

Encontro de Matemática Brasil-França

08 a 12 de setembro de 2009

IMPA - Rio de Janeiro

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Promoção



Auxílio



França.Br 2009

Encontro de Matemática Brasil-França

IMPA, Rio de Janeiro, de 08/09 até 12/09

Organizing Committee:

César Camacho - Diretor - IMPA
Cláudio Landim - Diretor Adjunto - IMPA
Jacob Palis - ABC/IMPA
Harold Rosenberg - Paris VI
Christian Bonatti - Université Dijon
Jean Christophe Yoccoz - Collège de France

Conferencistas Franceses Confirmados:

C. Bonatti - Université de Bourgogne (Dijon)
T. Cazenave - Université Pierre et Marie Curie
D. Cerveau - Université de Rennes 1
A. Chateauneuf - Université de Paris I
B. Daniel - Université Paris XII
M. Hindry - Université de Paris VII
F. Pacard - Université de Paris XII
B. Perthame - Université Pierre et Marie Curie
D. Ruelle - Institut des Hautes Études Scientifiques
S. Sorin - Université Pierre et Marie Curie
P. Mathieu - Université de Provence, Marseille
S. Olla - Université Paris Dauphine

Conferencistas Brasileiros Confirmados

Alcides Lins - IMPA
Aron Simis - UFPE
Cláudio Landim - IMPA
Fernando Coda - IMPA
Flavio Dickstein - UFRJ
Harold Rosenberg - IMPA
Hermano Frid - IMPA
Jorge Vitorio Pereira - IMPA
Lorenzo Diaz Casado - PUC-RIO
Luiz Renato Fontes - USP
Marcelo Viana - IMPA
Renato Tribuzy - UFAM

Social Activities:

Wednesday 09 - 05:30 PM
Opening ceremony and Cocktail

Scientific Activities:

Abstracts:

Christian Bonatti (Université de Bourgogne - Dijon)

Título/Title: A panorama of dynamical systems using the C^1 -topology

Resumo/Abstract:

The results of the last two decades let us hope the possibility of describing the dynamics of diffeomorphisms in an open and dense subset, for the C^1 topology, of the set of all diffeomorphisms (the same holds for flows).

I will try to present our approach by using conjectures justified by many concordant results."

Lorenzo Diaz Casado (PUC - Rio)

Título/Title: Non-hyperbolicities

Resumo/Abstract:

There are several forms of non-hyperbolic dynamics, some of them exhibiting a weak form of hyperbolicity (as partial hyperbolicity, existence of dominated splittings).

On the other hand, there are several features which are typical of non-hyperbolic dynamics: bifurcations, cycles (homoclinic tangencies and heterodimensional cycles), ergodic non-hyperbolic measures, super-exponential growth of the number of periodic points, non-existence of symbolic extensions, etc.

In this talk, we study relations between weak forms of hyperbolicity and the sort of non-hyperbolic feature exhibited by the systems.

Thierry Cazenave (Université Pierre et Marie Curie)

Título/Title: A Schrödinger equation with time-oscillating nonlinearity

Resumo/Abstract:

Abstract: In this joint work with Márcia Scialom (UNICAMP), we consider the nonlinear Schrödinger equation $iu_t + \Delta u + \theta(\omega t)|u|^\alpha u = 0$ in \mathbb{R}^N where α is an H^1 -subcritical exponent and θ is a periodic function. We show that, for a given initial condition $u(t_0) = \varphi \in H^1(\mathbb{R}^N)$, the solution u converges as $|\omega| \rightarrow \infty$ to the solution of the limiting equation $iU_t + \Delta U + I(\theta)|U|^\alpha U = 0$ with the same initial condition, where $I(\theta)$ is the average of θ . We also show that if the limiting solution U is global and has a certain decay property as $t \rightarrow \infty$, then u is also global if $|\omega|$ is sufficiently large.

Dominique Cerveau (Université de Rennes 1)

Título/Title: Singularités d'Hypersurfaces Levi-Plates

Resumo/Abstract:

Nous passerons en revue les travaux de Poincaré et d'Elie Cartan concernant la classification holomorphe locale des hypersurfaces réelles des espaces complexes; nous présenterons les résultats de Burns et Gong, de Brunella ainsi qu'un travail récent en collaboration avec Alcides Lins Neto.

Alain Chateauneufy (Univ. Paris I - Sorbonne)**Título/Title:** Continuity properties of totally monotone capacities on Polish spaces and impatience**Resumo/Abstract:**

Building upon the Choquet's integral representation Theorem, we characterize several continuity properties of totally monotone capacities ν defined on the Borel sets of a Polish space Ω , in terms of the specific properties of the related σ -additive Möbius transform. In the particular case of $\Omega = \mathbb{N}$, we show that these continuity properties characterize well-known impatience attitudes of a decision-maker evaluating income streams x through the Choquet integral of x with respect to the capacity ν .

Fernando Coda (IMPA)**Título/Title:** Isotopy Problems for Manifolds with Positive Curvature**Resumo/Abstract:**

There are several different notions of positive curvature in Differential Geometry, which all lead to topological classification questions. For each one of these notions there is also an associated isotopy problem. This consists in describing the connected components of the corresponding moduli space. These two types of questions are often related to each other.

In this talk we will give an overview of some of these isotopy problems, and discuss some new results in low dimensions. We will also mention some open problems.

Benoit Daniel (Université Paris XII)**Título/Title:** Existence and Uniqueness of Constant Mean Curvature Spheres in the Lie Group Sol₃**Resumo/Abstract:**

Constant mean curvature (CMC) surfaces are surfaces that locally minimize area under a certain volume constraint. A celebrated theorem of H. Hopf states that the only CMC topological spheres in Euclidean 3-space are round spheres. This theorem was generalized by U. Abresch and H. Rosenberg in some other ambient homogeneous 3-manifolds. In this talk we will investigate this problem in the Lie group Sol₃, i.e., in the only Thurston 3-geometry where it remains open. In particular we will prove existence and uniqueness of CMC spheres for values of the mean curvature greater than $1/\sqrt{3}$. This is joint work with Pablo Mira.

Flavio Dickstein (UFRJ)**Título/Title:** Blowup and global sign-changing solutions of the nonlinear heat equation**Resumo/Abstract:**

Given $\alpha > 0$ we consider the nonlinear heat equation $\partial_t u - \Delta u = |u|^\alpha u$ for $x \in \Omega$ and $t > 0$. We suppose that Ω is the whole space or a ball, imposing then either Dirichlet or Neumann boundary conditions. It is well-known that in all three cases there exist both global in time solutions and blowing up solutions. A natural question is to characterize the set G of initial data generating global solutions. This is a delicate problem, specially for sign-changing solutions. We describe some recent results obtained in collaboration with Thierry Cazenave and Fred Weissler giving some partial answers to this question. We show in particular examples where G is not star-shaped around 0.

Luiz Renato Fontes (USP)**Título/Title:** Scaling limits for trap models**Resumo/Abstract:**

We review recent results on scaling limits for trap models in various graphs, including the complete graph and Z^d , and present some new ones concerning convergence of the size of the currently visited trap. This is related to the aging phenomenon exhibited by those models.

Hermano Frid (IMPA)**Título/Title:** Homogenization of degenerate porous medium type equations in ergodic algebras**Resumo/Abstract:**

ABSTRACT. In this talk we present some recent results on homogenization of nonlinear PDE's obtained in collaboration with Luigi Ambrosio and Jean Carlos Silva. We will review the concepts of algebra with mean value and ergodic algebra introduced by Zhikov and Krivenko (1986). We also introduce the Fourier-Stieltjes algebra in \mathbb{R}^n which we denote by $FS(\mathbb{R}^n)$. It is a subalgebra of the algebra of bounded uniformly continuous functions in \mathbb{R}^n , $BUC(\mathbb{R}^n)$, strictly containing the almost periodic functions, whose elements are invariant by translations and possess a mean-value. Thus, it is a so called algebra with mean value. Namely, $FS(\mathbb{R}^n)$ is the closure in $BUC(\mathbb{R}^n)$, with the sup norm, of the real valued functions which may be represented by a Fourier-Stieltjes integral of a complex valued measure with finite total variation. We prove that it is an ergodic algebra and that it shares many interesting properties with the almost periodic functions. We show how two-scale Young measures can be constructed in the general context of algebras with mean value. We apply the framework developed to study the homogenization problem for a degenerate porous medium type equation of the general form $u_t = \Delta f(x, \frac{x}{\varepsilon}, u)$ with $f(x, y, u)$ monotone increasing for $u \geq 0$, $f(x, y, 0) = 0$. We analyse both the Cauchy problem and the initial boundary value problem with Dirichlet boundary condition.

Marc Hindry (Université Paris 7)**Título/Title:** Analogs of the Brauer-Siegel theorem for abelian varieties**Resumo/Abstract:**

Consideramos primeiro uma seqüência de corpos de números K_i de grau fixo cujo discriminante tende ao infinito. O teorema clássico de Brauer-Siegel afirma que o produto do regulador pelo número de classes de K_i se comporta assintoticamente como a raiz quadrada do discriminante.

Apresentaremos um análogo conjectural deste resultado para uma seqüência de variedades abelianas de dimensão fixa cujo condutor (ou a altura) tende ao infinito : o produto do regulador de Néron-Tate pela cardinalidade do grupo de Shafarevich-Tate se comporta assintoticamente como a altura exponencial. Este trabalho é baseado na veracidade da conjectura de Birch e Swinnerton-Dyer, então os resultados sobre corpos de números são todos condicionais. Entretanto alguns casos sobre corpos de funções em característica positiva podem ser completamente estabelecidos.

A palestra será dirigida a não especialistas, mencionaremos também Trabalhos de Kunyavskii, Tsfasman e Zykin. Trata-se de um trabalho junto com Amílcar Pacheco.

Claudio Landim (IMPA)**Título/Title:** Action functional and quasi-potential for the Burgers equation in a bounded interval**Resumo/Abstract:**

Consider the viscous Burgers equation on the interval $[0, 1]$ with Dirichlet boundary conditions:

$$\begin{cases} u_t + f(u)_x = \varepsilon u_{xx} \\ u(t, 0) = \rho_0, \quad u(t, 1) = \rho_1, \end{cases}$$

where the flux f is the function $f(u) = u(1 - u)$, $\varepsilon > 0$ is the viscosity, and the boundary data satisfy $0 < \rho_0 < \rho_1 < 1$. We examine the quasi-potential associated to an action functional arising in statistical mechanical models. We provide a static variational formula for the quasi-potential and we characterize the optimal paths. In contrast with previous cases, for small enough viscosity, the static variational problem admits more than one critical point.

Alcides Lins Neto (IMPA)**Título/Title:** Generalized Kupka components and foliations of degree three on \mathbb{P}^n **Resumo/Abstract:**

Abstract : A codimension one foliation \mathcal{F} of degree d on \mathbb{P}^n can be defined in homogeneous coordinates by an integrable 1-form $\Omega_{\mathcal{F}} = \sum_{j=0}^n A_j(z) dz_j$, where :

- 1. The A_j 's are homogeneous polynomials of degree $d + 1$ on \mathbb{C}^{n+1} .
- 2. $\sum_{j=0}^n z_j \cdot A_j(z) \equiv 0$.
- 3. $\text{cod}_{\mathbb{C}}(\text{Sing}(\mathcal{F})) \geq 2$, where $\text{Sing}(\mathcal{F}) = (A_0 = \dots = A_n = 0)$. The set of singularities of \mathcal{F} is, by definition $\text{sing}(\mathcal{F}) = \Pi(\text{Sing}(fa))$, where $\Pi: \mathbb{C}^{n+1} \setminus \{0\} \rightarrow \mathbb{P}^n$ is the canonical projection.

It is well known that $\text{sing}(\mathcal{F})$ has always irreducible components of codimension two. Denote by $\text{Sing}_2(\mathcal{F})$ the union of the codimension two irreducible components of $\text{Sing}(\mathcal{F})$.

We prove essentially two results :

Theorem 1. *Let \mathcal{F} be a holomorphic codimension one foliation on \mathbb{P}^n , $n \geq 3$. Assume that for any $p \in \text{Sing}_2(\mathcal{F}) \setminus \{0\}$ then $j_p^1(\Omega_{\mathcal{F}}) \neq 0$, where j_p^1 denotes the 1-jet at p . Then \mathcal{F} has a non-constant rational first integral.*

The above result generalizes a previous result, due to Cerveau, Lins Neto and J. Omegar, in which is assumed that $d\Omega_{\mathcal{F}}(p) \neq 0$ for all $p \in \text{Sing}_2(\mathcal{F})$.

As a consequence of theorem 1 and previous results about Godbillon-Vey sequences for codimension one foliations, due to Cerveau, Lins neto, Loray, Pereira and Touzet, we obtain the following consequence :

Theorem 2. *Let \mathcal{F} be a codimension one foliation of degree $d = 3$ on \mathbb{P}^n . Then :*

- either \mathcal{F} has a projective transverse structure outside a hypersurface,
- or \mathcal{F} is the pull-back of a foliation on \mathbb{P}^2 by a rational map $\Phi: \mathbb{P}^n \rightarrow \mathbb{P}^2$.

Pierre Mathieu (Université de Provence, Marseille)**Título/Title:** Symmetric Diffusions in a Random Environment: The Einstein Relation**Resumo/Abstract:**

Diffusions or random walks in random environments were introduced as models for dynamics in non-homogeneous or disordered media. Here, we shall only be concerned with symmetric diffusions in \mathbb{R}^d whose generators can be written in divergence form. The main focus of the talk is a new approach for the so-called Einstein relation that relates the diffusivity and the mobility of a diffusing particle. (The Einstein relation is often considered as an early example of a fluctuation-dissipation relation.) Before getting to the Einstein relation itself, we shall review classical results on Central Limit Theorems and Laws of Large numbers for such processes.

(Based on joint work with N. Gantert and A. Piatnitski).

Frank Pacard (Université Paris 12 et Institut Universitaire de France)

Título/Title: Stationary solutions for the nonlinear Schrödinger equation

Resumo/Abstract:

Abstract : We consider the existence of finite energy solitary waves for the nonlinear Schrödinger equation. Paralleling a construction of N. Kapouleas for compact constant mean curvature surfaces in euclidean 3-space, we prove the existence of infinitely many non-radial solutions in any dimension $N \geq 2$. These solutions are invariant under the action of $D_k \times O(N - 2)$ where $D_k \subset O(2)$ denotes the subgroup generated by the rotation of angle $2\pi/k$, for some integer $k \geq 7$, but they are not invariant under the action of $O(2) \times O(N - 2)$. I will explain the similarities between the two constructions.

Benoit Perthame (Université Pierre et Marie Curie)

Título/Title: Fragmentation-Aggregation and Cell Division Equations: Motivations, Theory and The Inverse Problem

Resumo/Abstract:

Many processes are described by the fragmentation-aggregation integro-differential equations; they range from polymer description to cell division dynamics when structured by their size.

Several questions are relevant. In the linear case the first eigenvalue problem is fundamental to predict the growth of the system and the asymptotic size repartition; it turns out that this eigenproblem is not always wellposed (shattering effect for instance). The question long time dynamics in nonlinear cases is largely open even though we can prove that trajectories remain bounded and away from zero.

For applications the inverse problem is very useful and several strategies can be used in order to fit the coefficients with given solutions.

This talk is taken from collaborations with P. Michel, S. Mischler and L. Ryzhik; M. Doumic and J. Zubelli.

Stefano Olla (Université Paris Dauphine)

Título/Title: From microscopic dynamics to heat equation: a weak coupling approach

Resumo/Abstract:

We consider a chain of weakly coupled oscillators whose Hamiltonian dynamics is perturbed by stochastic terms that conserve kinetic energy of each particle. In a large-time weak-coupling limit, the energies of the particles evolves autonomously following a (non-gradient) stochastic Ginzburg-Landau dynamics. Then a non linear heat equation can be deduced from this stochastic dynamics under a hydrodynamic diffusive limit. This is a joint work with Carlangelo Liverani.

Harold Rosenberg (IMPA)

Título/Title: The geometry of surfaces in 3-dimensional homogeneous spaces

Resumo/Abstract:

I will discuss surfaces in the 3-dimensional homogeneous spaces $S \times \mathbb{R}$, $H \times \mathbb{R}$, Berger spheres, Heisenberg space, $PSL(2, \mathbb{R})$ -tilda, and $Sol(3)$. Here, S and H are the sphere and hyperbolic plane of curvature one and minus one respectively. I describe some examples and theorems depending on the mean, intrinsic or extrinsic curvature of the surface.

David Ruelle (Institut Des Hautes Etudes Scientifiques)**Título/Title:** Susceptibility Function For SRB States**Resumo/Abstract:**

An analytic function of a complex variable, called susceptibility, is associated with an SRB state. It is related to linear response, i.e., first order change of the SRB state under a small perturbation of the dynamics. We discuss the singularities of the susceptibility.

Aron Simis (Universidade Federal de Pernambuco)**Título/Title:** Distinguished Birational Maps**Resumo/Abstract:**

It is well-known that rational maps behave quite differently according to the characteristic of the prime field. In this talk I intend to give a view of both cases by concrete case illustration hinging on some recent results. The methods vary substantially from one to the other. This report is based on joint work with C. Ciliberto, F. Russo and R. Villarreal for its different parts.

Sylvain Sorin (Université Pierre et Marie Curie)**Título/Title:** Adaptive Dynamics in Games**Resumo/Abstract:**

We consider dynamics generated by repeated interactions in games.

Among them the replicator dynamics and the fictitious play process (in discrete time) or the best reply dynamics (in continuous time) have been widely studied, in particular in terms of convergence to equilibrium.

The unilateral counterpart of these processes - obtained when only the behavior of one agent is specified- exhibits also interesting asymptotic "consistency" properties.

We will describe other non regret procedures sharing these characteristics and discuss the consequences on the global dynamics.

Part of this work was done in collaboration with M. Benaim, J. Hofbauer and Y. Viossat.

Renato Tribuzy (UFAM)**Título/Title:** A Hopf Theorem for ambient spaces of dimensions higher than three**Resumo/Abstract:**

Abstract. We consider surfaces M^2 immersed in $E_c^n \times \mathbb{R}$, where E_c^n is a simply connected n -dimensional complete Riemannian manifold with constant sectional curvature $c \neq 0$, and assume that the mean curvature vector of the immersion is parallel in the normal bundle. We consider further a Hopf-type complex quadratic form Q on M^2 , where the complex structure of M^2 is compatible with the induced metric. It is not hard to check that Q is holomorphic. We will use this fact to give a reasonable description of immersed surfaces in $E_c^n \times \mathbb{R}$ that have parallel mean curvature vector.

Marcelo Viana (IMPA)

Título/Title: Absolute Continuity, Lyapounov Exponents and Rigidity

Resumo/Abstract:

We study the dynamics of partially hyperbolic conservative diffeomorphisms and, more specifically, the metric properties of their invariant foliations. Methods developed recently in the theory of linear cocycles unveiled a surprising rigidity phenomenon: if the center foliation is absolutely continuous then it is smooth, and the diffeomorphism itself is smoothly conjugate to a rigid model. Also surprising, this rigidity breaks down in the dissipative case.

This is based on joint works with A. Avila, A. Wilkinson and J. Yang

Jorge Vitório (IMPA)

Título/Title: Characteristic Foliations

Resumo/Abstract:

A hypersurface $Y \subset X$ of a complex symplectic manifold (X, ω) of dimension $2n$ carries a natural foliation by curves. It is defined by the restriction of ω^{n-1} to Y and is called the characteristic foliation of Y . I will discuss one conjecture and one question about these characteristic foliations.

The conjecture, due to Bernstein-Lunts, claims that for a generic polynomial vector field ξ on \mathbb{C}^n the characteristic foliation of its conormal variety does not admit invariant algebraic sets besides the obvious ones: the zero section of $T^*\mathbb{C}^n$ and the fibers over singular points of ξ .

The question, due to Hwang-Viehweg, asks if every leaf of the characteristic foliation of an ample smooth hypersurface in a projective symplectic manifold is non-algebraic.

I will sketch the proof of a generalization of the conjecture, and will provide evidence toward a positive answer to the question.

Auditorium Ricardo Mañé

Tuesday 08		Wednesday 09		Thursday 10		Friday 11	
08:30 09:00 Registration							
09:00 09:50	The geometry of surfaces in 3-dimensional homogeneous spaces H. Rosenberg	Non-hyperbolicities Lorenzo J. Diaz	Singularités d'Hypersurfaces Levi-Plates D. Cerveau	From microscopic dynamics to heat equation: a weak coupling approach S. Olla			
10:00 10:50	Symmetric Diffusions in a Random Environment: The Einstein Relation P. Mathieu	Existence and Uniqueness of Constant Mean Urvature Spheres in the Lie Hroup Sol_3 B. Daniel	Blowup and global sign-changing solutions of the nonlinear heat equation F. Dickstein	Distinguished Birational Maps A. Simis			
10:50 11:20 Coffee		Coffee		Coffee		Coffee	
11:20 12:10	Characteristic Foliations J. Pereira	Generalized Kupka components and foliations of degree three on $Pn \geq 3$ A. Lins Neto	A Schrödinger equation with time-oscillating nonlinearity T. Cazenave	Continuity properties of totally monotone capacities on Polish spaces and impatience A. Chateauneuf			
12:10 14:00 Lunch		Lunch		Lunch		Lunch	
14:00 14:50	Stationary solutions for the nonlinear Schrödinger equation F. Pacard	Fragmentation-Aggregation and Cell Division Equations: Motivations, Theory and The Inverse Problem B. Perthame	Isotopy Problems for Manifolds with Positive Curvature F. Codá	A Hopf Theorem for ambient spaces of dimensions higher than three R. Tribuzy			
15:00 15:50	Adaptive Dynamics in Games S. Sorin	Action functional and quasi-potential for the Burgers equation in a bounded interval C. Landim	A panorama of dynamical systems using the C1-topology C. Bonatti	Homogenization of degenerate porous medium type equations in ergodic algebras H. Frid			
15:50 16:20 Coffee		Coffee		Coffee		Coffee	
16:20 17:10	Analogos of the Brauer-Siegel theorem for abelian varieties M. Hindry	Susceptibility Function For SRB States D. Ruelle	Scaling limits for trap models L. R. Fontes	Absolute Continuity, Lyapounov Exponents and Rigidity M. Viana			
17:30 20:00 Opening Ceremony Cocktail		Opening Ceremony Cocktail		Opening Ceremony Cocktail		Opening Ceremony Cocktail	

WELCOME TO IMPA!

1) Computational Facilities:

The participants can use the computers on the Hall of the 2nd floor

- The login is `impa2009`
- The password is `castorina110`

We also have wireless (WIFI) connection. The ESSID of the network is *impa-wl* and the password is *impacastorina*.

2) Location of IMPA:

IMPA is located near the Botanical Garden in the city of Rio de Janeiro, Brazil.

The address is:

Estrada Dona Castorina, 110 – CEP: 22460-320 Rio de Janeiro, RJ – Brasil.

However, many cab drivers may need the following instructions which we reproduce in Portuguese:

***HORTO, POR FAVOR: Vou para o IMPA na
ESTRADA DONA CASTORINA, 110
NO FINAL da rua PACHECO LEÃO à DIREITA DEPOIS do PONTO
FINAL da LINHA DE ONIBUS 409.***

3) Public Transportation:

How to get to IMPA:

The easiest and most cost effective (timewise) way to get to IMPA is by cab as described above. However, if you prefer to use public transportation see the next paragraph.

• From Copacabana:

You can use the bus line 125 (Jardim Botânico) from Avenida Princesa Isabel or Rua Barata Ribeiro and get off at the final stop. You should then walk uphill to Estrada Dona Castorina; IMPA is on the right hand side.

Since the 125 bus is somewhat infrequent, it is usually faster to follow a different route. Take the 572 or 584 bus and get off on Rua Jardim Botânico at the stop near ABBR and the “Pão de Açúcar” supermarket. Then, walk to Rua Lopes Quintas (which crosses Rua Jardim Botânico), go to the bus stop near the newsstand, take a 409 or 125 bus and get off at the final stop. From then on, follow the instructions at the end of the previous paragraph.

• From Ipanema and Leblon

You can use the bus line 125 (to Jardim Botânico) from Rua Prudente de Moraes (Ipanema), Avenida General San Martin (Leblon), or Avenida Bartolomeu Mitre (Leblon) and get off at the final stop. You should then walk uphill to Estrada Dona Castorina; IMPA is on the right hand side.

Since the 125 bus is somewhat infrequent, it is usually faster to follow a different route. Take the 572, 512 or 584 bus and get off on Rua Jardim Botânico at the stop near ABBR and the “Pão de Açúcar” supermarket. Then, walk to Rua Lopes Quintas (which crosses Rua Jardim Botânico), go

to the bus stop near the newsstand, take a 409 or 125 bus and get off at the final stop. From then on, follow the instructions at the end of the previous paragraph.

• **From Flamengo, Botafogo and Humaitá**

You can use the bus line 409 (Sans Pena – Horto) from Praia do Flamengo (Flamengo Beach), Praia de Botafogo (Botafogo Beach) or Rua Humaitá, and get off at the final stop. Then walk uphill to Estrada Dona Castorina; IMPA is on theright hand side.

Information:

1. Registration Fee

Ph. D	R\$100.00
Ph. D Students	R\$50.00
IMPA's Students	R\$30.00

2. Contact

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