graphs on $\mathbb{T}^2$. Finally, we exploit these results for three dimensional tori to give a partial answer to a conjecture by Carneiro-Ruggiero about the non-existence of Hedlund Lagrangian tori at supercritical energy levels.

References

[1] On the set of asymptotic homologies of orbits on invariant Lagrangian graphs. Math. Zeitscrhift, (2026) 313:47. https://doi.org/10.1007/s00209-026-04052-1

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Gauge momenta and Hamiltonization in (linear) nonholonomic systems with symmetry

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In this communication we consider the problem of Hamiltonization for mechanical systems with symmetry subjected to nonholonomic constraints that are linear in the velocities. It is well known that linear nonholonomic systems admits an almost Poisson bracket formulation and that, if symmetries are taken into account, the bracket descend to the quotient space and describes the reduced dynamics. It turn out that in certain cases the reduced bracket are twisted-Poisson or even truly Poisson. We here investigate how the failure of the Jacobi identity is modified after reduction by symmetries and possibly also by considering âĂŹgauge transformationsâĂŹ. Finally we exhibit some examples where Poisson and twisted Poisson brackets appear in the description of the reduced dynamics.

References

[1] P. Balseiro and L.C. Garcìa-Naranjo, *Gauge transformations, twisted poisson brackets and hamiltonization of nonholonomic systems*, Arch. Rational Mech. Anal. 205 (2012), 267–310.

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[3] P. Balseiro and N. Sansonetto, In preparation.

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