

# Rodrigo Felipe de Oliveira **Pena**

POST-DOCTORAL RESEARCH ASSOCIATE ·

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## Education

### USP(University of São Paulo)

PH.D. IN PHYSICS

Ribeirão Preto, São Paulo, Brazil

Feb. 2014 - Dec. 2018

### HUB(Humboldt Universität zu Berlin)

VISITING PH.D. STUDENT

Berlin, Germany

Sept. 2015 - Oct. 2016

### EPFL(École Polytechnique Fédérale de Lausanne)

RESEARCH INTERNSHIP AND EXCHANGE STUDIES

Lausanne, Switzerland

Mar. 2012 - Feb. 2013

### USP(University of São Paulo)

B.S. IN MEDICAL PHYSICS

Ribeirão Preto, São Paulo, Brazil

Mar. 2009 - Dez. 2013

### UNASP(University Center Adventist São Paulo)

TECHNICAL EDUCATION IN COMPUTER SCIENCE

Hortolândia, São Paulo, Brazil

Feb. 2005 - Dez. 2007

## Scientific projects & collaborations

### Post-Doctoral Research Associate (Supervised by Prof. Horacio G. Rotstein)

NEW JERSEY INSTITUTE OF TECHNOLOGY

Newark, New Jersey, USA

2019 - PRESENT

- Theoretical and computational research addressing neuronal mechanisms of generation of network resonance.
- Supported by the National Science Foundation grant DMS-1608077 (HGR).

### Ph.D project (Supervised by Prof. Antonio C. Roque)

UNIVERSITY OF SÃO PAULO

Ribeirão Preto, São Paulo

2014 - 2018

- Activity propagation in hierarchical and modular networks of spiking neurons.
- Supported by a FAPESP Ph.D. scholarship (grant 2013/25667-8).

### Collaboration with the Laboratory of Electrophysiology at the School of Medicine of Ribeirão Preto, University of São Paulo (Dra. Alexandra Cunha and Dr. Ricardo Leão)

UNIVERSITY OF SÃO PAULO

Ribeirão Preto, São Paulo

2017 - PRESENT

- Application of computational methods in electrophysiological recordings.

### Ph.D exchange project (Supervised by Dr. Michael Zaks)

HUMBOLDT UNIVERSITÄT ZU BERLIN

Berlin, Germany

2015 - 2016

- Self-sustained activity in hierarchical and modular networks with synaptic noise.
- Supported by a FAPESP Research Internships Abroad (BEPE) fellowship (grant 2015/09916-3).

### Ph.D exchange project (Supervised by Prof. Benjamin Lindner)

BERNSTEIN CENTER FOR COMPUTATIONAL NEUROSCIENCE

Berlin, Germany

2015 - 2016

- Determination of spike-train statistics with an iterative scheme.
- Research under the scope of the International Research Training Group (IRTG) 1740.

### Research internship project (Supervised by Dr. Christian Gaumier)

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Lausanne, Switzerland

2012 - 2013

- Modeling diseases propagation using graph theory.
- Supported by the Science without Borders fellow (CNPq).

### Undergraduate scientific project (Supervised by Prof. Antonio C. Roque)

UNIVERSITY OF SÃO PAULO

Ribeirão Preto, São Paulo

2010 - 2013

- Self-sustained activity in cortical networks of spiking neurons.
- Supported by a FAPESP scholarship for undergraduate students (grant 2011/06806-1).

- Integration of different institutional databases: acquisition of medical-hospital equipment, confrontation and correction of inconsistencies, and search for clinical evidence for technical-scientific advice.
- Supported by a FAEPA scholarship.

## Honors & Awards

2022	<b>Poster award winner</b> , 17th Annual Conference on Frontiers in Applied and Computational Mathematics	New Jersey, USA
2019	<b>Honorable Mention for Ph.D. Thesis due to its excellent quality</b> , Graduate Program in Physics Applied to Medicine and Biology (FAMB)	São Paulo, Brazil
2018	<b>Travel Award CNS*2018</b> , Conference Organization For Computational Neuroscience (2018)	Seattle, USA
2018	<b>Best project presented award</b> , LASCON – Latin American School on Computational Neuroscience (2018)	São Paulo, Brazil
2014	<b>John Roderick Cameron award</b> , Best student graduating with honors in Medical Physics	São Paulo, Brazil
2014	<b>Second best presentation award</b> , GCARI-RP meeting	São Paulo, Brazil
2012	<b>Best presentation award</b> , Brazilian Conference in Medical Physics	São Paulo, Brazil
2012	<b>Science Without Borders</b> , Brazilian scholarship to pursue one year of studies in Switzerland	Lausanne

## Publications

### PEER REVIEWED JOURNALS

- Pena, R.F.O.**, Rotstein, H.G. (2022). Oscillations and variability in neuronal systems: the role of autonomous transient dynamics in the presence of fast deterministic fluctuations. *Journal of Computational Neuroscience*, 50:331–355. doi:10.1007/s10827-022-00819-7
- Pena, R.F.O.**, Rotstein, H.G. (2022). The voltage and spiking responses of subthreshold resonant neurons to structured and fluctuating inputs: persistence and loss of resonance and variability. *Biological Cybernetics*, 116:163–190. doi:10.1007/s00422-021-00919-0
- Lima, V., **Pena, R.F.O.**, Shimoura, R.O., Kamiji, N.L., Ceballos, C.C., Higa, G.S.V., de Pasquale, R., Roque, A.C. (2021). Modeling and characterizing stochastic neurons based on in vitro voltage-dependent spike probability functions. *The European Physical Journal - Special Topics*, 230:2963–2972. doi:10.1140/epjs/s11734-021-00160-7.
- Shimoura, R.O., **Pena, R.F.O.**, Lima, V., Kamiji, N.L., Girardi-Schappo, M., Roque A.C. (2021). Building a model of the brain: from detailed connectivity maps to network organization. *The European Physical Journal - Special Topics*, 230:2887–2909. doi:10.1140/epjs/s11734-021-00152-7
- Ceballos, C.C., **Pena, R.F.O.**, Roque A.C. (2021). Impact of the activation rate of the hyperpolarization-activated current  $I_h$  on the neuronal membrane time constant and synaptic potential duration. *The European Physical Journal - Special Topics*, 230:2951–2961. doi:10.1140/epjs/s11734-021-00176-z
- Shimoura, R.O., **Pena, R.F.O.**, Kamiji, N.L., Lima, V., Roque A.C., Models of neocortical neuronal networks and observed emergent phenomena. *Brazilian Journal of Education in Physics*, 43: e20200452. doi:10.1590/1806-9126-RBEF-2020-0452
- Lima, V., Dellajustina, F.F., Shimoura, R.O., Girardi-Schappo, M., Kamiji, N.L., **Pena, R.F.O.**, Roque, A.C. Granger causality in the frequency domain: derivation and applications. *Brazilian Journal of Education in Physics*, 42:e20200007. doi:10.1590/1806-9126-RBEF-2020-0007
- Pena, R.F.O.**, Ceballos C.C., Deus, J.L., Roque, A.C., Garcia-Cairasco, N., Leão, R.M., Cunha A.O. (2020). Modeling hippocampal CA1 GABAergic synapses of audiogenic rats. *International Journal of Neural Systems*, 30:2050022. doi:10.1142/S0129065720500227
- Pena, R.F.O.**, Lima, V., Shimoura, R.O., Novato, J.P., Roque, A.C. (2020). Optimal interplay between synaptic strengths and network structure enhances activity fluctuations and information propagation in hierarchical modular networks. *Brain Sciences*, 10:228. doi:10.3390/brain-sci10040228
- Pena, R.F.O.**, Lima, V., Ceballos, C.C., Shimoura, R.O., Rotstein, H.G., Roque, A.C. (2019). Asymmetrical voltage response in resonant neurons shaped by nonlinearities. *Chaos*, 29:103135. doi:10.1063/1.5110033
- Borges, F.S., Protachevitz, P.R., **Pena, R.F.O.**, Lameu, E.L., Higa, G.S.V., Kihara, A.H., Matias, F.S., Antonopoulos, C.G., de Pasquale, R., Roque, A.C., Iarosz, K.C., Ji, P., Batista, A.M. (2020). Low frequency self-sustained activity in balanced networks. *Physica A*, 537:122671. doi:10.1016/j.physa.2019.122671
- Pena, R.F.O.**, Zaks, M., Roque, A.C. (2018). Spontaneous activity dynamics in random networks of spiking neurons with synaptic noise. *Journal of Computational Neuroscience*, 45:1–28. doi:10.1007/s10827-018-0688-6
- Pena, R.F.O.**, Ceballos, C.C., Lima, V., Roque, A.C. (2018). Interplay of activation kinetics and the derivative conductance determines resonance properties of neurons. *Physical Review E*, 97:042408. doi:10.1103/PhysRevE.97.042408
- Pena, R. F.O.**, Vellmer, S., Bernardi, D., Roque, A. C., and Lindner, B. (2018). Self-Consistent Scheme for Spike-Train Power Spectra in Heterogeneous Sparse Networks. *Frontiers in Computational Neuroscience*, 12:9. doi:10.3389/fncom.2018.00009
- Lima, V., **Pena, R.F.O.**, Ceballos, C.C., Shimoura, R.O., Roque, A.C. (2019). Information theory applications in neuroscience. *Brazilian Journal of Education in Physics*, 41:e20180197. doi:10.1590/1806-9126-rbef-2018-0197
- Cunha A.O., Ceballos C.C., Deus, J.L., **Pena, R.F.O.**, Oliveira, J.A.C., Roque, A.C., Garcia-Cairasco, N., Leão, R.M. (2018). Intrinsic and synaptic properties of hippocampal CA1 pyramidal neurons of the Wistar Audiogenic Rat (WAR) strain, a genetic model of epilepsy. *Scientific Reports*, 8:10412. doi:10.1038/s41598-018-28725-y
- Shimoura, R.O., Kamiji, N.L., **Pena, R.F.O.**, Cordeiro, V., Ceballos, C.C., Romaro, C., Roque, A.C. (2018). [Re] The cell-type specific cortical micro-circuit: relating structure and activity in a full-scale spiking network model. *The ReScience Journal*, 4:785-806. doi:10.5281/zenodo.1243268
- Ceballos, C. C., **Pena, R. F.**, Roque, A. C., and Leão, R. M. (2018). Non-Decaying postsynaptic potentials and delayed spikes in hippocampal pyramidal neurons generated by a zero slope conductance created by the persistent  $Na^+$  current. *Channels*, 12:81–88. doi:10.1080/19336950.2018.1433940
- Tomov, P., **Pena, R. F.**, Roque, A. C., and Zaks, M. A. (2016). Mechanisms of self-sustained oscillatory states in hierarchical modular networks with mixtures of electrophysiological cell types. *Frontiers in Computational Neuroscience*, 10:23. doi:10.3389/fncom.2016.00023
- Tomov, P., **Pena, R. F.**, Zaks, M. A., and Roque, A. C. (2014). Sustained oscillations, irregular firing, and chaotic dynamics in hierarchical modular networks with mixtures of electrophysiological cell types. *Frontiers in Computational Neuroscience*, 8:103. doi:10.3389/fncom.2014.00103

#### MANUSCRIPTS SUBMITTED OR IN PREPARATION

- Mondal, Y., **Pena, R.F.O.**, Rotstein, H.G. Temporal filters in response to presynaptic spike trains: Interplay of cellular, synaptic and short-term plasticity time scales. **Accepted**, Journal of Computational Neuroscience. [doi](https://doi.org/10.1101/2021.09.16.460719)10.1101/2021.09.16.460719

#### OTHER PUBLICATIONS

- My Career in the Midst of a Pandemic: Overcoming the Limitations of COVID-19. *Journal of Stories in Science*. [link](#)
- The publication "Modeling hippocampal CA1 GABAergic synapses of audiogenic rats" was in covered by the media in many important national Brazilian newspapers including UOL VivaBem which is a web newspaper content and the fifth most visited website in Brazil (data from 2012). [link](#)
- **Pena, R.F.O.**, Lima, V., Ceballos, C.C., Shimoura, R.O., Roque, A.C. (2019). A new measure to evaluate subthreshold resonance in neurons. Book Chapter at *The Production of Knowledge in Biomedical Engineering*, [doi](https://doi.org/10.22533/at.ed.8281901069)10.22533/at.ed.8281901069

## Teaching experience & organization of scientific events

#### INVITED LECTURER FOR THE COURSE INTRODUCTION TO SYSTEMS BIOLOGY AT NJIT 2022

2022

- Responsible for teaching crash courses on Python and Machine Learning.

#### SATELLITE WORKSHOP AT THE BERNSTEIN CONFERENCE 2021

2021

- Responsible for the organization and selection of speakers of the satellite workshop "Frequency-preference responses to external perturbations: from neurons to networks" at the Bernstein Conference 2021.

#### SATELLITE WORKSHOP AT THE BERNSTEIN CONFERENCE 2018

2018

- Responsible for the organization and selection of speakers of the satellite workshop "Resonance in neurons and neural networks: theoretical and experimental approaches" at the Bernstein Conference 2018.

#### INTRODUCTION TO COMPUTATIONAL NEUROSCIENCE

2018

- Responsible for a lecture in a 3 days Introduction to Computational Neuroscience course in the XLI Annual Meeting of the Brazilian Society for Neuroscience (SBNeC).

#### NUMERICAL METHODS FOR DIFFERENTIAL EQUATIONS

Autumn 2018

- Teaching Assistant.

#### TUTORIAL COURSE IN COMPUTATIONAL NEUROSCIENCE

2018

- Responsible for a 2 days hands-on Computational Neuroscience course Satellite of the XLI Annual Meeting of the Brazilian Society for Neuroscience (SBNeC).
- Course available at [sisne.org/eventos/pcn2](https://sisne.org/eventos/pcn2)

#### TUTORIAL COURSE IN COMPUTATIONAL NEUROSCIENCE

2017

- Responsible for a 2 days hands-on Computational Neuroscience course Satellite of the XL Annual Meeting of the Brazilian Society for Neuroscience (SBNeC).
- Course available at [sisne.org/eventos/praticoneuro](https://sisne.org/eventos/praticoneuro)

#### TUTORIAL COURSE IN COMPUTATIONAL NEUROSCIENCE

2017

- Responsible for a 5 days hands-on laboratory entitled "Neuro Mathematics" during the 4th Summer School on Intelligent signal processing for Frontier Research and Industry.

#### PHYSICS II – WAVES, FLUIDS AND THERMODYNAMICS

Autumn 2017

- Teaching Assistant.
- Helped prepare lecture material and answered student questions for office hours.

#### COMPUTATIONAL PHYSICS

Spring 2015

- Teaching Assistant.
- Helped prepare lecture material, graded students exercises, and answered student questions for office hours.

#### BIOPHYSICS II

Spring 2011

- Teaching Assistant.
- Answered student questions for office hours.

#### PHYSICS I – CLASSICAL MECHANICS

Spring 2010

- Teaching Assistant.
- Answered student questions for office hours.

## Selected abstracts & presentations

- **Pena, R.F.O.**, Ibarra, M., Rotstein, H.G., Extracting intrinsic neuronal dynamics from spike-train cross-correlation functions of synaptically connected neurons, 17th Annual Conference on Frontiers in Applied and Computational Mathematics (FACM'22), 2022.
- **Pena, R.F.O.**, Chialva, U., Rotstein, H.G., The contribution of subthreshold voltage patterns to the theta-gamma hippocampal activity: a computational model, 17th Annual Conference on Frontiers in Applied and Computational Mathematics (FACM'22), 2022.
- **Pena, R.F.O.**, Rotstein, H.G., Resonance-based flexible selection of cognitive tasks and memory suppression in a hippocampus–prefrontal cortex network regulated by the nucleus reuniens, 50th Annual Meeting SfN, 2021.
- **Pena, R.F.O.**, Revealing the Link between Spiking Cross-Correlation Patterns and the Underlying Subthreshold Neuronal Dynamics, Conference on Dynamical Systems at SIAM Society for Industrial and Applied Mathematics, 2021.
- **Pena, R.F.O.**, Rotstein, H.G., Modeling theta-band resonance in a neocortical circuit, NeuroMatch 2.0, 2020.
- **Pena, R.F.O.**, Rotstein, H.G., Biophysics and dynamics shape the cross-correlation properties of monosynaptic connections, 29th Annual Computational Neuroscience Meeting (CNS), 2020
- Y. Mondal, **Pena, R.F.O.**, Rotstein, H.G., Synaptic short-term plasticity and temporal filters: interplay of synaptic and postsynaptic dynamics, 29th Annual Computational Neuroscience Meeting (CNS), 2020.
- **Pena, R.F.O.**, Rotstein, H.G., Modeling theta-band resonance in a neocortical circuit, 29th Annual Computational Neuroscience Meeting (CNS), 2020.
- **Pena, R.F.O.**, Chialva, U., Rotstein, H.G., Neuronal resonance may not be apparent, but still present, for realistic input signals using standard impedance measurements, 29th Annual Computational Neuroscience Meeting (CNS), 2020.
- **Pena, R.F.O.**, Revealing the Link between Spiking Cross-Correlation Patterns and the Underlying Subthreshold Neuronal Dynamics, Dynamics Days D 2020, 2020.
- **Pena, R.F.O.**, Emergence of activity fluctuations in cortical network models with heterogeneous neural populations, Biomathematics / Computational Biology Colloquium at Courant Department of Mathematics at New York University (NYU), 2019.
- **Pena, R.F.O.**, Roque, A.C., Zaks, M.A., Lifetime of self-sustained activity in random networks of two-dimensional integrate-and-fire neurons: role of input strength, Bernstein Conference, 2018. [doi:10.12751/nncn.bc2018.0146](https://doi.org/10.12751/nncn.bc2018.0146)
- **Pena, R.F.O.**, Zaks, M.A., Roque, A.C., Spontaneous activity patterns in networks of two-dimensional integrate and fire neurons with synaptic noise, Bernstein Conference, 2018. [doi:10.12751/nncn.bc2018.0147](https://doi.org/10.12751/nncn.bc2018.0147)
- **Pena, R.F.O.**, Lima, V., Celis, C.C., Roque, A.C., On the subthreshold resonance properties of neurons, 27th Annual Computational Neuroscience Meeting (CNS), 2018.
- **Pena, R.F.O.**, Bernardi D., Roque A.C., Lindner B., Determination of the spike-train power spectrum statistics in modular networks with mixtures of different excitatory and inhibitory populations, BMC Neuroscience (Online) [doi:10.1186/s12868-017-0371-2](https://doi.org/10.1186/s12868-017-0371-2), 2017.
- **Pena, R.F.**, Zaks, Michael A., Roque A.C., Noise-enhanced transition from synchronized to desynchronized states in a cortical network model, 2017, Washington. SfN 2017.
- **Pena, R.F.O.**, Roque A.C., Zaks, Michael A., Synaptic noise facilitates transitions from sleep-like state to awake-like state, 2017, Araraquara. SBNeC annual meeting, 2017.
- **Pena, R.F.O.**, Bernardi, D., Roque A.C., Lindner, B., Self-consistency in the second-order correlation statistics: from network to a single-neuron scheme, PNLD 2016.
- **Pena, R.F.O.**, Tomov, P., Roque A.C., Zaks, M., Up-down states in a neural network model and their relation with the individual neurons, PNLD 2016.
- **Pena, R.F.O.**, Tomov, P., Roque A.C., Zaks, M.A., Mechanisms of oscillatory self-sustained activity in a cortical model. ICMNS 2016.
- **Pena, R.F.O.**, Tomov, P., Roque A.C., Zaks, M.A., Breakdown and resumption of oscillatory self-sustained activity in hierarchical modular networks, FENS 2016, Copenhagen.
- Shimoura, R.O., **Pena, R.F.O.**, Roque A.C., Effect of synaptic plasticity on functional connectivity and global activity of a neocortical network model. BMC Neuroscience (Online), [doi:10.1186/1471-2202-16-S1-P210](https://doi.org/10.1186/1471-2202-16-S1-P210), 2015.
- **Pena, R.F.O.**, Shimoura, R.O., Roque A.C., A cortical multi-layered model and the properties of its internally-generated activity. BMC Neuroscience (Online), [doi:10.1186/1471-2202-16-S1-P209](https://doi.org/10.1186/1471-2202-16-S1-P209), 2015.
- **Pena, R.F.O.**, Roque A.C., A cortical microcircuit model to study structure-activity relationships. USP - SP 2015.
- **Pena, R.F.O.**, Tomov, P., Zaks, M.A., Roque A.C., Self-sustained Activity Lifetime in a Cortical Network Model, 9th World Congress International Brain Research Organization, 2015.
- Shimoura, R., **Pena, R.F.O.**, Roque A.C., Dynamics of a Cortical Multi-layered Model with Cells of Different Electrophysiological Classes, 9th World Congress International Brain Research Organization, 2015.
- Petar, Tomov, **Rodrigo, Pena.**, Michael, Zaks, Antonio, Roque, Self-sustained activity in cortical network models. Frontiers in Neuroinformatics, [doi:10.3389/conf.fninf.2014.18.00007](https://doi.org/10.3389/conf.fninf.2014.18.00007), 2014.
- **Pena, Rodrigo F.O.**, Roque A.C., A bio-inspired computational model to study cortical dynamics, SBNeC anual meeting, 2014.
- Roque A.C., Zaks, M., **Pena, R.F.O.**, A cortical multi-layered computational model and its dynamical properties. INPE, IRTG anual meeting at São José dos Campos 2014.
- Vieira, Diogo PC, **Pena, F.O.**, Roque, Antonio C., Self-sustained activity in neural networks: influence of network topology and cell types. BMC Neuroscience (Online), [doi:10.1186/1471-2202-14-S1-P411](https://doi.org/10.1186/1471-2202-14-S1-P411), 2013.
- Vieira, D. P. C., **Pena, R.F.O.**, Roque A.C., A study of spontaneous activity in modular neural networks made of neurons of different intrinsic dynamics, Dynamics Days Madrid, 2013.
- **Pena, R. F. O.**, Vieira, D. P. C., Roque A.C., Effect of topology and neuronal composition of a computational cortical model on self-sustained activity, SBNeC annual meeting, 2013.
- **Pena, R.F.O.**, Gaumier, C., Modeling diseases propagation using graph theory, Brazilian Conference in Medical Physics 2013.
- Tomov, P., Roque A.C., **Pena, R. F. O.**, Zaks, M., Modeling of self-sustained activity in neural networks, Dynamics Days BB, TU Berlin, 2013.
- **Pena, R.F.O.**, Roque A.C., Vieira, D. P. C., Construction and Analysis of a Modular and Hierarchical Model for the Cerebral Cortex, USP - Universidade de São Paulo 2011.

## Experience as a reviewer

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- IEEE Access (reviewed 7 papers)
- Cognitive Neurodynamics (reviewed 4 papers)
- Entropy (reviewed 3 papers)
- Frontiers in Computational Neuroscience (reviewed 3 papers)
- Frontiers in Neural Circuits (reviewed 1 paper)
- Frontiers in Applied Mathematics and Statistics (reviewed 1 paper)
- Frontiers in Cellular Neuroscience (reviewed 1 paper)
- Applied Sciences (reviewed 3 papers)
- European Physical Journal - Special Topics (reviewed 1 paper)
- Review of Scientific Instruments (reviewed 1 paper)
- Chaos: An Interdisciplinary Journal of Nonlinear Science (reviewed 1 paper)
- Big Data and Cognitive Computing (reviewed 2 papers)
- Processes (reviewed 1 paper)
- Journal of Sensor and Actuator Networks (reviewed 1 paper)
- Scientific Reports (reviewed 1 paper)
- Electronics (reviewed 2 papers)
- International Journal of Environmental Research and Public Health (reviewed 1 paper)
- Sensors (reviewed 4 papers)
- Mathematics (reviewed 2 papers)
- Algorithms (reviewed 1 paper)
- Symmetry (reviewed 1 paper)
- Brain Sciences (reviewed 1 paper)

## Programming Languages & Environments

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- Fluent in C/C++, Matlab, Python.
- Simulation tools for neuroscience including Brian, Brian2 and NEURON.
- Machine learning and Deep learning python packages such as scikit-learn and PyTorch.
- Experience with parallel programming (joblib and multiprocessing libraries for Python).
- Good experience with  $\text{\LaTeX}$  and UNIX-based systems.