Kyung Hyuk Kim

Acting Assistant Professor
Bioengineering at University of Washington

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Education:

Ph.D.	in Physics	University of Washington, Seattle	9/1999 – 12/2006
M.S.	in Physics	University of Washington, Seattle	9/1999 – 3/2001
Ph.D. Program in Physics		University of California, Davis	10/1998 – 6/1999
B.S.	in Physics	Seoul National University	3/1992 – 1/1998

Skills:

- Extensive knowledge in C, Python, Mathematica, R. Working knowledge of SQL, JavaScript, AJAX, Perl and Java.
- Monte-Carlo, ODE, stochastic simulation, linear and nonlinear regression, and machine learning.
- Expertise in stochastic processes, stochastic differential equations, and partial differential equations.
- Lab skills: Flow cytometry (one paper published and two papers in preparation), Primer design, DNA extraction, PCR (Polymerase Chain Reaction), gel electrophoresis, DNA purification, restriction enzyme digest, DNA ligation, DNA sequencing, Gibson assembly, transformation.

Achievements:

- NSF grant award as a role of a PI, Standard Grant, MCB Systems and Synthetic Biology, $500K (2016-2018)
- Two NSF grant awards: MCB Systems and Synthetic Biology (2012-2015) and Theoretical Biology (2009-2012).
- 20 journal publications / book chapters / conference papers
- 26 oral presentations in international conferences, workshops, and research institutes.

Work Experience:

Acting Assistant Professor, Bioengineering, University of Washington **12/2012 – Present**

Principal Investigator for multiple projects on systems and synthetic biology.
Current group members: 2 postdocs, 1 grad student and 3 undergrads.

- Project 1 (Experiment/Computation/Theory): NSF grant awarded project from MCB Systems and Synthetic Biology, $500K, 2 years, 2016-2018, Standard Grant #1515280. PI – Kyung Kim (NSF award link)
  Title: Engineering functionally robust gene regulatory networks with fitness landscape design.
  The goal of this research is to develop design principles for enhancing functional robustness of genome-edited or genetically-modified cells (*E. coli*, yeast, human stem cell) under mutation pressure by using genetic homology and regulatory circuit topology.
- Project 2 (Experiment/Computation): Pending proposal (NSF standard grant; PI – Kyung Kim) – RNA aptamer scaffold probe design (malachite green) and its application. Aimed to achieve four-color multiplex probing: two for RNAs and the other two for proteins.
- Project 3 (Computation): Predicting unknown drug combination synergy. Advising two undergrads to perform decision tree learning by participating AstraZeneca-Sanger Drug Combination Prediction DREAM Challenge 2016.
- Project 4 (Computation): Predicting genetic mutations in yeast (*S. Cerevisiae*) under stress environments. Advising an undergrad to perform flux balance analysis on yeast metabolism. Collaborator: Maitreya Dunham (UW Genome Science)
- Project 5 (Experiment/Computation/Theory): Engineering cellular networks using stochastic measurements. (1) Developed an intuitive but fully quantitative analysis method for designing and understanding noise-induced cellular phenotypes. Predicted that the genetic regulation functions (e.g., Hill-type equations) can be significantly affected by the fluctuations (noise) in intracellular protein (transcription factor) copy numbers. (2) Demonstrated the noise level of *E. coli* transcription factors can be controlled and varied up to ten fold, while mean concentrations remain fixed. Used a flow cytometer (EC800 Sony Biotechnology) with R Bioconductor package and custom python codes and a single cell microscope with Matlab codes. (3) Demonstrated transcriptional activation (LuxR), measured at the population level, can be significantly different from the measurement done at the single-cell level. This implies that when characterizing transcription factor regulation, noise propagation along connected gene regulatory pathways – in other words, context dependency – needs to be taken into account carefully.
- Project 6 (Experiment/Computation/Theory) Algorithmic design of gene regulatory networks with statistical (machine learning based) and mechanistic models. The proposal on this project will be submitted to Amazon Catalyst.

- 7 professional publications and 3 papers in preparation.
- Advised 7 graduate and undergraduate students from physics, biochemistry, biology, and bio-informatics.

Senior Fellow to Dr. Herbert M. Sauro, Bioengineering, University of Washington 6/2007– 12/2012

Systems and synthetic biology: Computational and mathematical analysis of gene regulatory and metabolic networks in both the stochastic and deterministic regimes.

- Extended the Metabolic Control Analysis (MCA) to the stochastic regime. The extended theory, I named Stochastic Control Analysis (SCA), was applied for controlling gene expression noise.
- Applied the engineering concept of fan-out to gene regulatory networks to quantify the maximum number of downstream regulation links.
- 7 professional publications on computational modeling of biological and physical systems.
- Two NSF grant awards
  - Theoretical research: Extension of Metabolic Control Analysis and Biochemical Systems Theory to Stochastic Systems. NSF Theoretical Biology, $660K (2009-2012) (I wrote all the main research plan).
  - Experimental research: Characterizing and Engineering Cellular Networks using Stochastic Measurements. NSF Molecular and Cellular Biosciences, $546K (2012-2015) (I wrote the whole grant proposal).

Research Assistant to Dr. den Nijs (Graduate Advisor), Physics, Univ. of Washington 2004 – 12/2006

Statistical Physics (Non-equilibrium critical phenomena; asymmetric exclusion process).

- Performed the Monte-Carlo simulations for asymmetric exclusion processes of two different kinds of interacting particles.
- Analytically and numerically showed the special screening properties of the interacting particles by using the matrix product ansatz method.
- One Physical Review E paper

Research Assistant to Dr. Hong Qian (Graduate Co-Advisor), Applied Math, Univ. of Washington 2000 – 2003
Senior Fellow to Dr. Hong Qian 1/2007 – 5/2007

Mathematical biology (stochastic biological reaction systems; nonequilibrium thermodynamics).

- Introduced a new concept of entropy pumping for differential feedback control systems (molecular refrigerators).
- Extended the Jarzynski equality and the fluctuation theorems to the differential feedback control systems.
- Two papers: Physical Review Letter and Physical Review E.

Publications:

1. **KH Kim**, BA Bartley, WB Copeland, HM Sauro. Synthetic Biology – Building Genetic Networks from Scratch. Biophysical Journal (review paper; in preparation).
2. **KH Kim**, HM Sauro. Biological noise affects Hill-coefficients in genetic regulation in *E. coli*. (in preparation)
3. **KH Kim**, K Choi, HM Sauro. Controlling cell-to-cell variability by using plasmid systems. (in preparation)
4. WB Copeland, JM Nunez, **KH Kim**, BA Bartley, and H. M. Sauro. Quantitative characterization of DNA regulatory elements using fluorescence-activating aptamers (in preparation)
5. **KH Kim**, K Choi, BA Bartley, HM Sauro. Controlling *E. coli* gene expression noise. IEEE Transactions on Biomedical Circuits and Systems, 9:497—504 (2015) doi: 10.1109/TBCAS.2015.2461135. PMID: 26372647.
6. P Meyer, T Cokelaer, D Chandran, **KH Kim**, P-R Loh, G Tucker, M Lipson, B Berger, C Kreutz, A Raue, B Steiert, J Timmer, HM Sauro, G Stolovitzky. Network topology and parameter estimation: from experiments to gene regulatory network kinetics using a community based approach. BMC Systems Biology 8:13 (2014) doi: 10.1186/1752-0509-8-13. PMID: 24507381.
7. **KH Kim**, HM Sauro. Modular analysis for gene circuits: Interplay between retroactivity, nonlinearity, and stochasticity. In Marchisio M. Andrea, et al, Computational Methods in Synthetic Biology. Springer-Verlag. (2014) doi: 10.1007/978-1-4939-1878-2_14. PMID: 25487103. (book chapter)
8. TR Maarleveld, BK Ng, HM Sauro, **KH Kim**. In Silico Design of Self-Optimizing Integrated Metabolic and Gene Regulatory Networks. bioRxiv, 007658 (2014) doi: 10.1101/007658. (preprint)
9. **KH Kim**, H Qian, HM Sauro. Nonlinear Biochemical Signal Processing via Noise Propagation. Journal of Chemical Physics 139:144108-1—9 (2013) doi: 10.1063/1.4822103. PMID: 24116604.

10. HM Sauro, **KH Kim**. It's an analog world. Nature 497:572—573 (2013) doi: 10.1038/nature12246. PMID: 23676675 (news and views)
11. **KH Kim**, HM Sauro. Measuring the degree of modularity in gene regulatory networks from the relaxation of finite perturbations. Proc. IEEE Conf. on Decision and Control 5330—5335 (2012) doi: 10.1109/CDC.2012.6425827.
12. WB Copeland, D Chandran, BA Bartley, M Galdzicki, **KH Kim**, C Maranas, SC Sleight, HM Sauro. Computational Tools for Metabolic Engineering. Metabolic Engineering 14:270—280 (2012) PMID: 22629572.
13. **KH Kim**, HM Sauro. In Search of Noise-Induced Bimodality. BMC Biology 10:89-1—4 (2012) doi: 10.1186/1741-7007-10-89. PMID: 23134773. (news and views)
14. **KH Kim**, HM Sauro. Adjusting Phenotypes by Noise Control. PLoS Comp. Biol. 8:e1002344-1—14 (2012) doi: 10.1371/journal.pcbi.1002344. PMID: 22253584.
15. **KH Kim**, HM Sauro. Measuring the Degree of Modularity from Gene Expression Noise in Gene Regulatory Circuits. Biophysical Journal 100:1167—1177 (2011) doi: 10.1109/CDC.2012.6425827.
16. **KH Kim**, D Chandran, HM Sauro. Toward Modularity in Synthetic Biology: Design Patterns and Fan-out. In Heinz Koeppl, et al, Design and Analysis of Bio-molecular Circuits. Springer-Verlag. pp117-138 (2011) doi: 10.1007/978-1-4419-6766-4_6. (book chapter)
17. **KH Kim**, HM Sauro. Fan-out in Gene Regulatory Networks. J. Biological Engineering 4:16-1—14 (2010) doi: 10.1186/1754-1611-4-16. PMID: 21167053.
18. **KH Kim**, HM Sauro. Sensitivity Summation Theorems for Stochastic Biochemical Reaction Systems. Mathematical Biosciences 226:109—119 (2010) doi: 10.1016/j.mbs.2010.04.004. PMID: 20447412.
19. **KH Kim**, M den Nijs. Dynamic Screening in a Two-Species Asymmetric Simple Exclusion Process. Phys. Rev. E 76:021107-1—14 (2007) doi: 10.1103/PhysRevE.76.021107. PMID: 17930006.
20. **KH Kim**. Heat Dissipation from Brownian Particles under Hydrodynamic Interactions. arXiv:cond-mat/0609636 (2006) (preprint)
21. **KH Kim**, H Qian. Fluctuation Theorems of a Molecular Refrigerator. Phys. Rev. E 75:022102-1—4 (2007) doi: 10.1103/PhysRevE.75.022102. PMID: 17358382.
22. **KH Kim**, H Qian. Entropy Production of Brownian Macromolecules with Inertia. Phys. Rev. Lett. 93:120602-1—4 (2004) doi: 10.1103/PhysRevLett.93.120602.
23. **KH Kim**. Stochastic Driven Systems Far From Equilibrium (Doctoral Dissertation). Retrieved from ProQuest Dissertations and Theses. (2006) (Accession Order No. AAI3241916)

Selected Oral Presentations (out of 26 invited and contributed talks):

1. American Physical Society March Meeting, Baltimore, MD. March 15, 2016
2. Seminar in Intelligent Systems Engineering at the Indiana University, Bloomington, IN. March 9, 2016
3. Seminar in Biomedical Engineering at the University of Michigan, Ann Arbor, MI. Feb. 4, 2016
4. NIAC (Northwest Institute for Advanced Computing) Seminar at the Pacific Northwest National Laboratory, Richland, WA. Jan 4, 2016
5. Departmental Seminar in Bioengineering at the University of Washington, Seattle, WA. Mar. 12, 2015
6. Synthetic Biology Center Symposium at MIT, Boston, MA. Nov. 20, 2014
7. Departmental Seminar in Biomedical Engineering at Boston University, Boston, MA. Nov. 19, 2014
8. Biomedical Engineering Society (BMES) Annual Meeting, San Antonio, TX. Oct. 22-25, 2014
9. 6th International Workshop on Bio-Design Automation (IWBDA), Boston, MA. June 11-12, 2014

Professional Activity:

- 2014 Session Chair of BMES Annual Meeting. The session name was “Single Cell, Heterogeneity, Noise”.
- 2013 Technical Program Committee of KSEA Northwest Regional Conference; organized three sessions.
- 2012 Curator of DREAM7 Estimation of Model Parameters Challenge
- 2011 Curator of DREAM6 Estimation of Model Parameters Challenge

Teaching Experience:

- Supervised students

B.S.	10/2015-Present	Keagan Moo	DREAM Challenge for Multi-drug combination synergy Effect (computation); genetic stability (experiment, modeling)
B.S.	10/2015-Present	Allen Kim	DREAM Challenge for Multi-drug combination synergy effect
B.S.	10/2015-Present	Christian Selig	Flux balance analysis for predicting mutation frequency under environmental stress in collaboration with Dr. Dunham of UW Genome Science.
Ph. D.	06/2014-Present	Kiri Choi	Noise control in gene expression (theoretical analysis; single cell microscope experiment; 3 papers)
Ph. D.	10/2013-12/2015	Bryan Bartley	Fan-out and noise control in E. coli gene expression (experiment; 2 paper)
Ph. D.	10/2013-06/2015 (now post-doc)	Wilbert Copeland	RNA aptamer probe development (mathematical modeling; 1 paper and an NSF grant proposal)
M. S.	01/2011-08/2014	Timo Maarlevald	Metabolic flux optimization under cellular constraints (statistical modeling and numerical analysis;1 paper)
B.S.	06/2013-02/2014	Jayit Biswas	Gene circuit robustness under mutations (experiment; NSF/DARPA grant proposals)

- Supervised postdocs

Postdoc	03/2016-Present	Jooyoung Lee	Genetic stability (experiment; molecular biology)
Postdoc	04/2016-Present	Siddartha Yerramilli	RNA scaffold design (experiment; SELEX, single cell microscope)

- Synthetic Biology Lab Techniques. Synthetic and Systems Biology (Course lecture) Oct. 30 and Nov. 1, 2013
- Characterizing Gene Circuits by Using Noise. Synthetic and Systems Biology (Course lecture) May 18, 2012
- Stochastic Systems and Gillespie Algorithm, and Modularity in Gene Circuits. Advanced Synthetic Biology (Course lecture) Feb. 25 and 28, 2011
- Tutorials on Systems Biology Workbench. International Conference on Systems Biology. Palo Alto, CA. Aug. 30, 2009
- Stochastic Systems and Gillespie Algorithm, and Chemical Langevin Equation. Systems and Synthetic Biology (Course lecture) Feb. 11, 13, and 18, 2009
- Tutorials on Systems Biology Workbench. International Conference on Systems Biology. Götenborg, Sweden. Aug. 22, 2008
- The Basis of the Gillespie Stochastic Simulation Algorithm, and Effects of Noise. Systems and Synthetic Biology (Course lecture) Apr. 24 and 25, 2008
- Teaching Assistant for Physics Labs (Physics 121,122, 123, 114, 115, 116). University of Washington, Jul. 1999 - Dec. 2001 and Jan. 2003 - Dec. 2003

Manuscript Review:

- 2015 IEEE Transactions on Biomedical Circuits and Systems, Journal of Royal Society Interface
- 2013 PLoS Computational Biology, BMC Systems Biology, Journal of the Royal Society Interface
- 2012 Journal of Statistical Mechanics, IEEE Annual Conference on Decision and Control (CDC), BMC Systems Biology
- 2011 Molecular Systems Biology, Biophysical Journal, Journal of the Royal Society Interface
- 2010 Molecular Systems Biology, IEEE Transactions on Biomedical Circuits and Systems
- 2009 Molecular Systems Biology, BMC Systems Biology, Molecular BioSystems, IEEE Transactions on Biomedical Circuits and Systems
- 2008 Physical Review Letters, BMC Systems Biology, Molecular BioSystems, Physics Letters A
- 2007 Molecular Systems Biology, IEEE Transactions on Biomedical Circuits and Systems

Professional Society Memberships:

- Biophysical Society
- Biomedical Engineering Society
- American Physical Society