



CENTRE
HENRI LEBESGUE
CENTRE DE MATHÉMATIQUES

SUMMER
SCHOOL

ANALYTICAL
ASPECTS
OF HYPERBOLIC
FLOWS — JULY 2017
NANTES 3>7

MINI
COURSES

SEMYON
DYATLOV
MASSACHUSETTS
INSTITUTE
OF TECHNOLOGY

LIVIO
FLAMINIO
UNIVERSITÉ
LILLE 1

CARLANGLO
LIVERANI
UNIVERSITÀ ROMA
TOR VERGATA

MACIEJ
ZWORSKI
UNIVERSITY
OF BERKELEY

SPEAKERS

YVES COLIN DE VERDIÈRE
UNIVERSITÉ GRENOBLE ALPES
FRÉDÉRIC FAURE
UNIVERSITÉ GRENOBLE ALPES
FRÉDÉRIC NAUD
UNIVERSITÉ D'AVIGNON
FRANÇOISE PÈNE
UNIVERSITÉ DE BRETAGNE
OCCIDENTALE

MARK POLLICOTT
UNIVERSITY OF WARWICK
GABRIEL RIVIÈRE
UNIVERSITÉ DE LILLE 1
MASATO TSUJII
KYUSHU UNIVERSITY
TOBIAS WEICH
UNIVERSITÄT PADERBORN

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LABORATOIRE DE MATHÉMATIQUES JEAN LERAY
DÉPARTEMENT DE MATHÉMATIQUES, ÉNS RENNES
LABORATOIRE DE MATHÉMATIQUES DE BRETAGNE ATLANTIQUE
LABORATOIRE ANGEVIN DE RECHERCHE EN MATHÉMATIQUES

SUPPORTS

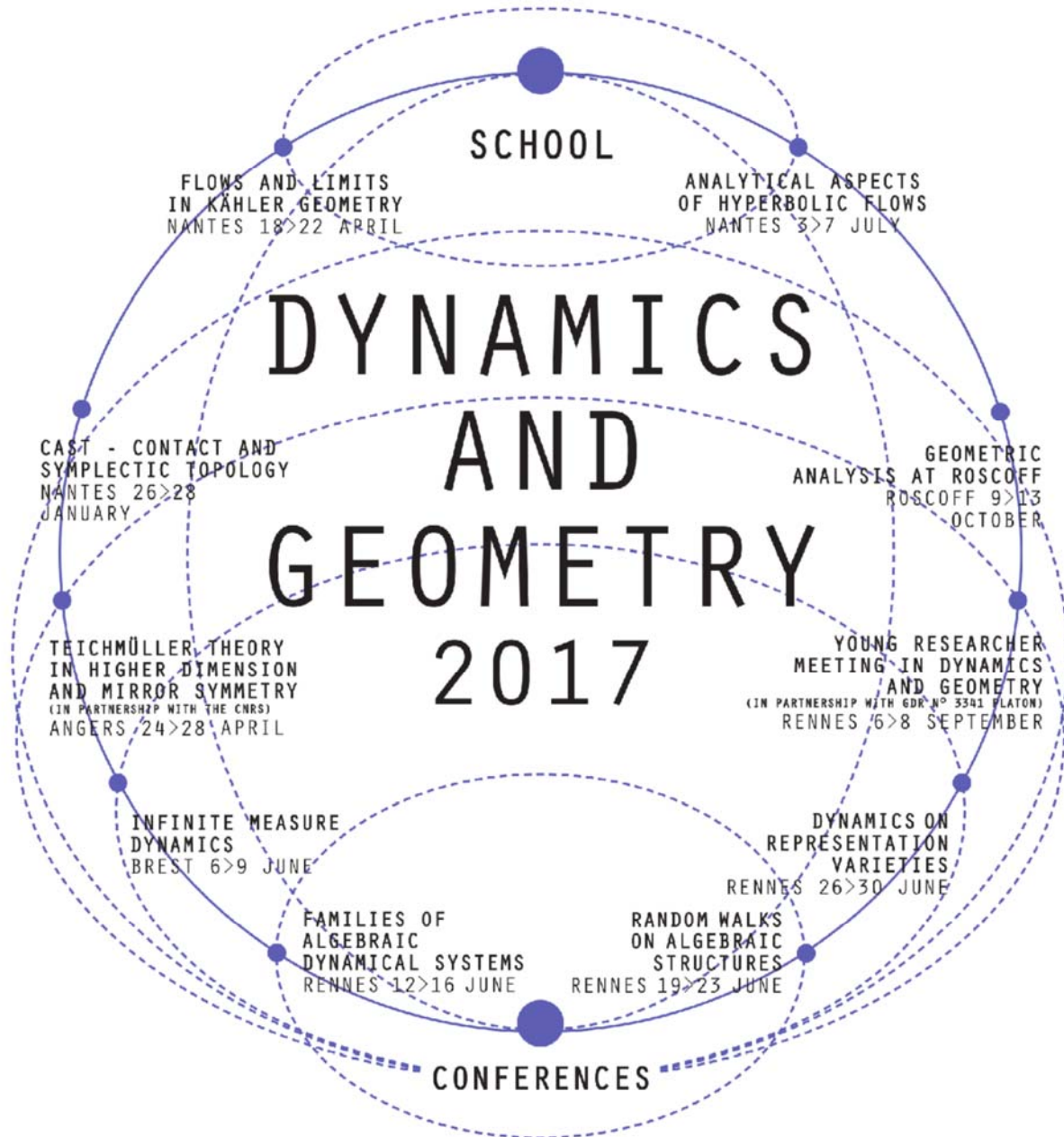
AGENCE NATIONALE
DE LA RECHERCHE
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Coming to the Campus

From downtown: At the station "Commerce" take the tramway line 2 in the direction of "Orvault-Grand Val". Get off at the station "Michelet Sciences". The cost of a one-hour-valid ticket is 1,60 Euros and there are some vending machines at each stop. You can also buy a book of 10 tickets which costs 14,70 Euros.

From the train station: Upon your arrival at the main station (La Gare), take the north exit (Sortie nord) and walk in the direction of the tramway stop "La Gare" which is in front of the main entrance of the station. Take the tramway line 1 in the direction of "François Mitterrand", get off at "Commerce" then take the tramway line 2 in the direction of "Orvault-Grand Val" and get off at "Michelet Sciences". The cost of a one-hour-valid ticket is 1,60 Euros and there are some vending machines at each stop. You can also buy a book of 10 tickets which costs 14,70 Euros.

Once on the campus: Walk to **building 1 (Amphi A)** where the conference will take place (see map 2).

Attention: The vending machines may not take non-France issued credit/Banking cards. Almost certainly, they will not take US issued credit/ATM cards.

For detailed bus and tramway schedules please visit **TAN** (<http://www.tan.fr>).

From the Nantes-Atlantique airport (<http://www.nantes.aeroport.fr>):

By bus: You can get to the city center by the airport shuttle bus (TAN AIR Shuttle) in 20 minutes. The final stop of the shuttle is "Commerce" and there is one bus every 30 minutes. From there you can take the tramway line 2 in the direction of "Orvault Grand Val" and get off at "Michelet Sciences". The cost of a one-hour-valid ticket is 8,50 Euros, valid for tramway and bus.

By taxi: At the main entrance of the Hall 4 you will find a taxi shelter where you can call for a taxi to pick you up.

Accommodation

The speakers of the conference will be accommodated in the hotel :

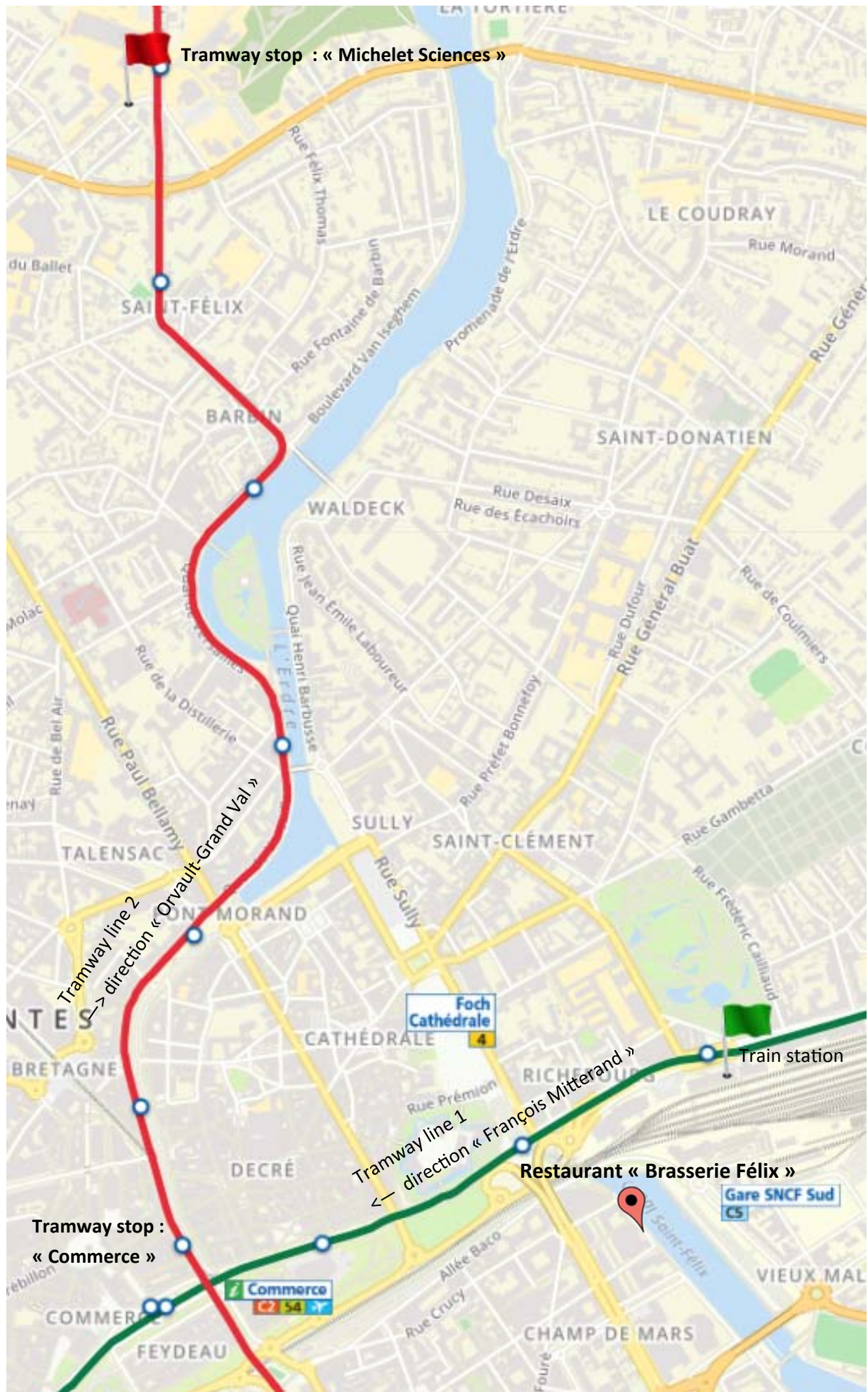
« Voltaire »
10 Rue Gresset
44000 Nantes
Phone +33 (0)2 40 73 31 04

The participants will be accommodated in the hotels :

« Duc de Bretagne »
2/4 Rue Emile Pehant
44000 Nantes
Phone +33 (0)2 40 35 25 02

« Hotel Amiral »
26 bis Rue Scribe
44000 Nantes
Phone +33 (0)2 40 69 20 21

Map 1 : Train station - Campus Sciences



Map 2: Campus Sciences - Amphi A (Building 1)



Site 06

Campus Lombardia

Sciences et techniques
Maison des services universitaires



Map 3 : Restaurant Universitaire « Le Tertre »



Laboratoire de Mathématiques Jean Leray : Information and facilities

Maths Building (n°10 on map 2)

Organizers of the conference:

- Sébastien Gouëzel - office 137 - Mobile phone +33 (0)6 66 76 45 36
- Laurent Guillopé - office 106 - Mobile phone +33 (0)6 28 46 37 55
- Samuel Tapie - office 108—Mobile phone +33 (0)6 86 43 14 38

Laboratory secretary :

- Stéphanie Benoit - Office 130 - Phone +33 (0)2 51 12 58 78
- Annick Egurbide - Office 125 - Phone +33 (0)2 51 12 59 01
- Ana Paula Dutra-Azevedo - Office 125 - Phone +33 (0)2 51 12 59 95
- Anaïs Gouliau - Office 136 - Phone +33 (0)2 51 12 59 04

Department secretary :

- Brigitte Joubert - Office 141 - Phone +33 (0)2 51 12 59 00

Wifi network and internet access



How to connect to the wifi network "univ-nantes":

After starting the browser you will have access to the web page of the University of Nantes.

Enter the login and the password that you will find on the backside of your badge.

Mark with a cross the box "*J'ai pris connaissance de la charte d'utilisation et j'en accepte les termes.*"

You can print documents in the computer room 127 (please bring a usb key).

To have access to the room, please see the secretaries .

IT service - Office 143

Saïd El Mamouni Phone +33 (0)2 51 12 59 45 - Eric Le Douaran Phone +33 (0)2 76 64 50 56

E-mail: mathsys@univ-nantes.fr



The library - Centre Régional de Documentation Mathématique (CRDM)

<http://www.math.sciences.univ-nantes.fr/CRDM/>

Access: Building 25 (directly accessible by Mathematics building)

Office hours: Monday to Friday : 9:00 am to 17:30

Librarian:

Claude Jouault: library reception - Phone +33 (0)2 51 12 59 02



List of participants

Adam	Alexander	UPMC
Adamou	Saidou	Université Dan Dicko Dankoulodo de Maradi
Aimino	Romain	University of Porto
Baladi	Viviane	IMJ-PRG and UPMC
Boil	Grégory	Université de Rennes 1
Boulanger	Adrien	Université Paris 6
Cantrell	Stephen	The University of Warwick
Carron	Gilles	Université de Nantes
Coates	Douglas	University of Exeter
Colin De Verdière	Yves	Université de Grenoble
Dang	Nguyen Thi	Université de Rennes 1
Deleporte	Alix	Université de Strasbourg
Ding	Xiaoxuan	Loughborough University
Diop	El Hadji Abdou Aziz	Cheikh Anta Diop de Dakar
Dyatlov	Semyon	MIT
Elong	Ouissam	Université d'Oran1
Eslami	Peyman	University of Warwick
Federico	Hugo	Université de Paris-Sud Orsay
Filip	Simion	Harvard University
Flaminio	Livio	Université de Lille
Fraczek	Krzysztof	Nicolaus Copernicus University in Torun
Faure	Frédéric	Université de Grenoble-Alpes
Finski	Siarhei	IMJ-PRG and UPMC
Galkowski	Jeffrey	McGill University
Gomes	Sean	Australian National University/Northwestern University
Gouëzel	Sébastien	Université de Nantes
Guillarmou	Colin	Université de Paris-Sud Orsay
Guillopé	Laurent	Université de Nantes
Han	Xiaolong	California State University, Northridge
Hasselblatt	Boris	Tufts University
Hassell	Andrew	Australian National University
Helffer	Bernard	Université de Nantes
Hurtado Salazar	Sebastian	University of Chicago
Jammes	Pierre	Université Nice Sophia Antipolis
Jézéquel	Malo	Université Paris-Sud Orsay

Karpukhin	Mikhail	McGill University
Kenison	George	University of Warwick
Keszthelyi	Gabriella	Alfréd Rényi Institute of Mathematics
Küster	Benjamin	Philipps-Universität Marburg, Germany
Lefeuvre	Thibault	UPMC/Polytechnique
Liverani	Carlangelo	Università di Roma, Tor Vergata
Magee	Michael	Yale University
Matheus	Carlos	Université de Paris 13
Mohammadpour	Reza	Institute of Mathematics Polish Academy of Sciences
Naud	Frédéric	Université d'Avignon
Nguyen Duc	Tho	Université de Rennes 1
Nguyen	Kien	University of Massachusetts Amherst
Novel	Maxence	Université Paris-Sud Orsay
Pène	Françoise	Université de Brest
Picaud	Jean-Claude	Université de Tours
Pollicott	Mark	University of Warwick
Rivière	Gabriel	Université Lille 1
Robert	Didier	Université de Nantes
Ruziboev	Marks	Loughborough University
Schapira	Barbara	Université de Rennes 1
Sedro	Julien	Université Paris-Sud Orsay
Shen	Shu	Université Paris-Sud Orsay
Stoyanov	Luchezar	University of Western Australia
Tanzi	Matteo	Imperial College London
Tapie	Samuel	Université de Nantes
Tomilov	Yuri	Instytut Matematyczny PAN
Truc	Françoise	Institut Fourier
Tsujii	Masato	Kyushu University
Tzou	Leo	University of Sydney
Vig	Benjamin Amir	University of California, Irvine
Viola	Joe	Université de Nantes
Weich	Tobias	Universität Paderborn
Zhang	Zhiyuan	Université de Paris VII
Zhu	Xuwen	Stanford University
Zubov	Dmitry	Higher School of Economics, Moscow
Zworski	Maciej	University of California, Berkeley

Program

Monday 3rd

9am - 9:30am	Welcome and registrations
9:30am - 11am	Liverani 1
11am - 11:15am	Coffee break
11:15am - 12:15am	Pollicott
12:30am - 2pm	Lunch
2pm - 3:30pm	Dyatlov 1
3:30pm - 4:00pm	Coffee break
4:00pm - 5:30pm	Flaminio 1

Tuesday 4th

9:30am-10am	Speech
10am - 11am	Colin de Verdière
11am - 11:15am	Coffee break
11:15am-12:15am	Naud
12:30am - 2pm	Lunch
2pm-3:30pm	Liverani 2
3:30pm - 4:00pm	Coffee break
4pm - 5pm	Faure
5pm - 5:30pm	Speech

7:30pm	Conference dinner
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Wednesday 5th

9:30am - 11am	Liverani 3
11am - 11:15am	Coffee break
11:15am - 12:45am	Zworski 1
1pm -	Lunch

Free afternoon

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Program

Thursday 6th	
9:30am - 11am	Flaminio 2
11am - 11:15am	Coffee break
11.15am - 12:15am	Weich
12.30am - 2pm	Lunch
2pm - 3:30pm	Dyatlov 2
3:30pm - 4pm	Coffee break
4pm - 5pm	Rivière

Friday 7th	
9:30am - 11am	Zworski 2
11am - 11:15am	Coffee break
11:15am-12:15am	Tsujii
12:30-2pm	Lunch
2pm-3:30pm	Flaminio 3
3:30pm-4pm	Coffee break
4pm-5pm	Pène

* Lunch will be taken at the Restaurant Universitaire « Le Tertre » (see map 3).

** The conference dinner will take place at the restaurant « Brasserie Félix» (see map 1).

Minicourses :

Semyon Dyatlov and Maciej Zworski :

Microlocal methods in chaotic dynamics.

Following the insights of Faure–Sjostrand and Tsujii, microlocal/semiclassical methods have proved themselves very useful in the study of closed and open smooth hyperbolic systems. We will explain how they give a simple proof of the meromorphy of Ruelle zeta function for Anosov flow (and indicate the ideas behind the Axiom A case), show stochastic stability of Ruelle resonances, and explain the order of vanishing of the zeta function at zero in the case of negatively curved surfaces (showing in particular that the length spectrum determines the genus).

Livio Flaminio :

$SL_2(\mathbb{R})$: harmonic analysis and dynamics.

The group $SL_2(\mathbb{R})$ is at the cross-road of several lines of mathematical development: for number theorists its arithmetical lattices are objects of fundamental interest; in dynamics, it provides the simplest example of mixing Anosov flow; for harmonic analysts $SL_2(\mathbb{R})$ is the starting point of the harmonic analysis of reductive Lie groups.

In this course, we will review the geometrical and analytic properties of $SL_2(\mathbb{R})$, introduce its representation theory and its applications to hyperbolic surfaces, thereby providing a fundamental example of the theory of resonances for hyperbolic flows developed in the parallel courses.

Carlangelo Liverani :

Functional analytic approach to dynamical systems.

I will discuss the study of the statistical properties of dynamical systems from a functional analytic point of view.

-*Lecture 1*: The basic idea: expanding maps. Synopsis: I will discuss how to study statistical properties and limit theorems for the simple case of smooth expanding maps.

-*Lecture 2*: Hyperbolic systems and anisotropic Banach spaces. Synopsis: I will discuss how to upgrade the strategies put forward in the previous lecture to the case of hyperbolic dynamics. To do so it is necessary to introduce unconventional functional spaces. Such spaces came in various forms, I will discuss the so called “geometric spaces”.

-*Lecture 3*: An application to the case of parabolic dynamics. Synopsis: I will discuss how parabolic dynamics can be treated via renormalization techniques. In the case in which the renormalising dynamics is hyperbolic, the results discussed in the previous lectures can be used to obtain results on statistical properties of the parabolic system.

Talks :

Yves Colin de Verdière

On the dynamics of internal waves in a domain with topography.

This is a work in progress with Laure St-Raymond (ENS Lyon) and Frédéric Faure (IF).

Stratification of the density in an incompressible fluid is responsible for the propagation of internal waves. In domains with topography, these waves exhibit interesting properties. In particular, numerical and lab experiments performed in the team of Thierry Dauxois, especially by Christophe Brouzet, at ENS Lyon, show that in 2D these waves concentrate on attractors for some generic frequencies of the forcing.

I will present simplified mathematical model and discuss some of their properties.

Frédéric Faure :

A semi-classical analysis with wave packets for the Ruelle-Pollicott spectrum of hyperbolic dynamics.

Uniformly hyperbolic dynamics (Anosov, Axiom A) have “sensitivity to initial conditions” and manifest “determinist chaotic behavior”, e.g. mixing, statistical properties etc. The generator of the evolution operator (the “transfer operator”) has a discrete spectrum, called “Ruelle-Pollicott resonances” which describes the effective convergence and fluctuations to-wards equilibrium. We will present a method of analysis using decomposition into wave packets (or wavelets) that gives new results. This method is similar to the “Weyl-Hörmander phase-space metric method”. We will also discuss numerical computation of the spectrum. Joint work with Masato Tsujii.

Frédéric Naud :

Large covers and resonances of hyperbolic surfaces.

In this talk, after a brief refresher on the spectral theory of infinite area surfaces, we will investigate the behaviour of resonances for families of Galois covers of a given surface when the degree goes to infinity. In particular, we will prove a “Weyl Law” for large covers, and an existence result of non-trivial sharp resonances in the case of congruence subgroups.

Françoise Pène :

Stochastic properties of the Z₂-periodic Sinai billiard.

We study some stochastic properties of the Z₂-periodic Sinai billiard. We investigate the following properties of this dynamical system preserving an infinite measure: recurrence, ergodicity, mixing, decorrelation, limit theorems.

Mark Pollicott :

Rigorous bounds in computing dynamical in-variants.

In the context of analytic dynamical systems, it is possible to use zeta functions and determinants to give good numerical estimates on associated values, such as: Hausdorff Dimension of Limit sets; Entropy and Lyapunov exponents of hyperbolic systems; variance, etc. We will discuss the method, illustrating it with specific examples, concentrating on new rigorous bounds on the errors in the approximation. This is joint work with Oliver Jenkinson.

Gabriel Rivière :

Spectral analysis of Morse-Smale gradient flows.

Given a smooth function and a Riemannian metric on a compact and boundaryless manifold, one can define a gradient vector field. Under generic assumptions (of Morse-Smale type), I will explain how one can compute explicitly the spectrum of the associated Lie derivative acting on certain anisotropic Sobolev spaces of currents. I will also discuss the relation of this spectral analysis with differential topology. This is a joint work with Nguyen Viet Dang (University Lyon 1)

Masato Tsujii :

Exponential decay of correlations for Anosov flows.

In this talk, I would like to present a result on exponential decay of correlations for generic volume-preserving Anosov flows on 3-dim manifolds. The main ingredient of the proof is a simple observation on local geometric structure of the strong unstable foliation. If time allows, I would like to discuss about generalization of such an observation to higher dimensional cases.

Tobias Weich :

Numerical calculation of resonances on convex- cocompact surfaces via zeta-functions.

Convex-cocompact surfaces are a certain class of noncompact constant curvature surfaces, that can be obtained by taking the quotient of the upper half-plane with respect to a certain discrete subgroup of $PSL(2, \mathbb{R})$. Thanks to their strong geometric and algebraic structures, these surfaces are an ideal class of geometries to study of resonances of the geodesic- flow transfer operator as well as resonances of the Laplacian. Concerning the distribution of those resonances there have been established a large number of interesting results and conjectures during the past years.

In this talk we will explain how the resonances on convex-cocompact surfaces can be efficiently calculated numerically. This allows to test existing conjectures as well as to discover new interesting structures in the resonances spectrum. The method of these numerical calculations is entirely based on approximating dynamical zeta functions and uses techniques developed by Jenkinson-Pollicott and in joint work with David Borth

Dinner – Tuesday July 4th at 7.30pm

Restaurant "Brasserie Félix"

1 Rue Lefèvre Utile , 44000 Nantes

Phone: 33 (0)2 40 34 15 93



The restaurant « Brasserie Félix» (see map 1) is located close to the tramway line 1 (8mn walk)

stop : Duchesse Anne





Château des Ducs de Bretagne
4, Place Marc Elder 44000 Nantes
Phone +33 (0) 811 46 46 44



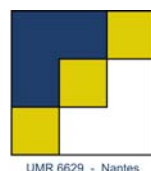
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Bd Léon Bureau
44200 Nantes



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Laboratoire de
Mathématiques
Jean
Leray

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