Davide Maestrini

Curriculum Vitae

Current Position

Postdoctoral Research Fellow
Dep. of Mathematics
California State Univeristy at Nortridge
Northridge, CA

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Previous Positions

03/2017 - 07/2019 Postdoctoral Research Fellow
City of Hope National Research Center,
Department of Mathematical Oncology
Duarte, CA, USA.

Education

2012-2016 Ph.D. in Applied Mathematics, University of East Anglia, Norwich, United Kingdom.
Thesis title: *A Statistical Mechanical Approach of Self-Organization of a Quantised Vortex Gas in a Two-Dimensional Superfluid.*
Supervisor: Dr. Hayder Salman.

2006–2011 Laurea Specialistica (Master's Degree) in Physics of the Fundamental Interactions (Theoretical Physics), Università degli Studi di Torino, Italy.
Thesis title: *Dynamics of a Bose-Einstein condensate: numerical simulation of the Gross-Pitaevskii equation.*
Supervisor: Prof. Miguel Onorato (second supervisor: Dr. Davide Proment).

2002–2006 Laurea Triennale (Bachelor's degree) in Physics, Università degli Studi di Torino, Italy. Final project title: *Description and characterisation of a macroscopic state of strings.*
Supervisor: Prof. Marco Billò.

Teaching experience

03/2017 - 07/2019 City of Hope National Medical Center, Department of Mathematical Oncology, Duarte, CA, USA.
Lectures on stochastic processes and Ito calculus, statistical mechanics and phase transitions, dimensional reduction techniques.

02/2019 - 07/2019 City of Hope National Medical Center, Irell & Manella Graduate School of Biological Science, Duarte, CA, USA.
Lecturer for the module Mathematical Modelling and Methods for Biomedical Science.

08/2016-02/2017 University of East Anglia, Norwich, United Kingdom.
Learning Enhancement Tutor for Mathematics and Statistics

10/2012-02/2017 University of East Anglia, Department of Mathematics, Norwich, United Kingdom.
Teaching Assistant

2013-2017	Università degli Studi di Torino, Department of Physics (Invited by Prof. M. Onorato) Lectures on superfluids and Bose-Einstein Condensates.
2007-2012	High School Mathematics and Physics teacher.

Research interests

I am a theoretical physicist with specific training and expertise in quantum fluids, statistical mechanics, and Bose-Einstein condensates. I am interested in applying theoretical physics models to biological processes and I am currently working on theoretical aspects of the process of aging, disease development, and cancer dynamics.

- Aging and Disease Development
  Since DNA methylation is recognized as an important biomarker which characterizes the process of aging and it plays an important role in the development and progression of many common diseases, I am working on the extension of the concept of thermodynamics temperature to the DNA methylation state of the genome. In order to do so, I apply the Ising model and the statistical mechanics of phase transitions to study the correlation function associated with a sequence of methylated or unmethylated sites in the genome with data collected from the peripheral blood of a mouse model of acute myeloid leukmia. In this framework, aging and disease development, can be seen as a time evolution of a thermodynamic system characterized by a well-defined thermodynamic temperature and information, or Shannon, entropy. Preliminary results shown that time evolution of this last quantity can be used to describe the progression of acute myeloid leukemia. I am also interested in extending this approach to study chromosome organization with a particular note of interest on the topic of X Chromosome inactivation.

  I have also developed a theoretical model which may provide a possible explanation on different rates of aging. In particular, I extended the concepts of physical space and time to an abstract, mathematically-defined space, called "biological space-time" in which biological clocks operate. Assuming that a biological process may be represented as the motion of a point along a trajectory on a manifold, the concepts of precipitous or protracted aging can be described in terms of decelerating or accelerating motion of the point along the trajectory. As a consequence, precipitous (faster than chronological time) or protracted (slower) aging can be interpret as a dilation or contraction of time in the manifold in which the aging process occurs.

- Cancer Dynamics.
  I am currently working on a mathematical model of acute myeloid leukemia in which we hypothesize that the transcriptome as a whole undergoes a state change during the evolution form a reference health state to a leukemia state. The dynamics is conceptually represented as a particle undergoing Brownian motion in a double well quasi-potential energy. In unperturbed (normal) hematopoiesis, a large energy barrier reduces the probability that the system will transition to a state of leukemia while in the presence of an oncogenic event, the quasi-potential energy landscape is altered, lowering the energy barrier and thus increasing the probability of transition to leukemia.

During my Ph.D I focused on studying the dynamics and the relaxation of a vortex gas from a non-equilibrium initial condition consisting of vortices and antivortices in a two-dimensional Bose Einstein condensate. Using the point vortex model and by modeling the process of vortex-antivortex annihilation in superfluids by removing vortex dipoles, the vortex gas enters in the negative temperature regime and subsequently relaxes to a maximum entropy configuration with a consequent formation of large coherent structures. Because of the long-range nature of the Coulomb interactions between vortices, the large scale flow structures strongly depend on the container and their dynamics can be explained in terms of a maximum entropy principle for the vortex gas that

leads to the Boltzmann-Poisson equation. Moreover, I provided a direct qualitative and quantitative comparison between the predictions of the mean-field theory and dynamical simulations of a point of a point vortex model in different confining geometries. I have also extended the study to the dynamics of quantised vortices in the same confined geometries in a two-dimensional Bose-Einstein condensate described by the Gross-Pitaevskii equation providing a thorough connection between the point vortex model and the dynamics of quantized vortices in superfluids.

Grants & Awards

2018	Center for Cancer and Aging Research Pilot Awards, "Development and Validation of a Mathematical Framework for Cancer-Induced Accelerated Aging".
2012-2016	Winner of a Ph.D. research studentship funded by the University of East Anglia, Norwich, United Kingdom.

Publications

Submitted or in preparation

8. A mathematical modeling approach to explore kinetics of Chimeric Antigen Receptor (CAR) T-cell Response in glioma: the CARRGO model. P. Sahoo, X. Yang, D. Abler, **D. Maestrini**, V. Adhikarla, D. Frankhouser, H. Cho, V. Machuca, D. Wang, M. Barish, M. Gutova, S. Branciamore, C. Brown, and R. Rockne. *Submitted.*
7. On the concept of temperature in the Acute Myeloid Leukemia development. **D. Maestrini**, S. Branciamore, M. Caselle and R. Rockne, *in preparation.*
6. Activation of non-canonical mechanisms of microRNA biogenesis in FLT3-ITD Acute Myeloid Leukemia L. X. T. Nguyen, B. Zhang, D. H. Hoang, D. Zhao, E. Troadec, S. Branciamore, **D. Maestrini**, H. Wu, Y.-L. Su, A. Stein, H. Dong, D. Q. Nguyen, S. Rodriguez-Rodriguez, B. Armstrong, I. Aldoss, V. Pullarkat, L. Budde, L. Ghoda, D. Perrotti, F. Pichiorri, S. Rosen, M. Caligiuri, S. Forman, J. Chen, L. Li, M. Kortylewski, R. Rockne, Y.-H. Kuo, S. Khaled, N. Carlesso, and G. Marcucci. *In preparation.*
5. Evolutionary exploitation of PD-L1 expression in hormone receptor positive breast cancer. J. West, D. Park, C. Harmon, D. Williamson, P. Ashcroft, **D. Maestrini**, A. Ardaseva, R. Bravo, P. Sahoo, H. Khong, K. Luddy, and M. Robertson-Tessi. Preprint, bioRxiv 454447; doi: https://doi.org/10.1101/454447
4. Transcriptome dynamics describe and predict state transition from health to leukemia. R. C. Rockne, S. Branciamore, J. Qi, G. J. Cook, W.-K. Hua, E. Carnahan, A. Marom, H. Wu, **D. Maestrini**, X. Wu, C. Guo, D. O'Meally, Y.-C. Yuan, Z. Liu, N. Carlesso, L. D. Wang, S. Forman, Y.-H. Kuo, G. Marcucci bioRxiv 238923; doi: https://doi.org/10.1101/238923
3. Aging in a relativistic biological space-time. **D. Maestrini**, D. Abler, V. Adhikarla, S. Armenian, S. Branciamore, N. Carlesso, G. Marcucci, Y.-H. Kuo, P. Sahoo, R. Rockne Front. Cell Dev. Biol., 29 May 2018 | https://doi.org/10.3389/fcell.2018.00055
2. Entropy of Negative Temperature States for a Point Vortex Gas. **Maestrini, D.** and Salman, H. J Stat Phys (2019) 176: 981. https://doi.org/10.1007/s10955-019-02329-w
1. Long-range ordering of topological excitations in a two-dimensional superfluid far from equilibrium, Salman H. and **Maestrini D**., Phys. Rev. A **94**, 043642 (2016)

Conferences, workshops and seminars

02/2019	*8th Annual Southern California Systems Biology Conference* Univeristy of California Irvine, United States.

02/2018 *Ninth Workshop Dynamical Systems Applied to Biology and Natural Sciences (DSABNS)* Dipartimento di Matematica, Università di Torino, Italy
Poster: *Equation and dynamics of state transition from health to leukemia.*

11/2017 *Multi-scale Systems Modeling Biology Methods for Studying Biomedical Processes Under Stress or with Chronic or Acute Disease* University California Riverside, United States.

10/2017 *IMO Workshop 7: Stroma.* Moffitt Cancer Center, Tampa, United States.

04/2017 *Frontiers in Mathematical Oncology: Young Investigators Conference*, University of Maryland, College Park, United States.

12/2015 *Nonlinear Physics Workshop*, Torino, Italy.
Talk: *Geometry Induced Transition of Turbulent Vortex States in 2D Bose-Einstein Condensates.*

11/2015 *I.O.P. Hybrid Quantum Systems Far From the Equilibrium Conference*, Chicheley, UK.
Poster: *Vortex Clustering and Negative Temperature States in Two-Dimensional Bose-Einstein Condensates.*

07/2015 *Non-equilibrium Quantum Dynamics in Low Dimensions*, Durham, UK.
Poster: *Vortex Clustering and Negative Temperature States in Two-Dimensional Bose-Einstein Condensates.*

06/2015 *First Eastern Arc Conference on Topological Solitons and Quantum Fluids*, Norwich, UK.
Talk: *Vortex Clustering and Negative Temperature States in Two-Dimensional Bose-Einstein Condensates.*

06/2015 Day Seminar, Università degli Studi di Torino, Italy.
Talk: *The Superfluidity of ^{4}He and Bose Einstein Condensates.*

03/2015 *Outreach in Maths*, Norwich, UK.
Talk: *The Shape of the Droplets.*

08/2014 *S.I.A.M. Conference on Nonlinear Waves and Coherent Structure*, Cambridge, UK.
Talk: *Clustering and Negative Temperature Regime in a Point Vortex Gas.*

06/2014 *TIQF 2014 - Turbulence in Quantum Fluids Workshop*, Glasgow, UK.
Talk: *Clustering and Negative Temperature Regime in a Point Vortex Gas.*

07/2013 *NOTSCON - Conference on Statistical Physics and Condensed Matter*, Nottingham, UK.
Poster: *Vortex Dynamics in Two-Dimensional Bose-Einstein Condensates.*

Computer skills

- Excellent knowledge of MATLAB, good knowledge of C programming language and FFTW libraries
- Basic knowledge of Python and programming on graphic card devices using CUDA C.

References

These people are familiar with my professional qualifications and my character:

Dr. Russell Rockne
Division of Mathematical Oncology
City of Hope Beckman Research Institute
Duarte, CA, USA
Email: rrockne@coh.org

Dr. Sergio Branciamore
Dept. of Diabetes and Metabolic Diseases
City of Hope Beckman Research Institute
Duarte, CA, USA
Email: sbranciamore@coh.org

Dr. Hayder Salman
School of Mathematics
University of East Anglia
Norwich, United Kingdom
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Prof. Miguel Onorato
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Guido Marcucci M.D.
Dept. of Hematologic Malignancies
City of Hope Beckman Research Institute
Duarte, CA, USA
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