

# Rodrigo Felipe de Oliveira **Pena**

POST-DOCTORAL RESEARCH ASSOCIATE · FEDERATED DEPARTMENT OF BIOLOGICAL SCIENCES · NEW JERSEY INSTITUTE OF TECHNOLOGY

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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

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, US
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

- 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*, 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*, 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*, 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 microcircuit: 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

- **Pena, R.F.O.**, Rotstein, H.G.R. Oscillations and variability in neuronal systems: the role of autonomous transient dynamics in the presence of fast deterministic fluctuations. **in review**. doi:10.1101/2021.06.14.448371
- **Pena, R.F.O.**, Rotstein, H.G.R. The voltage and spiking responses of subthreshold resonant neurons to structured and fluctuating inputs: resonance, loss of resonance and variability. **in review**. doi:10.1101/2021.06.14.448368
- Mondal, Y., **Pena, R.F.O.**, Rotstein, H.G.R. Temporal filters in response to presynaptic spike trains: Interplay of cellular, synaptic and short-term plasticity time scales. **in preparation**.

## 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 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:10.22533/at.ed.8281901069

## Programming Languages & Environments

- 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.

## Teaching experience & organization of scientific events

## 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.

## Experience as a reviewer

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- IEEE Access (reviewed 5 papers)
- Cognitive Neurodynamics (reviewed 2 papers)
- Frontiers in Neural Circuits (reviewed 1 paper)
- Frontiers in Computational Neuroscience (reviewed 2 papers)
- Frontiers in Applied Mathematics and Statistics (reviewed 1 paper)
- 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)
- Entropy (reviewed 1 paper)
- Big Data and Cognitive Computing (reviewed 1 paper)

## Abstracts & presentations

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- **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
- **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
- **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, 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.**, 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, 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, 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, 2014.
- **Pena, Rodrigo F.O.**, Roque A.C., A bio-inspired computational model to study cortical dynamics, SBNeC anual meeting, 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, 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.