

Heat, Time and Roulette Wheels

Craig Callender and Christian Wüthrich

Phil 285, Spring 2008

Class schedule: Th 2:00-4:50pm, HSS 7077 (Philosophy seminar room)
Website: <http://philosophy.ucsd.edu/faculty/wuthrich/>
Craig Callender: Office hours TBA
Room 8077 HSS ☎ 858-822-4911 ✉ ccallender@ucsd.edu
Christian Wüthrich: Office hours are Tu 3-5, and by appointment
Room 8047 HSS ☎ 858-534-6548 ✉ wuthrich@ucsd.edu

In this course we will learn about the philosophical foundations of statistical physics. We will tackle philosophical questions such as the nature of theory reduction, the direction of time, the interpretation of probability in natural science, and more. The primary focus will be on issues squarely within philosophy of physics, but given the nature of the subject, philosophers with more general interests may also wish to attend. For example, philosophers interested in reductionism may be interested in the closest thing to a reduction, the putative reduction of thermodynamics to statistical mechanics; the material on probability in natural selection and games of chance may interest philosophers of biology and others; and philosophers interested in the nature of time will be interested in better understanding what if anything follows from one of the more pervasive temporally asymmetric processes in the world. Various topics in the history of science, especially 19th century science, will also be considered.

Required texts

You should buy a copy of Larry Sklar's *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics* (Cambridge: Cambridge University Press, 1993), which we hope will be available at the bookstore. We will try to make all other readings available through e-reserves. The Stanford Encyclopedia of Philosophy entries are downloadable from <http://plato.stanford.edu/>. Go to the course web page for links.

Course requirements and evaluation

In order to obtain credit for this class, participants must give class presentations and submit a term paper by Friday, 13 June 2008.

Tentative schedule

Please note that the topics listed may not map as directly to the dates given, as some will take longer than others. The reading list is tentative and may still change slightly.

(1) Thermodynamics (3 April)

- Venkataraman, G., *A Hot Story* (London: Sangam, 1993), Ch. 2 (“Thermodynamics”), pp. 5-35.
- Sklar, Sec. 2.I, pp. 14-28.
- Harman, P. M., *Energy, Force, and Matter: the Conceptual Development of Nineteenth-Century Physics* (Cambridge: Cambridge University Press, 1982), Ch. V (“Matter theory: problems of molecular physics”), pp. 120-148.

Further Study

- Ehrlich, Philip, “Negative, infinite, and hotter than infinite temperatures”, *Synthese* 50 (1981): 233-277; selections.
- Lieb, Elliott H and Yngvason, Jakob, “A fresh look at entropy and the second law of thermodynamics”, *Physics Today* 53/4 (2000): 32-37.
- Carnot, excerpts from “Reflexions on the motive power of fire” (1824) (Carnot cycle)
- Uffink, Jos, “Irreversibility and the Second Law of Thermodynamics” (abbreviated version of “Bluff Your Way in the Second Law of Thermodynamics”), both available at his web page (<http://www.phys.uu.nl/igg/jos/>)
- Psillos versus Hasok Chang
- Brown, Harvey, and Uffink, Jos, “The origins of time-asymmetry in thermodynamics: the minus first law”, *Stud Hist Phil Mod Phys* 32 (2001): 525-538.
- Callender, “Thermodynamic asymmetry in time”, SEP

(2) Kinetic gas theory (10 April)

Kinetic gas theory, Maxwell distribution, Boltzmann’s H-theorem, Liouville theorem, reversibility objection, dog-flea model/Ehrenfest urn, Kac ring model

- Sklar, Sec. 2.II, pp. 28-48.
- Albert, D., *Time and Chance* (Cambridge, MA: Harvard University Press, 2000), Ch. 4 (“The Reversibility Objections and the Past Hypothesis”), pp. 70-96.
- Bricmont, Jean, “Science of Chaos or Chaos in Science?” In: *The Flight from Science and Reason, Annals of the New York Academy of Sciences* 775, ed. by P.R. Gross, N. Levitt, M.W. Lewis (The New York Academy of Sciences, New York 1996), pp. 131-175; Appendix (“The Kac Ring Model”).
- Ehrenfest, Paul and Ehrenfest, Tatiana, *The Conceptual Foundations of the Statistical Approach in Mechanics* (New York: Dover, 1990), Ch. 1 (“The older formulation...”), pp. 4-16, and Ch. 2 (“The modern formulation...”), pp. 17-42.

Further Study

- Brush, S., “Irreversibility and Indeterminism: Fourier to Heisenberg”, *Journal of the History of Ideas* 37 (1976): 603-630.
- Brush, S., *Statistical Physics and the Atomic Theory of Matter* (Princeton: Princeton University Press, 1983).
- Brush, S., *The Kind of Motion we call Heat* (Amsterdam: North Holland, 1986) 2 vols.
- Brush, S., *The Kinetic Theory of Gases: An Anthology of Classic Papers with Historical Commentary* (London: Imperial College Press, 2003).
- Price, H., *Time’s Arrow and Archimedes’ Point* (New York: Oxford University Press, 1996), Ch. 2 (“‘More apt to be lost than got’: the lessons of the second law”), 22-48.

(3) Interpretations of probability (17 April)

- Sklar, Ch. 3, pp. 90-127.
- Hajek, Alan, “Interpretations of probability”, SEP.
- Loewer, Barry, “Determinism and chance”, *Stud Hist Phil Mod Phys* 32 (2001): 609-620.
- Reichenbach, Hans, *The Direction of Time* (Mineola, NY: Dover, 1999), Ch. 10 (“A deterministic interpretation of thermodynamical statistics”), pp. 72-81 (same pagination as original University of California Press paperback edition of 1971).

Further Study:

- Popper, Karl R, “The propensity interpretation of probability”, *Brit J Phil Sci* 10 (1959): 25-42.
- Clark, Peter J, “Statistical mechanics and the propensity interpretation of probability”, in *Chance in Physics: Foundations and Perspectives*, J. Bricmont et al. (eds), *Lecture Notes in Physics* 574 (2001): 271-281, Springer-Verlag.
- Maudlin, Tim, “Interpreting probabilities: what’s interference got to do with it?” in *Chance in Physics: Foundations and Perspectives*, J. Bricmont et al. (eds), *Lecture Notes in Physics* 574 (2001): 283-288, Springer-Verlag.
- Earman, John, and Salmon, Wesley, “The confirmation of scientific hypotheses”, in Salmon et al. (eds.), *Introduction to the Philosophy of Science*, part III on probability, pp. 66-89.
- Hacking, Ian, *An Introduction to Probability and Inductive Logic*, Chs. 11 and 12 (very elementary, perhaps as background).
- Howson, Colin, and Urbach, Peter, *Scientific Reasoning: the Bayesian Approach*, Ch. 2 (“The probability calculus”), pp. 13-44, Ch. 3 (“The Laws of Probability”), pp. 45-90.

(4) Boltzmann and the combinatorial approach (24 April)

- Goldstein, S., “Boltzmann’s approach to statistical mechanics,” in *Chance in Physics: Foundations and Perspectives*, J. Bricmont et al. (eds), *Lecture Notes in Physics* 574 (2001): 39-54, Springer-Verlag.
- Uffink, Jos, “Boltzmann’s work in statistical physics”, SEP.
- TBA: some anti-Boltzmann piece

Further study:

- Lebowitz, Joel L
- Uffink, Jos, “Compendium to the foundations of classical statistical physics”, in *Philosophy of Physics (Handbook of the Philosophy of Science)*, J. Butterfield and J. Earman (eds) (Amsterdam: North Holland, 2007), pp. 923-1074.
- Callender, “Past Hypothesis Meets Gravity”, selections.

(5) Gibbs, phase averaging and mixing (1 May)

- Sklar, Sec. 2.III-V, pp. 48-89.
- Malament, David and Zabell, Sandy, “Why Gibbs Phase Averages Work—The Role of Ergodic Theory”, *Philosophy of Science* 47 (1980): 339-349.
- Earman, John and Rédei, Miklós, “Why Ergodic Theory Does Not Explain the Success of Equilibrium Statistical Mechanics”, *British Journal for the Philosophy of Science* 47 (1996): 63-78.
- Landsman on the thermodynamic limit?

Further study:

- Gibbs
- van Lith, Janneke, “Stir in Stillness. A study in the foundations of equilibrium statistical mechanics”, PhD thesis, Utrecht University, June 2001; selections.

(6) Reduction: does thermodynamics reduce to mechanics? (8 May)

- Sklar, Ch. 9, pp. 333-373.
- Callender, Craig, “Reducing thermodynamics to statistical mechanics: the case of entropy”, *J Phil* 96/7 (1999): 348-373.
- Hooker, Clifford A., “Towards a General Theory of Reduction. Part I: Historical and Scientific Setting. Part II: Identity in Reduction. Part III: Cross-Categorical Reduction”, *Dialogue (Canadian Philosophical Review)* 20 (1981): 38-59, 201-236, 496-529; selections.

Further study:

- Batterman, Robert, “Interttheory relations in physics”, SEP.
- Batterman, Robert, “Critical Phenomena and Breaking Drops: Infinite Idealizations in Physics”, *Studies in History and Philosophy of Modern Physics* 36 (2005): 225-244.
- Callender, Craig, “Taking thermodynamics too seriously”, *Stud Hist Phil Mod Phys* 32 (2001): 539-553.
- Jaynes, E. T., “Gibbs vs Boltzmann Entropies”, *Am J Phys* 33 (1965), 391-398.
- Lavis?

(7) What explains the thermodynamic asymmetry? (15 May)

Branches, interventions, common causes, and the past hypothesis

- Sklar, Ch. 10, pp. 375-412.
- Reichenbach, Hans, *The Direction of Time*, selection from Part III (“The time direction of thermodynamics and microstatistics”).
- Albert, David, *Time and Chance* (Cambridge, MA: Harvard University Press, 2000), Ch. 4 again? (**Craig: which selections?**)
- Penrose, Oliver, “The direction of time”, in *Chance in Physics: Foundations and Perspectives*, J. Bricmont et al. (eds), *Lecture Notes in Physics* 574 (2001): 61-82, Springer-Verlag.

Further study:

- Callender, Craig, “Thermodynamic asymmetry in time”, SEP.
- Callender, Craig, “The view from no-when”, *Brit J Phil Sci* 49 (1998): 135-159.
- Callender, Craig, “Measures, explanation, and the past: should ‘special’ initial conditions be explained?” *Brit J Phil Sci* 55 (2004): 195-217.
- Winsberg, Eric, “Can Conditioning on the ‘Past Hypothesis’ Militate against the reversibility objections?” *Philosophy of Science* 71 (2004): 489-504.

(8) The knowledge asymmetry (22 May)

Why do we know more about the past than future?

- Albert, David, *Time and Chance* (Cambridge, MA: Harvard University Press, 2000), Ch. 6 (“The asymmetries of knowledge and intervention”), pp. 113-130.
- Earman, John, “The ‘past hypothesis’: not even false”, *Stud Hist Phil Mod Phys* 37 (2006): 399-430.

- Leeds, Stephen, “Foundations of Statistical Mechanics—Two Approaches”, *Philosophy of Science* 70 (2003): 126-144.

Further study:

- Earman, John, “An Attempt to Add a Little Direction to ‘The Problem of the Direction of Time’ ” *Philosophy of Science* 41 (1974): 15-47.
- Horwich, Paul, *Asymmetries in Time: Problems in the Philosophy of Science* (Cambridge, MA: MIT Press, 1987), particularly Ch. 5 (“Knowledge”), pp. 77-90.

(9) Probability in biology (29 May)

- Beatty, John, “Replaying Life’s Tape” *Journal of Philosophy* 103 (2006): 336-362.
- Millstein, Roberta, “Interpretations of probability in evolutionary theory” *Philosophy of Science* 70 (2003): 1317-1328.

(10) Chaos, chance, games (5 June)

- Strevens, Michael, *Bigger Than Chaos: Understanding Complexity through Probability* (Cambridge, MA: Harvard University Press, 2003), selections.

Further study:

- Ruha, Charles, *The Physics of Chance: From Blaise Pascal to Niels Bohr* (Oxford: Oxford University Press, 1992), Ch. 6 (“Poincaré, or deterministic chaos”), 127-149.