Journée Mathématiques Physiques

Tous les exposés auront lieu le 26/10/2022 en salle A 318.

- 10h00-10h30: E. Brandon de Leon: **Computational approach to the Schottky problem**
- 10h30-11h00: H. Aldarak: **Explicit Computations for twisted periodic spin chains with the underlying algebra So(2n) from the Co-derivative approach**
- 11h00-11h30: S. Spruck: **Effective Dynamics of the Bose-Einstein Condensate**
- 11h30-12h00: O. Gloton: TBA
- 12h-14h: **BUFFET** (Salle des Conseils)
- 14h00-14h30: O Menenses-Rojas: **Lagrangian and Legendrian Singularities: Application to the event horizon "birth"**
- 14h30-15h00: M. Bahhi: **A Quasilinear Schrödinger Equation**
- 15h00-15h30: I. Loubbardi: **Frobenius-Schur Indicators for Spherical Categories**
- 15h30-16h00: J. Pillet: **Geometric Approach to Integrable Systems**
- 16h15-17h15: J. Frauendiener: **On the asymptotic structures of spacetimes**

Abstracts

H. Aldarak: **Explicit Computations for twisted periodic spin chains with the underlying algebra So(2n) from the Co-derivative approach**
In quantum physics, models with some algebraic properties that permit them to have the Yang-Baxter equation are called quantum integrable. More precisely, we will define spin chains with some underline Lie algebra "gl(n), so(2n)", formulate the objects "T,Q" called Transfer matrices and Q-operators respectively. Then, illustrate the change in the definition for these objects using the Co-derivative method in the gl(n) case and show that the complicated computations to find such objects change to to diagrammatic manipulations of "D-diagrams". Moreover, we will continue by looking at the so(2n) Lie algebra, show the difference between the two cases and formulate the "T,Q" operators the reformulated Co-derivatives for the symmetric and spinorial representations of so(2n), reformulate the conserved charges of the symmetric case in terms of the generating series of the gl(n) Lie algebra and introducing the conserved charges in a general "rectangular" representations.

M. Bahhi: **A Quasilinear Schrödinger Equation**
In nuclear physics the behavior of particles inside the atomic nucleus can be described by a system of non linear Schrödinger type equations. In this talk our goal is to prove the existence and uniqueness of a solution to this Non linear Schröndinger equation.

E. Brandon de Leon: **Computational approach to the Schottky problem**
The goal of this work is to determine up to a given numerical precision whether a given Riemann matrix is the period matrix of some compact Riemann surface. This is equivalent to determining whether a principally polarized Abelian variety (PPAV) is the Jacobian variety of some suitable Riemann surface. Our approach is based on the celebrated Fay identity, a relation between theta functions defined on a Riemann surface. This is interpreted geometrically as the points of the Riemann surface parametrizing a family of collinear points in the embedding of the PPAV into projective space, known as the Kummer variety. It turns out that the existence of such collinear points characterizes Jacobian varieties, as proven by Krichever (2010). Since Fay's identity involves the Abel map, which is only defined on a Jacobian variety and parametrizes the collinear points in the Kummer variety, we treat this question as an optimization problem. Namely, we define a function on the PPAV such that its global minimum is zero if and only if the PPAV is a Jacobian variety.

I. Loubbardi: **Frobenius-Schur Indicators for Spherical Categories**
Fusion categories are semisimple categories with a tensor product, such as representations of groups or certain quantum groups. They appear naturally in various contexts of pure mathematics and mathematical physics (invariants of knots and varieties, operator algebras, conformal field theory, quantum groups and Hopf algebras). Frobenius-Schur indicators, which give a family of numeri-

cal invariants of a fusion category that has proved very useful for the theoretical study of the structure of categories, in some cases can be calculated explicitly, leaving many open-ended problems concerning computation, conceptual interpretation, and behavior of values. In this talk I will define fusion categories and the Frobenius-Schur indicators to then present some of their properties and the explicit calculation of these invariants for examples that are constructed explicitly from finite groups.

O.Meneses-Rojas: **Lagrangian and Legendrian Singularities: Application to the event horizon "birth"**

In the setting of spherically symmetric gravitational collapse, the "moment" when a black hole event horizon is "born" corresponds to a spacetime event onto which null geodesics focus before entering into the horizon null hypersurface. Considering the process backwards in time, this point can be seen as a caustic, namely the focal point of an effective lens. In the non-spherically symmetric case, the "birth" of the event horizon corresponds to a stable caustic with simple singularities. The systematic study of the qualitative properties of such caustics is the subject of singularity theory for the so-called Lagrangian and Legendrian singularities. In this talk I will set the language addressed to the study of singularities in null hypersurfaces by giving some basic examples that may help in the understanding of a gravitational collapse process.

J. Pillet: **Geometric approach to integrable systems**

In this talk I will present some useful geometrical tools in the study of integrable systems. First I will discuss how to extend an approach initiated by D. Mumford during the 1980s based on degenerations of Fay's trisecant identity. Then I will review some notions on the geometry of the moduli space of Riemann surfaces, the goal being to show how the construction of some line bundles over this space leads to the characterization of some relevant features of integrable systems.

S. Spruck: **Effective Dynamics of the Bose-Einstein Condensate**

Abstract: In this talk we examine the mathematical description of the dynamics of a Bose-Einstein-condensate in the high particle density regime. We start by reviewing the Mean-Field theory describing the condensate and fixing initial conditions for a physical set-up in $\mathbb{R}^3$. Then we go beyond the Mean-Field regime and also consider excitations out of the condensate described by the Bogoliubov theory. After that we insert an impurity particle in the Bose gas. The dynamics of the new system of impurity and excitations is given by the Bogoliubov-Fröhlich theory.

J. Frauendiener: **On the asymptotic structures of space-times**

There is a fundamental difference between the quantum and the cosmological worlds. The microscopic physics is invariant under the Poincare group, but this group is utterly meaningless in the macroscopic world, because it is intimately tied to the flat Minkowski space-time and general relativity tells us that

generically space-times are not flat. There exist many attempts to bridge this gap. In this talk I will focus on one particular approach which seeks to find flat regions in appropriate space-times. This leads to many important results of general relativity such as the Bondi-Sachs massloss formula, the memory effect and the Newman-Penrose constants.