

# Lightning Introductions

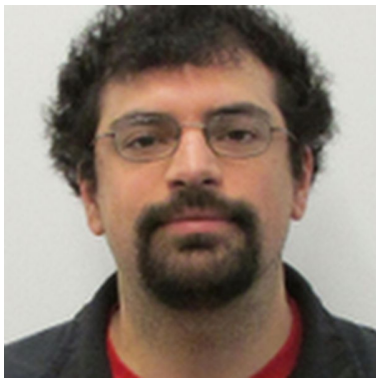
**Thermodynamic Computing**  
January 3-5, 2018



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# Alex Alemi/Google Research



Some modern machine learning perspectives with an information theoretic bent.

*0: There is a game. 1: You can't win.  
2: You must lose. 3: You can't quit.*



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# Lee Altenberg/University of Hawai'i at Manoa



*What do you hope to bring to the workshop?*

Perspectives from theoretical biology, evolutionary dynamics, and evolutionary computation.

*What is your favorite quote or movie related to thermodynamics?*

"The inexactitude of our methods of measurement has no more reason in statistics than it has in physics to dim our conception of that which we measure." –R.A. Fisher, *The Genetical Theory of Natural Selection* (1930)



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## Tom Conte/Georgia Tech



What do you hope to bring to the workshop?  
a systems and CS perspective  
and a *Mai Tai*

Quote: “*Banzai! I'll'a see you in'a HELL!!*”  
- Lord John Whorfin

# Gavin Crooks/~~Rigetti Computing~~ TBD



What do you hope to bring to the workshop?  
Perspectives on non-equilibrium  
thermodynamics and the physics of  
computation.

“Lisa, in this house we obey the laws of  
thermodynamics!” -- Homer Simpson



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# Jim Crutchfield/Complexity Sciences Ctr, UC Davis



Information Engines & Thermodynamic Computing  
Theory:

Information Processing Second Law

Principle of Requisite Complexity

Modularity Dissipation

Engineering: Design, Control, Optimization

Experiment: Flux Qubit

George Carlin: Entropy Fan (First 1:33 of)

<https://www.youtube.com/watch?v=ZX7d-LUklzo>



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# Erik DeBenedictis/Sandia National Lab



What do you hope to bring to the workshop?

Neal Stephenson's book "Diamond Age." It actually had a subtheme about reversible computing, but the technical depth wasn't enough for there to be a difference.



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# Lídia del Rio/ETH Zurich



VSD  
**ETH** zürich

- Extend scope of quantum thermodynamics through information theory
- Intelligent cooling inside a quantum computer

*"Heat won't pass from a cooler to a hotter  
You can try it if you like but you far better notter"*

- [Flanders & Swan](#)



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# Josh Deutsch/UC Santa Cruz



I hope to bring my experience from work in a number of areas, quantum stat mech, condensed matter, biophysics, and machine learning.

Murphy's Law of Thermodynamics:  
Things get worse under pressure.



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# Michael DeWeese/UC Berkeley



\*My group studies neuroscience, machine learning, and nonequilibrium stat. mech.

\*I will bring enthusiasm for developing new frameworks for optimal computation/directed work in thermal environments without explicit control.

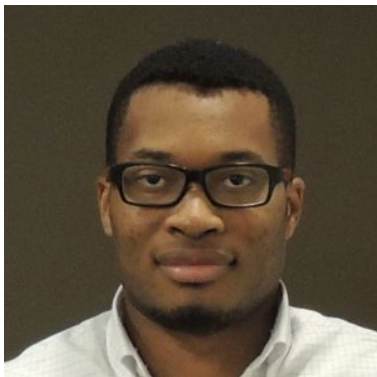
Mickey Rourke in *The Wrestler*:  
“Bring the cheap heat.”



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# Khari Douglas/CCC



I hope we are able to define an agenda for thermodynamic computing and finish a draft of the white paper before we leave.

“Nothing in life is certain except death, taxes and the second law of thermodynamics.” - Seth Lloyd

Read more at: <https://www.brainyquote.com/topics/thermodynamics>



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# Massimiliano Esposito/University of Luxembourg



I would like to discuss to what extent the recent developments in nonequilibrium thermodynamics impose fundamental constraints on computation.

“Thermodynamics is the only physical theory of universal content concerning which I am convinced that, within the framework of applicability of its concepts, it will never be overthrown”, A. Einstein

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# Michael Frank/Sandia National Labs



- I bring a robust understanding of Landauer's principle and the fundamental thermodynamics of computation, and reversible computation in particular.
- At this meeting, I will argue that nonequilibrium thermodynamics poses no barrier to approaching physically reversible computation in fast real machines.



If your theory is found to be against the second law of thermodynamics, I give you no hope; there is nothing for it but to collapse in deepest humiliation.

(Arthur Eddington)



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# Robert Fry/Johns Hopkins University



What do you hope to bring to the workshop?  
A philosophy and theory of TCs with examples.

What is your favorite quote or movie related to thermodynamics?

“The Last Question” - [Isaac Asimov](#) short story.



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# Natesh Ganesh/UMass Amherst



Broad interest in thermodynamics, computing devices & architectures, AI & complex systems. Lots of enthusiasm, willingness to unlearn, and start all over again.

“...memory relies crucially on the second law of thermodynamics. Why do we remember the past and not the future? Because, as entropy increases, we develop correlations between the external universe and our brains; if our universe was in a state of maximum entropy, we wouldn’t be able to remember the past or the future.”

Sean Carroll



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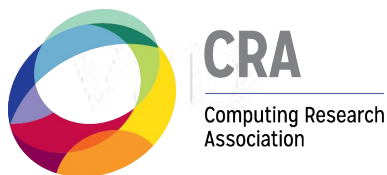
# Peter Harsha/Computing Research Association



A desire to understand what a research agenda in Thermodynamic Computing looks like and how best to convey that to policymakers.



? (eh, I got nothin'...)



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# Mark D. Hill/University of Wisconsin-Madison



**UW-Madison & CCC Chair**

I have been successful with CCC whitepapers leading to multi-million-dollar-per-year programs

Software is like entropy. It is difficult to grasp, weighs nothing, and obeys The Second Law of Thermodynamics; i.e., it always increases.

--Norman Augustine



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# Todd Hylton/UC San Diego



UC San Diego

JACOBS SCHOOL OF ENGINEERING

- I will bring a thermodynamic neural network model and a vision for thermodynamic computing systems to the workshop.
- Ex-Machina with all the back and forth about computing, Turing tests, intelligence, the explanation of the “gooey” brain and the creepy robots.



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## Chris Kello/UC Merced



A cognitive science perspective, and a principle  
of homeostasis integral to computation

Tyrell from *Blade Runner*:  
*Do Androids Dream of Electric Sheep?*  
“More human than human is our motto”



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## Jeff Krichmar/UC Irvine



Bringing together neuroscience, modeling, and robots.

“Chaos killed the dinosaurs”, from Heathers.

or

“Be a thinker, not a stinker” Apollo Creed in the original Rocky movie.



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## Suhas Kumar/Hewlett Packard Labs



Hewlett Packard  
**Labs**

What do you hope to bring to the workshop?

*Electronic devices are driven by thermodynamics, and we need to know this to to build intelligent computers.*

What is your favorite quote or movie related to thermodynamics?

*Don't you know the first law of thermodynamics?  
Anything that's FUN costs AT LEAST eight dollars*



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# Shih-Chii Liu/Univ of Zurich & ETH Zuerich

Personal Photo

Knowledge and experience in neuromorphic computing circuits and their design

“In other words, living organisms are very complicated aggregations of elementary parts, and by any reasonable theory of probability or thermodynamics highly improbable”

- *John von Neumann, 1949*



**University of  
Zurich**<sup>UZH</sup>



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MIT, Mechanical  
Engineering, Physics

## Seth Lloyd/MIT

The interplay between information, entropy, computation, and quantum mechanics.

“Energy is born free but is everywhere in chains.”



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# Ilya Nemenman/Emory University



What do you hope to bring to the workshop?  
*Some knowledge of how biology computes and learns.*

What is your favorite quote or movie related to thermodynamics?  
*Don't Panic!*



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## Alex Nugent/Knowm Inc



What do you hope to bring to the workshop?  
Hopefully useful observation about how nature  
self-organizes.

"Anyone who considers arithmetical methods of  
producing random digits is, of course, in a state  
of sin."

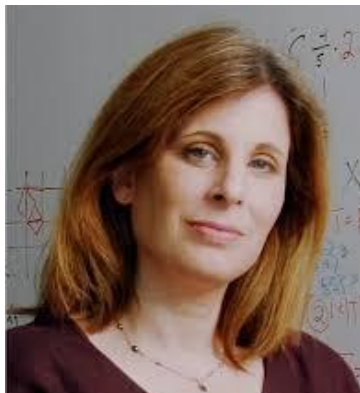
- John von Neumann



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# Dana Randall/Georgia Tech



I'll bring expertise in randomized and distributed algorithms for interacting particles systems and stochastic processes...

...and absolutely no knowledge of witty quotes related to thermodynamics.

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# Peter Sadowski/University of Hawai'i at Manoa



Energy-efficient (non-backprop) learning algorithms for deep neural networks.

"We will make you your very own Demon of the Second Kind, which is magical and thermodynamical, nonclassical and stochastic, and from any old barrel or even a sneeze it will extract information for you about everything that was, is, may be or ever will be."  
(Lem, *The Cyberiad*)



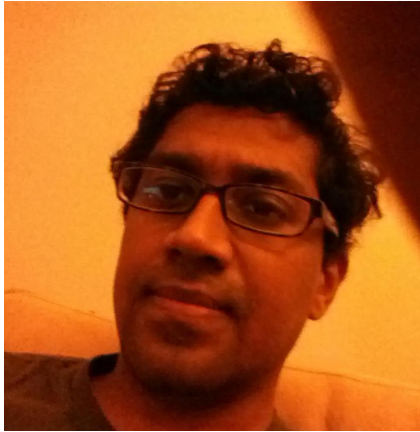
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# Prasad Santhanam/University of Hawai'i at Manoa



Curiosity and a perspective from information theory and statistics.

Quote: “... *more importantly, nobody knows what entropy really is, so in a debate, you will always have the advantage*”--- von Neuman to Shannon on why he should call his measure of information as entropy, other than the fact that it had already been used in statistical mechanics.



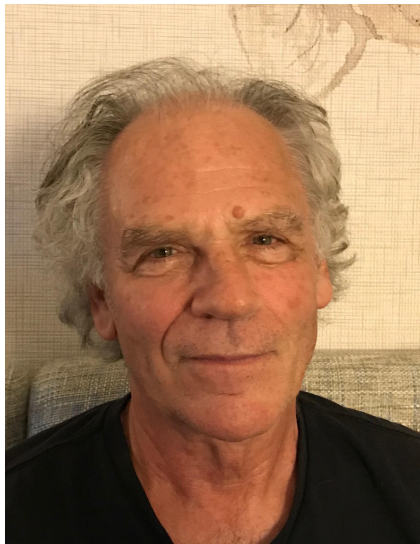
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## Robert Shaw/Protolife



Interest in non-standard models of computation, maybe a few ideas.

In black-body radiation at 3000 K, and often in discussions of the foundations of computation,  
“More heat than light!”



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## Adam Stieg/UCLA



What do you hope to bring to the workshop?  
Thoughts on how to construct physical systems  
whose intrinsic thermodynamics can be  
harnessed for computing.

“Nothing in life is certain except death, taxes, and  
the second law of thermodynamics”

- Seth Lloyd



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# Susanne Still/University of Hawai'i at Manoa



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There is a deep connection between the efficient use of energy and the efficient use of information. We should be able to leverage that to build a new type of adaptive, ultra low power computing device.

Quote:

“It’s the Second Law, not the Second Suggestion.”

Video:

<https://www.youtube.com/watch?v=Tay3-2WKQ5Y>



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# Elan Stopnitzky/University of Hawai'i at Manoa



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What do you hope to bring to the workshop?

Some suggestions for how thermodynamic behavior might be useful for computation, and vice versa

What is your favorite quote or movie related to thermodynamics?

*"This silent functioning, comparable to that of God, gives rise to all manner of conjectures..." -Jorge Luis Borges, The Lottery in Babylon*



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# John Paul Strachan/Hewlett Packard Labs



What do you hope to bring to the workshop?  
A perspective going from device physics capabilities at the bottom to end-user's (customers) needs at the top (with many many holes in between)!

Homer Simpson: "In this house, we obey the laws of thermodynamics!"



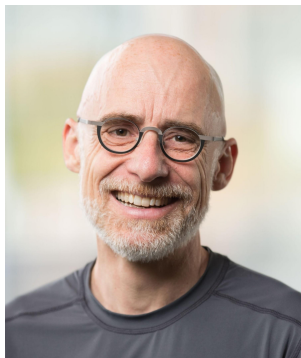
Hewlett Packard  
**Labs**



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# Christof Teuscher/Portland State University



*What do you hope to bring to the workshop?*  
Perspectives on unconventional and intrinsic computation.

1st Law of Thermodynamics: *You can't win.*  
2nd Law of Thermodynamics: *You can't break even.* 3rd Law of Thermodynamics: *You can't stop playing.*



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# Chris Watkins/Royal Holloway, University of London



Models of evolution that satisfy detailed balance

Movies break the second law because the plot has a neat conclusion instead of dissipating in eddies of small consequences...



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**ENGINEERING**  
TEXAS A&M UNIVERSITY

# Stan Williams

What do you hope to bring to the workshop?

Leon Chua's Principle of Local Activity

What is your favorite quote or movie related to thermodynamics?

$$S = k \cdot \log W$$



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# David Wolpert/Santa Fe Institute



NSF-funded wiki on **Thermodynamics of computation**:

[centre.santafe.edu/thermocomp](http://centre.santafe.edu/thermocomp)

Register and start editing it!

*“The Energetics of Computing in Life and Machines”*,  
D. Wolpert, C. Kempes, P. Stadler, J. Grochow (Ed.),  
SFI Press, *appearing Winter 2019*

**Research focus:** Combining stochastic thermodynamics and  
computer science theory



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# Joshua Yang/UMass Amherst



## What do you hope to bring to the workshop?

Artificial synapses and neurons driven by thermodynamic principles can form neural networks with interesting computing capabilities.

## What is your favorite quote or movie related to thermodynamics?

Thermodynamics is a funny subject. The first time you go through it, you don't understand it at all. The second time you go through it, you think you understand it, except for one or two points. The third time you go through it, you know you don't understand it, but by that time you are so used to the subject, it doesn't bother you anymore.

— Arnold Sommerfeld



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# Yan Yufik/Virtual Structures Research Inc.

Personal Photo

Academia or  
Industry Logo

What do you hope to bring to the workshop?

Thermodynamics shapes cognitive mechanisms. Exploring this relationship might inform thermodynamic computing.

What is your favorite quote or movie related to thermodynamics?

All ideas we form of the outer world are ultimately only reflections of our own perceptions. Max. Planck.



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