Marcelo Viana

Birth: March 4, 1962 - Rio de Janeiro. **Citizenship:** Brazilian & Portuguese

Degrees: B.Sc. University of Porto, 1984, Ph.D. IMPA, 1990

Affiliation: Professor of Mathematics
Instituto de Matemática Pura e Aplicada (IMPA)
Est. D. Castorina 110, Jardim Botânico, 22460-320 Rio de Janeiro, Brazil
Tel: +55 21 2529 5114 Fax: +55 21 5112 4115 Email viana@impa.br

Selected Invited Lectures

- Invited Speaker, *Intern. Congr. of Mathematicians*, ICM-Zurich, 1994.
- Plenary Speaker, *Intern. Congr. of Mathematical Physics*, Paris, 1994.
- Plenary Speaker, *Intern. Congr. of Mathematicians*, ICM-Berlin, 1998.
- *Equadiff*, Berlin, 1999.
- Medal Lecture, *1st Latin American Congr. of Math.*, Rio de Janeiro, 2000.
- *Colloque Michael Herman*, Institut Henri Poincaré, Paris, 2002.
- *Clay Institute Conference on Dynamical Systems*, MSRI, Berkeley, 2004.
- *Nonlin. Science in 3 Continents*, Cons. for the Americas, Santa Fé, 2005.
- *European Conference on Complex Systems*, Oxford, 2006.
- *Mathematics in the World*, Hungarian Academy of Sciences, 2008.
- *Dynamical Trends in Analysis*, Royal Institute of Technology, Stockholm, 2009.

Ph.D. Students:

José F. Alves, 1997; Maria João Costa, 1998; Isabel Rios, 1998; Armando Castro, 1998; Vítor Araújo, 1998; Vanderlei Horita, 1999; Alexandre Baraviera, 2000; Paulo Sabini, 2001; Nivaldo Muniz, 2001; Jairo Bochi, 2001; Flávio Abdenur, 2002; Krerley Oliveira, 2002; Mychelle Dysman, 2003; Alexander Arbieto, 2004; Carlos Matheus, 2004; Nuno Luzia, 2005; Mário Bessa, 2005; Martin Andersson 2007; Jimmy Santamaria, 2007; Paulo Varandas, 2007; Jiagang Yang, 2008; Javier Solano, 2009; Maria João Resende, 2009; Alien Herrera Torres, 2009.

Grants and Distinctions

- Calouste Gulbenkian Foundation Fellowship, 1988-1990
- Guggenheim Foundation Fellowship, 1993-1994
- Brazilian Academy of Sciences, elected in 1997
- TWAS Award in Mathematics, 1998
- TWAS-Academy of Sciences for the Developing World, elected in 2000.
- Grand Croix Order of Scientific Merit, by the President of Brazil, 2000.
- Ramanujan Prize, ICTP, 2005.
- Portuguese Academy of Sciences, elected in 2006
- Prize University of Coimbra, 2007.
- "Grande Cientista Brasileiro", Universidade Federal Fluminense, 2009.
- Chilean Academy of Sciences, elected in 2009.

Editorial

Editor/Editorial Board Member for Dynamics and Stability of Systems, Nonlinearity, Ergodic Theory & Dynamical Systems, Dynamical Systems: An International Journal, Portugaliae Mathematica, Discrete and Continuous Dynamical Systems, Journal of Stochastics and Dynamics, Dynamics of Partial Differential Equations. Referee for all major mathematical journals.

Selected Publications (complete list includes some 65 scientific publications)

• *Abundance of strange attractors*, with L. Mora, Acta Math. 171 (1993), 1-71.

• *High dimension diffeomorphisms displaying infinitely many periodic attractors*, with J. Palis, Annals of Math. 140 (1994), 207-250.

• *Strange attractors in saddle-node cycles: prevalence and globality*, with L. J. Díaz and J. Rocha, Invent. Math. 125 (1996), 37-74.

• *Multidimensional nonhyperbolic attractors*, Publ. Math. IHES. 85 (1997), 63-96.

• *Infinite-modal maps with global chaotic behavior*, with M. J. Pacifico and A. Rovella, Annals of Math. 148 (1998), 1-44.

• *Dynamics: a probabilistic and geometric perspective*, Documenta Mathematica - ICM98 vol. 1 (1998), 557-578.

• *SRB measures for partially hyperbolic systems whose central direction is mostly expanding*, with J. F. Alves and C. Bonatti, Invent. Math. 140 (2000), 351-398.

• *Solution of the basin problem for Hénon-like attractors*, with M. Benedicks, Invent. Math. 143 (2001), 375–434.

• *Lyapunov exponents with multiplicity* 1 *for deterministic products of matrices*, with C. Bonatti, Ergod. Th. & Dynam. Sys. 24 (2004), 1295-1330.

• *Dynamics beyond uniform hyperbolicity*, with C. Bonatti and L. J. Díaz, vol 102 of Enc. Math. Sciences, Springer Verlag, Heidelberg, 2004.

• *Abundance of stable ergodicity*, with C. Bonatti, C. Matheus, A. Wilkinson, Commentarii Math. Helvetici 79 (2004), 753-757.

• *Lyapunov exponents of generic volume preserving and symplectic systems*, with J. Bochi, Annals of Math. 161 (2005), 1423-1485.

• *Simplicity of Lyapunov spectra: Proof of the Zorich-Kontsevich conjecture*, with A. Avila, Acta Math. 198 (2007), 1–56.

• *Almost all linear cocycles over a hyperbolic system have non-vanishing Lyapunov exponents*, Annals of Math. 167 (2008), 645–682.

• *Singular hyperbolic attractors are chaotic*, with V. Araújo, M. J. Pacifico, E. Pujals, Trans. Amer. Math. Soc. 361 (2009), 2431–2485.

Administration

• IMPA: Chair for Scientific Activities (1996–2003) and Deputy Director (2004-2007)

• UMALCA - Mathematical Union for Latin America and the Caribbean: Scientific Coordinator (2001–2008)

• CNPq - Brazil's National Research Council: Chair Committee for Mathematics (1998–2001 and 2004–2007) and member of Directing Council (nominated in 2009).

• CAPES - Brazil's Graduate Studies Agency: Chair Committee for Mathematics (2008–2010)

• IMU - International Mathematical Union: Member Executive Committee (2007-2010)

• SBM - Brazilian Mathematical Society, Vice-President (2009-2011)

• Organizer of some 40 scientific meetings, in Brazil and abroad (USA, China, Italy, Portugal, Mexico, Chile).

• Member of several international prize committees and evaluation panels.

Main Scientific Contributions

•**Coexistence of infinitely many attractors:** In Annals of Mathematics, 1994 Viana and Palis extend to arbitrary dimension a famous theorem on coexistence of infinitely many attractors, proved in the 1970's by Newhouse in dimension two. The difficulties involved in this extension are substantial. The coexistence phenomenon relies on fine geometric properties of hyperbolic sets and their associated invariant laminations, many of which are still unknown, or simply false in higher dimensions. To overcome these difficulties, they develop an "intrinsic calculus", based on a notion of differentiability a la Whitney, which proved to be the right tool for describing the geometry of invariant laminations. This is a very elegant and powerful approach, and it applies in great generality.

•**Rigorous construction of strange attractors:** In his thesis "Strange attractors in the higher dimensions" Viana proved that chaotic attractors are a probabilistically persistent phenomenon for systems in any manifold. This was a follow-up to his paper in Acta Mathematica 1993, joint with Mora, which dealt with the case of surface diffeomorphisms: chaotic attractors or repellers occur, with positive probability in parameter space, whenever a homoclinic tangency is generically unfolded. The work of Benedicks and Carleson (winner of the Abel Prize 2007) on the Hénon maps had just appeared, and these results of Viana not only extended it substantially, they also provided a natural set-up for it, in the context of bifurcations of dissipative systems.

•**Prevalence of chaotic behavior:** Also in this direction went another series of remarkable results, published in Inventiones 1996, where Viana proves that chaotic dynamics occurs persistently in other major bifurcation mechanisms, jointly with Díaz and Rocha. Perhaps even more striking, this paper contains the first construction of global chaotic attractors, that is, with a basin of attraction that is prescribed a priori.

•**Solution of the basin problem:** Possibly one of Viana's best results was the solution of the basin problem for Hénon-like systems. By the mid-nineties the dynamics of Hénon-like maps was better understood, and it had been shown that the attractor supports a unique physical (Sinai-Ruelle-Bowen) measure. But a major question remained open. The basin problem, raised by Sinai and Ruelle in the seventies, asked whether almost every point in the basin of attraction has the statistics prescribed by physical measure. This was brilliantly solved by Viana, affirmatively, in a paper that appeared in Inventiones, 2001, joint with Benedicks.

•Staibility under random noise: In another important recent contribution, Viana and Benedicks also show that Hénon-like attractors are stochastically stable, that is, the statistics of orbits in the basin attraction are stable under small random noise.

•Construction of multidimensional attractors: The paper "Multidimensional non-hyperbolic attractors", in Publ. Math. IHES, 1997, pushes a different aspect of the theory. Viana constructs chaotic non-hyperbolic attractors genuinely multi-dimensional, not only topologically but also dynamically (several expanding directions). These attractors turn out to be very different from the low-dimensional counterparts, in particular they are robust (open set of perturbations) and not just probabilistically persistent. This fundamental paper pioneered a focus on partial

hyperbolicity, which has been one of the most active topics ever since, and opened the way to understanding multi-dimensional chaotic behaviour.

In that same year, Viana also solved the problem of existence of robust multi-dimensional attractors for vector fields. The question had been around since the seventies, motivated by the construction of the so-called geometric Lorenz attractors.

•**Ergodic theory of partially hyperbolic systems:** Also among Viana's finest results are his recent contributions to the ergodic theory of partially hyperbolic systems. In two papers published in 2000 in Inventiones and Israel J. of Mathematics, jointly with Alves and Bonatti, he proves a series of existence and finiteness theorems for physical measures. The proof is based on a notion of hyperbolic times, introduced in a particular case in the thesis of Alves, Viana's first graduate student.

•**Theory of Lyapunov exponents of linear cocycles:** More recently, Viana has been working on the dependence of Lyapunov exponents and entropy on the dynamical systems. Together with Bochi, another of his graduate students, he has just proved the following striking dichotomy for conservative systems: a residual subset of all volume-preserving diffeomorphisms on a compact manifold are either uniformly projectively hyperbolic (dominated decomposition of the tangent space) or not at all hyperbolic (all Lyapunov exponents equal to zero), almost everywhere. The two-dimensional case, which is easier, had been announced by Mañé in the early eighties, and the first proof was given in Bochi's thesis.

•**Solution of the Zorich-Kontsevich conjecture:** Then, less than a year ago, Viana pushed the theory of Lyapunov

•**Thermodynamical formalism for non-hyperbolic maps:**

December 2, 2009, Marcelo Viana