

## Arvind Murugan

### Curriculum Vitae

#### Personal details

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Contact address	James Franck Institute, 929 E. 57th Street Chicago IL 60637	<i>amurugan@uchicago.edu</i>
Research areas	Problems in quantitative biology, materials design, disordered systems, non-equilibrium dynamics and theoretical computer science. I am particularly interested in 'hardware' implementations (e.g., in biomolecules, reaction networks, self-assembly, soft materials/robotics) of behaviors usually seen in 'software' (e.g., error correction, inference, neural networks and machine learning).	

#### Employment

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Assistant Professor	<b>University of Chicago</b> , July 15– (present) Physics + James Franck Institute, Chicago, IL
Postdoc	<b>Harvard University</b> , Sep 12– May 15 School of Engineering and Applied Sciences, Cambridge, MA
Member	<b>Institute for Advanced Study</b> , Aug 09– Aug 12 School of Natural Sciences, Princeton, NJ
Visiting Researcher	<b>Rockefeller University</b> , Aug 09 – Aug 12 Laboratory of Living Matter, New York City, NY

#### Education

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PhD (Physics)	<b>Princeton University</b> , Sep 04– Jul 09 Princeton, NJ 08540 Thesis: "Gauge-gravity duality with renormalization group flow and reduced supersymmetry" Advisor: Prof. Igor R. Klebanov
M.S. (Physics)	<b>California Institute of Technology</b> , Jun 04 Pasadena, CA 91125 Advisor: Prof. Anton Kapustin

B.S. (Mathematics) **California Institute of Technology**, *with Honors*, Sep 00–Jun 04  
Pasadena, CA 91125  
Advisor: Prof. Dinakar Ramakrishnan

### Research articles

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#### **Natural odor statistics and optimal receptor design**

in collaboration with: D. Zwicker, M. Brenner  
in preparation

#### **Capacity of specific glues**

in collaboration with: M. Huntley, M. Brenner  
in preparation

#### **Biological implications of dynamical phases in non-equilibrium reaction networks**

in collaboration with: S. Vaikuntanathan  
invited contribution to the Journal of Statistical Physics (special issue), to appear

#### **Multifarious Assembly Mixtures: Systems Allowing Retrieval of Diverse Stored Structures**

in collaboration with: Z. Zeravcic, S. Leibler, M. Brenner  
Proceedings of the National Academy of Sciences **112**(1) 54-59 (2014)

#### **Undesired Usage and the Robust Self-Assembly of Heterogeneous Structures**

in collaboration with: J. Zou, and M. Brenner  
Nature Communications **6**, 6203 (Jan 2015)

#### **Discriminatory proofreading regimes in non-equilibrium systems**

in collaboration with: D.A. Huse, and S. Leibler  
Physical Review X **4** (2), 021016

#### **Speed, dissipation, and error in kinetic proofreading**

in collaboration with: D.A. Huse, and S. Leibler  
Proceedings of the National Academy of Sciences **109**(30):12034-9 (2012)

#### **AdS<sub>4</sub>/CFT<sub>3</sub> – squashed, stretched and warped**

in collaboration with: I.R.Klebanov and T.Klose  
Journal of High Energy Physics **0903** 140 (2009) arxiv:0809.3773 [hep-th]

#### **Goldstone Bosons and Global Strings in a Warped Resolved Conifold**

in collaboration with: I. R. Klebanov, D. Rodriguez-Gomez and J. Ward  
Journal of High Energy Physics **0805**, 090 (2008), arXiv:0712.2224 [hep-th]

**Entanglement as a Probe of Confinement**

in collaboration with: I. R. Klebanov and D. Kutasov  
 Nuclear Physics B **796**, 274 (2008), arXiv:0709.2140 [hep-th]

**Gauge/Gravity Duality and Warped Resolved Conifold**

in collaboration with: I. R. Klebanov  
 Journal of High Energy Physics **0703**, 042 (2007), arXiv:hep-th/0701064

**On D3-brane potentials in compactifications with fluxes and wrapped D-branes**

in collaboration with: D. Baumann, A. Dymarsky, I. R. Klebanov, J. M. Maldacena & L. McAllister  
 Journal of High Energy Physics **0611**, 031 (2006), arXiv:hep-th/0607050

**Fatgraph expansion for noncritical superstrings**

in collaboration with: A. Kapustin  
 arXiv:hep-th/0404238

**A new 3-D Regional Velocity Model for Real-time Hypocenter Determinations in Southern California**

in collaboration with: E. Hauksson  
 Proceedings of the Southern California Earthquake Center (Annual Meeting), 2002

**Invited talks and presentations**

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|---|---------------|
| <p><b>Rockefeller University</b>, New York, NY<br/>         Center for Studies in Physics and Biology,<br/>         “Control vs multi-functionality in disordered frustrated systems”</p>   | <p>Apr’15</p> |
| <p><b>University of Colorado</b>, Boulder, CO<br/>         Department of Physics, Colloquium<br/>         “Design principles for heterogeneous structure synthesis: Lessons from biology”<br/>         Department of Physics, Seminar<br/>         “Non-equilibrium error correction in biological and synthetic systems”</p> | <p>Mar’15</p> |
| <p><b>APS Invited Talk</b>, San Antonio, TX<br/>         “Non-equilibrium error correction in biological and synthetic systems”</p>   | <p>Mar’15</p> |
| <p><b>University of Massachusetts, Amherst</b>, Amherst, MA<br/>         Department of Physics,<br/>         “Design principles for heterogeneous structure synthesis: Lessons from biology”</p>  | <p>Mar’15</p> |

- University of San Diego**, San Diego, CA Feb'15  
Department of Physics,  
“Design principles for heterogeneous structures”
- MIT**, Cambridge, MA Feb'15  
Department of Physics,  
“Design principles for heterogeneous structure synthesis: Lessons from biology”
- Aspen Institute for Physics**, Aspen, CO Feb'15  
Unified Concepts in Glass Physics VI,  
“Associative memory: A forgotten property of marginal frustrated systems”
- Cornell**, Ithaca, NY Jan'15  
LASSP and Applied Physics seminar,  
“Design principles for heterogeneous structure synthesis: Lessons from biology”
- University of Chicago**, Chicago, IL Jan'15  
James Franck Institute,  
“Design principles for heterogeneous structure synthesis: Lessons from biology”
- Princeton University**, Princeton, NJ Dec'14  
Department of Chemistry,  
“Design principles for heterogeneous structure synthesis: Lessons from biology”
- Universite Joseph Fourier**, Grenoble, France Jul'14  
Laboratory of Interdisciplinary Physics,  
“Associative memory and bottom-up materials synthesis”
- University of Nice**, Nice, France Jun'14  
Laboratory of Condensed Matter Physics,  
“Associative memory and bottom-up materials synthesis”
- Ecole Superieure de Physique et de Chimie Industrielles (ESPCI)** , Paris Jun'14  
jointly with Ecole Normale Superieure (ENS),  
“Associative memory and bottom-up materials synthesis”
- Brandeis**, Waltham, MA Jun'14  
Physics Department  
“Design principles for heterogeneous materials synthesis: Lessons from biology”

- University of Chicago**, Chicago, IL May'14  
Computations in Science Seminar,  
"Design principles for heterogeneous materials synthesis: Lessons from biology."
- University of Maryland** College Park, MD Apr'14  
Institute for Physical Science and Technology,  
"Design principles for material synthesis : Lessons from biology"
- Northwestern**, Evanston, IL Jan'14  
Applied Math Colloquium  
"Design principles for material synthesis : Lessons from biology"
- Boston Physical Biology Hangout**, MIT Dec'13  
"Principles of non-equilibrium error-correction"
- Harvard University**, Bauer Forum Nov'13  
"Self-assembly in imperfect conditions"
- Harvard University**, Cambridge, MA Dec'11, Oct'12  
Kavli Talk at the Kavli Institute for Bionano Science & Technology,  
Condensed Matter Kids Seminar  
"Kinetic Proofreading and Non-Equilibrium Occupancy of States"
- Perimeter Institute for Theoretical Physics**, Ontario, Canada Dec 2008  
at the "Young Researchers Conference",  
"Gauge-gravity duality in  $2 + 1$  dimensions"
- Institute for Nuclear Theory, U. Washington**, Seattle, WA May 2008  
at the "String Theory Methods in the Real World" conference,  
"Entanglement as a probe of confinement"
- Princeton University**, Princeton, NJ Apr 2008  
High-energy theory group seminar,  
"Entanglement and Confinement"
- Cornell University**, Ithaca, NY Apr 2008  
High-energy theory group seminar,  
"Entanglement and Confinement"
- University of Chicago**, Chicago, IL Nov 2007  
High-energy theory group seminar,  
"Entanglement entropy as a measure of confinement"

**University of Colorado**, Boulder, CO

Jun 2007

Research presentations at the TASI Summer School

“Hidden symmetries and the Wilson loop”

### Awards and fellowships

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Addie and Harold Broitman Member in Biology, IAS 2010 - 2011.

Princeton University Graduate Centennial Fellowship 2004 - 2009.

Princeton University Joseph Henry Prize 2004.

Caltech Carnation Merit Award 2004

D.S.Kothari Prize for research in Physics (Caltech).

Herbert J.Ryser Scholarship in Mathematics (Caltech)

Caltech Carnation Merit Award (2002) and the Milton & Jane Mohr Scholarship (2001)

31<sup>st</sup> International Physics Olympiad (UK 2000), Gold Medal

### Other research experience

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CERN, Geneva     **CMS experiment at the Large Hadron Collider**, Jun - Aug 04  
with Prof. Christopher Tully  
Testing and calibrating hadron calorimetry of the Compact Muon Solenoid (CMS) particle detector.

Caltech     **Matrix Models and String theory**, Jun - Aug 03  
with Prof. Anton Kapustin, *supported by SURF, Caltech*  
Studied relations between Matrix Quantum Mechanics and string theory in 1 + 1 dimensional spacetime.

USGS & Caltech     **Southern California Seismic Network**, Jun - Sep 02  
with Dr. Egill Hauksson, Caltech & U.S.Geological Survey  
Improving the seismic wave velocity model for Southern California by inverting earthquake and quarry data from seismometers.

Caltech     **Energy deposition in metals by large molecules**, Jun - Aug 01  
with Prof. Tom Tombrello, *supported by SURF, Caltech*  
Theoretical research on Coulombic effects on  $C_{60}$  “Buckyballs” moving rapidly through metals.

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**Teaching experience**

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- Fall 06, 07, 08    **Quantum Field Theory** , Ph 509, *Graduate level*  
with Prof. Alexander Polyakov, Princeton University  
Introductory graduate level course for PhD students
- Spring 06, 07    **Electromagnetism**, Ph 106, *Freshman course*  
with Prof. Herman Verlinde, Princeton University  
Second course in electromagnetism for potential physics majors.
- Spring 05    **Introductory Physics II**, Ph 102, *Freshman lab*  
with Prof. Nai Phuan Ong, Princeton University  
General physics labs in mechanics and optics for pre-medical students
- Fall 05    **Classical Mechanics**, Ph 205 *advanced*, Ph 203 *beginners*  
with Prof. Steven Gubser & Prof. Michael Romalis, Princeton  
Advanced topics in classical mechanics for physics majors.

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**Other academic experience**

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- Referee    Referee for “PNAS”, “Journal of the Royal Society Interface”, “Physical Biology”, “Journal of High Energy Physics”, “Nuclear Physics B”, “Physical Review D”, “Physical Review X”, “Journal of Statistical Physics”, “PLoS One”
- Judge    Served as a judge at the Princeton Undergraduate Research Symposium, May 4 2011

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**References**

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**Prof. Michael P. Brenner**

SEAS, Harvard University, Cambridge, MA 02138

**Prof. Stanislas Leibler**

Institute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540

**Prof. John J. Hopfield**

Princeton University, Princeton, NJ, 08544, USA,

**Prof. Igor Klebanov**Princeton University, Center for Theoretical Science,  
Jadwin Hall, Washington Road, Princeton, NJ, 08544, USA,

**Prof. David Kutasov**

Enrico Fermi Institute and Department of Physics, University of Chicago,  
5640 S. Ellis Av., Chicago, IL 60637, USA,