

# Azimuth

## ACT2020 Tutorial Day

17 June, 2020



(<http://act2020.mit.edu/>)

If you're wanting to learn some applied category theory, register for the tutorials ([https://docs.google.com/forms/d/e/1FAIpQLScUg8cvR28Sr2zx1WMGgeWsDXbz\\_o4C5SnkbqeAizc7Fusp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLScUg8cvR28Sr2zx1WMGgeWsDXbz_o4C5SnkbqeAizc7Fusp=sf_link)) that are taking place on July 5, 2020 as part of ACT2020 (<http://act2020.mit.edu/>)!

Applied category theory offers a rigorous mathematical language and toolset for relating different concepts from across math, science, and technology. For example, category theory finds common patterns between geometry (shapes), algebra (equations), numbers, logic, probability, etc. Applied category theory (ACT) looks for how those very same patterns extend outward to data, programs, processes, physics, linguistics, and so on—things we see in the real world. The field is currently growing, as new applications and common patterns are being found all the time. When you understand these ideas, more of your intuitions about the world can be made rigorous and thus be communicated at a larger scale. This in turn gives our community a chance to solve larger and more complex scientific, technological, and maybe even societal problems.

This year's international applied category theory conference ACT2020 (<http://act2020.mit.edu/>) is having a tutorial day, meant to introduce newcomers to applied category theory. Tutorial day will take place on July 5 and will include a few main topics that will be taught semi-traditionally (via presentation, exercises, and discussion) over Zoom, as well as mentors who will be available throughout the day to work with smaller groups and/or individuals. We invite you to sign up here ([https://docs.google.com/forms/d/e/1FAIpQLScUg8cvR28Sr2zx1WMGgeWsDXbz\\_o4C5SnkbqeAizc7Fusp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLScUg8cvR28Sr2zx1WMGgeWsDXbz_o4C5SnkbqeAizc7Fusp=sf_link)) if you're interested, so we can keep you posted. Hope to see you there!

The four courses will be roughly as follows:

- David Spivak: categorical databases for introducing sets, functions, categories, and functors.

- Fabrizio Genovese: string diagrams as a graphical language for category theory.
- Emily Riehl: the Yoneda lemma in the context of matrices.
- Paolo Perrone: monads and comonads.

💬 3 Comments | 📁 computer science, conferences, mathematics | 🔗 Permalink

👤 Posted by John Baez

## Thermalization

12 June, 2020

I'm wondering if people talk about this. Maybe you know?

Given a self-adjoint operator  $H$  that's bounded below and a density matrix  $D$  on some Hilbert space, we can define for any  $\beta > 0$  a new density matrix

$$D_\beta = \frac{e^{-\beta H/2} D e^{-\beta H/2}}{\text{tr}(e^{-\beta H/2} D e^{-\beta H/2})}$$

I would like to call this the **thermalization** of  $D$  when  $H$  is a Hamiltonian and  $\beta = 1/kT$  where  $T$  is the temperature and  $k$  is Boltzmann's constant.

For example, in the finite-dimensional case we can take  $D$  to be the identity matrix, normalized to have trace 1. Then  $D_\beta$  is the Gibbs state at temperature  $T$ : that is, the state of thermal equilibrium at temperature  $T$ .

But I want to know if you've seen people do this thermalization trick starting from some other density matrix  $D$ .

💬 27 Comments | 📁 physics | 🔗 Permalink

👤 Posted by John Baez

## Categorical Statistics Group

10 June, 2020

As a spinoff of the workshop Categorical Probability and Statistics

([http://perimeterinstitute.ca/personal/tfritz/2019/cps\\_workshop/schedule.html](http://perimeterinstitute.ca/personal/tfritz/2019/cps_workshop/schedule.html)), Oliver Shetler has organized a reading group on category theory applied to statistics. The first meeting is Saturday June 27th at 17:00 UTC.

You can sign up for the group here (<http://meetu.ps/e/J5nZg/ygGjg/d>), and also read more about it there. We're discussing the group on the Category Theory Community Server (<https://categorytheory.zulipchat.com/#narrow/stream/232160-learning.3A-reading.20groups/topic/Statistics.20reading.20group>), so if you want to join the reading group should probably also join that (<https://johncarlosbaez.wordpress.com/2020/03/25/category-theory-community-server/>).

Here is a reading list. I'm sure the group won't cover *all* these papers—we'll start with the first one and see how it goes from there. But it's certainly helpful to have a list like this.

- McCullagh, What is a statistical model? (<https://projecteuclid.org/euclid.aos/1035844977>)
- Morse and Sacksteder, Statistical isomorphism ([https://projecteuclid.org/download/pdf\\_1/euclid.aoms/1177699610](https://projecteuclid.org/download/pdf_1/euclid.aoms/1177699610)).
- Simpson, Probability sheaves and the Giry monad (<https://drops.dagstuhl.de/opus/volltexte/2017/8051/pdf/LIPIcs-CALCO-2017-1.pdf>).
- Fritz, A synthetic approach to Markov kernels, conditional independence and theorems on sufficient statistics (<https://arxiv.org/abs/1908.07021>).
- Jacobs, Probabilities, distribution monads, and convex categories (<http://www.cs.ru.nl/B.Jacobs/PAPERS/triangle.pdf>).
- Keimel, The monad of probability measures over compact ordered spaces and its Eilenberg-Moore algebras (<https://www.sciencedirect.com/science/article/pii/S0166864108002496>).
- McCullough, Di Nardo, Senato, Natural statistics for spectral samples ([https://projecteuclid.org/download/pdfview\\_1/euclid.aos/1369836967](https://projecteuclid.org/download/pdfview_1/euclid.aos/1369836967)).
- Perrone, *Categorical Probability and Stochastic Dominance in Metric Spaces* (<http://www.paoloperrone.org/phdthesis.pdf>). (Ph.D. thesis)
- Patterson, *The Algebra and Machine Representation of Statistical Models* (<https://www.epatters.org/assets/thesis.pdf>). (Ph.D. thesis)
- Tuyeras, A category theoretical argument for causal inference (<https://arxiv.org/abs/2004.09999>).
- Culbertson and Sturtz, A categorical foundation for Bayesian probability (<https://arxiv.org/abs/1205.1488>).
- Fong, *Causal Theories: A Categorical Perspective on Bayesian Networks* (<https://arxiv.org/abs/1301.6201>). (Masters thesis)
- Fritz and Perrone, A probability monad as the colimit of spaces of finite samples (<http://www.tac.mta.ca/tac/volumes/34/7/34-07.pdf>).
- Fritz and Perrone, Bimonoidal structure of probability monads (<https://arxiv.org/abs/1804.03527>).
- Fritz, A presentation of the category of stochastic matrices (<https://arxiv.org/abs/0902.2554>).

- Jacobs and Furber, Towards a categorical account of conditional probability (<https://arxiv.org/abs/1306.0831>).
- Bradley, *At the Interface of Algebra and Statistics* (<https://arxiv.org/pdf/2004.05631.pdf>). (Ph.D. Thesis)
- Bradley, Stoudenmire and Terilla, Modeling sequences with quantum states (<https://arxiv.org/abs/1910.07425>).
- Jacobs, Categorical aspects of parameter learning (<https://arxiv.org/abs/1810.05814>).
- Jacobs, Parameters and parameterization in specification, using distributive categories (<http://www.cs.ru.nl/B.Jacobs/PAPERS/FI95.ps>).
- Parzygnat, Inverses, disintegrations, and Bayesian inversion in quantum Markov categories (<https://arxiv.org/pdf/2001.08375.pdf>).
- Jacobs, A channel-based perspective on conjugate priors (<https://arxiv.org/abs/1707.00269>).

💬 10 Comments | 📁 mathematics, probability, seminars | 🔗 Permalink

👤 Posted by John Baez

## ACT@UCR Seminar (Part 2)

7 June, 2020

The spring 2020 seminar on applied category theory at U.C. Riverside is done! Here you can see videos of all the talks, along with talk slides, discussions and more:

- John Baez: Structured cospans and double categories (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#baez>).
- Prakash Panangaden: A categorical view of conditional expectation (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#panangaden>).
- Jules Hedges: Open games: the long road to practical applications (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#hedges>).
- Michael Shulman: Star-autonomous envelopes (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#shulman>).
- Gershon Bazerman: A localic approach to the semantics of dependency, conflict, and concurrency (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#bazerman>).
- Sarah Rovner-Frydman: Separation logic through a new lens (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#rovner-frydman>).
- Tai-Danae Bradley: Formal concepts vs. eigenvectors of density operators (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#bradley>).

- Gordon Plotkin: A complete axiomatisation of partial differentiation (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#plotkin>).
- Simon Willerton: The Legendre–Fenchel transform from a category theoretic perspective (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#willerton>).
- Nina Otter: Values and inclusivity in the applied category theory community (<http://math.ucr.edu/home/baez/ACT@UCR/index.html#otter>).

Thanks to everyone for participating in this!

 Leave a Comment » |  mathematics, seminars |  Permalink

 Posted by John Baez

## Values and Inclusivity in the ACT Community

27 May, 2020

In the tenth and final talk of this spring's ACT@UCR seminar

(<https://johncarlosbaez.wordpress.com/2020/03/24/actucr-seminar/>), Nina Otter

(<https://www.math.ucla.edu/~otter/>) led a discussion about diversity in the applied category theory community, with these speakers:

- Nina Otter: introduction, and some potential initiatives
- Jade Master: Experience in setting up an online research community for minorities in ACT
- Brendan Fong: Statement of values for ACT community
- Emily Riehl: Experience at MATRIX institute
- Christian Williams: Quick overview of ACT server

This is a change from her originally scheduled talk, due to the killing of George Floyd and ensuing events.

The discussion took place at the originally scheduled time on Wednesday June 3rd. Afterwards we had discussions at the Theory Community Server, here:

<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/June.203rd.3A.20Nina.20Otter>

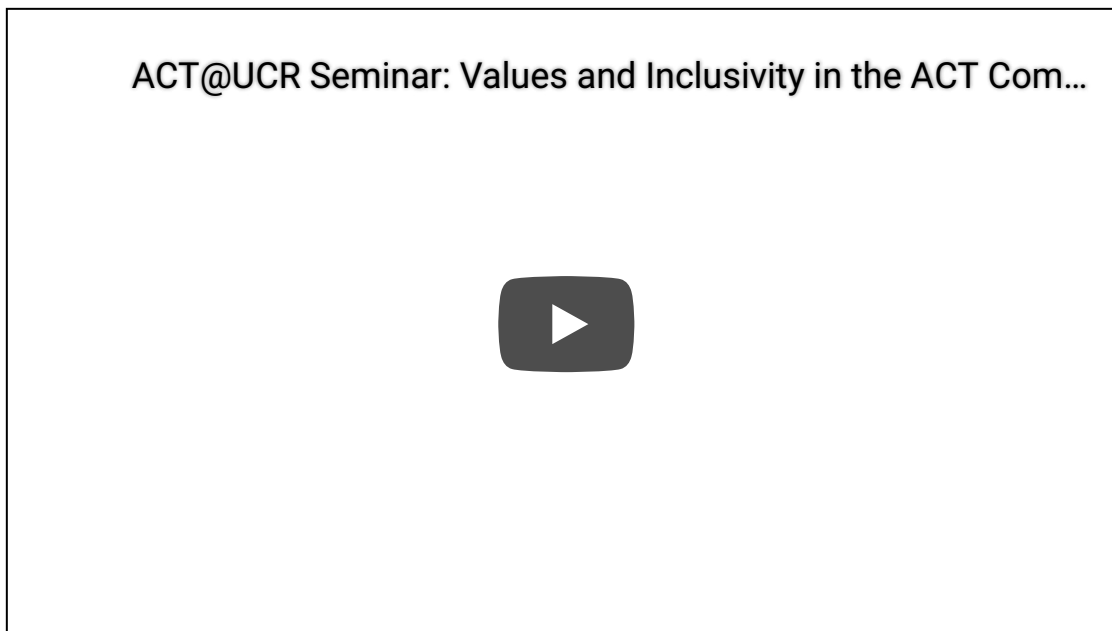
(<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/June.203rd.3A.20Nina.20Otter>)

You can join the conversation there if you sign in

(<https://johncarlosbaez.wordpress.com/2020/03/25/category-theory-community-server/>).

You can see her slides here

([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Otter\\_Diversity.pdf](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Otter_Diversity.pdf)), or download a video here ([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Nina\\_Diversity.mp4](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Nina_Diversity.mp4)), or watch the video here:



- Nina Otter, Values and inclusivity in the applied category theory community.

**Abstract.** Saddened by the current events, we are taking this opportunity to pause and reflect on what we can do to change the status quo and try to bring about real and long-lasting change. Thus, we are holding a discussion aimed at finding concrete solutions to make the Applied Category Theory community more inclusive, and also to reflect about the values that our community would like to stand for and endorse, in particular, in terms of which sources of funding go against our values. While this discussion is specific to the applied category theory community, we believe that many of the topics will be of interest also to people in other fields, and thus we welcome anybody with an interest to attend. The discussion will consist of two parts: we will have first several people give short talks to discuss common issues that we need to address, as well as present specific plans for initiatives that we could take. We believe that the current pandemic, and the fact that all activities are now taking place remotely, gives us the opportunity to involve people who would otherwise find it difficult to travel, because of disabilities, financial reasons or care-taking responsibilities. Thus, now we have the opportunity to come up with new types of mentoring, collaborations, and many other initiatives that might have been difficult to envision until just a couple of months ago. The second part of the discussion will take place on the category theory community server, and its purpose is to allow for a broader participation in the discussion, and ideally during this part we will be able to flesh out in detail the specific initiatives that have been proposed in the talks.

💬 2 Comments | 📁 mathematics, seminars | 🔗 Permalink

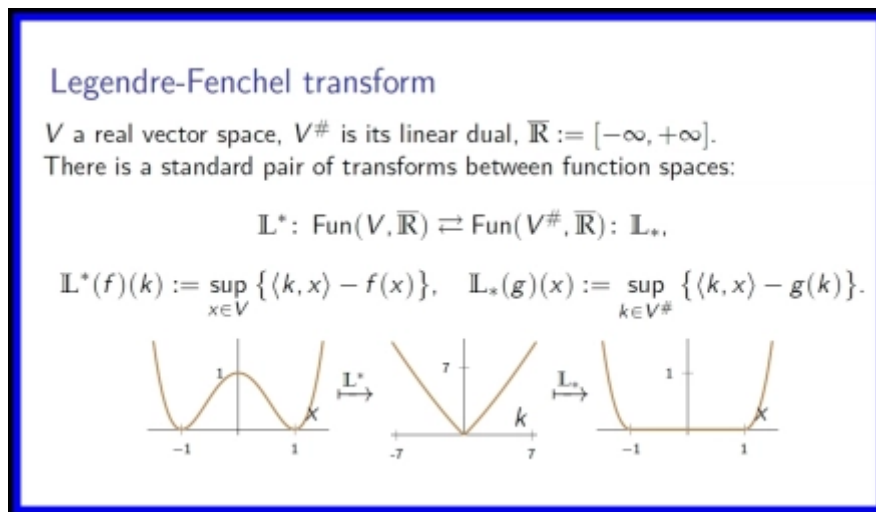
👤 Posted by John Baez

## The Legendre Transform: a Category Theoretic Perspective

- Simon Willerton, The Legendre-Fenchel transform from a category theoretic perspective (<https://arxiv.org/abs/1501.03791>).

Also see his blog article:

- Simon Willerton, The nucleus of a profunctor: some categorified linear algebra ([https://golem.ph.utexas.edu/category/2013/08/the\\_nucleus\\_of\\_a\\_profunctor\\_so.html](https://golem.ph.utexas.edu/category/2013/08/the_nucleus_of_a_profunctor_so.html)), *The n-Category Café*.



([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton\\_Legendre\\_Transform.pdf](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton_Legendre_Transform.pdf))

1 Comment | mathematics, seminars | Permalink

Posted by John Baez

## A Complete Axiomatisation of Partial Differentiation

18 May, 2020



([https://johncarlosbaez.files.wordpress.com/2020/05/gordon\\_plotkin.jpg](https://johncarlosbaez.files.wordpress.com/2020/05/gordon_plotkin.jpg))

26 May, 2020

In the ninth talk of the ACT@UCR seminar (<https://johncarloshaez.wordpress.com/2020/03/24/actucr-seminar/>), Simon Willerton ([https://maths.dept.shef.ac.uk/maths/staff\\_info\\_17.html](https://maths.dept.shef.ac.uk/maths/staff_info_17.html)) told us about a categorical approach to the Legendre transform, and its connection to tropical algebra.

He gave his talk on Wednesday May 27th. Afterwards we discussed it on the Category Theory Community Server, here:

<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/May.2027th.3A.20Simon.20Willerton>  
(<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/May.2027th.3A.20Simon.20Willerton>)

You can view or join the conversation there if you sign in (<https://johncarloshaez.wordpress.com/2020/03/25/category-theory-community-server/>).

You can see his slides here

([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton\\_Legendre\\_Transform.pdf](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton_Legendre_Transform.pdf)), or download a video here

([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton\\_Legendre\\_Transform.mp4](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Willerton_Legendre_Transform.mp4)), or watch the video here:

### ACT@UCR Seminar: The Legendre Transform: a Category T...



- Simon Willerton, The Legendre–Fenchel transform from a category theoretic perspective.

**Abstract.** The Legendre–Fenchel transform is a classical piece of mathematics with many applications. In this talk I’ll show how it arises in the context of category theory using categories enriched over the extended real numbers  $\overline{\mathbb{R}} := [-\infty, +\infty]$ . It turns out that it arises out of nothing more than the pairing between a vector space and its dual in the same way that the many classical dualities (e.g. in Galois theory or algebraic geometry) arise from a relation between sets.

I won’t assume knowledge of the Legendre–Fenchel transform.




The talk is based on this paper:



## A Complete Axiomatisation of Partial Differentiation

Gordon Plotkin

ACT Seminar, May 2020

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 [Posted by John Baez](#)

**Azimuth**

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In the eighth talk of the ACT@UCR seminar (<https://sites.google.com/ucr.edu/actucr/>), Gordon Plotkin (<http://homepages.inf.ed.ac.uk/gdp/>) told us about partial differentiation, viewed as a logical theory.

He gave his talk on Wednesday May 20th. Afterwards we discussed it on the Category Theory Community Server, here:

<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/May.2020th.3A.20Gordon.20Plotkin>  
(<https://categorytheory.zulipchat.com/#narrow/stream/229966-ACT.40UCR-seminar/topic/May.2020th.3A.20Gordon.20Plotkin>)

You can view or join the conversation there if you sign in (<https://johncarlosbaez.wordpress.com/2020/03/25/category-theory-community-server/>).

You can see his slides here ([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Plotkin\\_Partial\\_Differentiation.pdf](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Plotkin_Partial_Differentiation.pdf)), or download a video of his talk here ([http://math.ucr.edu/home/baez/mathematical/ACTUCR/Plotkin\\_Partial\\_Differentiation.mp4](http://math.ucr.edu/home/baez/mathematical/ACTUCR/Plotkin_Partial_Differentiation.mp4)), or watch his video here:



- Gordon Plotkin, A complete axiomatisation of partial differentiation.

**Abstract.** We formalise the well-known rules of partial differentiation in a version of equational logic with function variables and binding constructs. We prove the resulting theory is complete with respect to polynomial interpretations. The proof makes use of Severi's theorem that all multivariate Hermite problems are solvable. We also hope to present a number of related results, such as decidability and Hilbert–Post completeness.