Schedule of Lectures for "Foundational Problems of Thermodynamics and Statistical Mechanics"

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office hours: by appointment (email me)

course website:
http://strangebeautiful.com/lmu/2017-winter-thermo-sm.html

Winter, 2017–2018
Wed. 12:00–14:00 *C.T.*
Ludwigstr. 31, 028

Contents

N.b.: many of the required and suggested readings are available online at the course's website, though they may not be listed as such in the bibliography:

http://strangebeautiful.com/lmu/2017-winter-thermo-sm.html

Week 1: Introduction (18. Oct)

Required Reading

1. Curiel (2011), "Notes on Learning Philosophy"

Weeks 2–7: A Crash Course in Thermodynamics and Statistical Mechanics (25. Oct – 29. Nov)

Week 2: Thermodynamics I (25. Oct)

Required Reading

1. Fermi (1956), *Thermodynamics*: Intro., pp. IX–X; chs. I–III, pp. 1–45

Suggested Reading

1. Ehrenfest-Afanassjewa (1956), *Die Grundlagen der Thermodynamik*: chs. I–III
2. Benedict (1969), *Fundamentals of Temperature, Pressure and Flow Measurements*
3. Carathéodory (1909), "Untersuchungen über die Grundlagen der Thermodynamik"
4. Chang (2008), *Inventing Temperature: Measurement and Scientific Progress*
5. Planck (1926), *Treatise on Thermodynamics*: Prefaces to the first through fifth editions, pp. VII–XII; Parts I–II, pp. 1–77
6. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §I, pp. 14–27
7. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: Author's Preface, pp. V–VII; ch. 1, §§1–5, pp. 1–25
8. Truesdell (1980), *The Tragicomical History of Thermodynamics: 1822–1854*
9. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §2
10. Wallace (2014), "Thermodynamics as Control Theory"

Week 3: HOLIDAY, NO LECTURE (01. Nov)

Weeks 4–5: Thermodynamics II (08–15 Nov)

Required Reading

1. Fermi (1956), *Thermodynamics*: ch. IV, §§11–14, pp. 46–59
2. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. I, §6.F, pp. 40–41

Suggested Reading

1. Ehrenfest-Afanassjewa (1956), *Die Grundlagen der Thermodynamik*: chs. IV–VIII
2. Carathéodory (1909), "Untersuchungen über die Grundlagen der Thermodynamik"
3. Carnot (1824), *Réflexions sur la Puissance Motrice du Feu et sur les Machines Propres á Développer Cette Puissance*
4. Planck (1926), *Treatise on Thermodynamics*: Part III, pp. 78–124
5. Planck (1915), *Eight Lectures on Theoretical Physics, Delivered at Columbia University in 1909*: Lecture 1
6. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §I, pp. 14–27
7. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. I, §§6–8, pp. 26–54; ch. 1, §11, pp. 68–71
8. Truesdell (1980), *The Tragicomical History of Thermodynamics: 1822–1854*
9. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §2
10. Wallace (2014), "Thermodynamics as Control Theory"

Week 6: Statistical Mechanics I — Boltzmannian Picture (22. Nov)

Required Reading

1. Frigg (2008), "A Field Guide to Recent Work on the Foundations of Statistical Mechanics": §§2.1–2.3 (pp. 8–30 in the arXiv preprint)
2. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §2, pp.28–48; ch. 2, §4.1, pp.59–67
3. Wallace (2015), "The Quantitative Content of Statistical Mechanics"

Suggested Reading

1. Boltzmann (1896, 1898), *Vorlesungen über Gastheorie* (2 vols.); English translation Boltzmann (1964), *Lectures on Gas Theory*: part I, forward, introduction, ch. I, §§3–9; part II, ch. III, ch. VII
2. Brown, Myrvold, and Uffink (2009), "Boltzmann's H-Theorem, Its Discontents, and the Birth of Statistical Mechanics"
3. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*: chs. I–II
4. Goldstein (2001), "Boltzmann's Approach to Statistical Mechanics"
5. Jaynes (1965), "Gibbs vs Boltzmann Entropies"
6. Maxwell (1860a), "Illustrations of the Dynamical Theory of Gases.—Part I. On the Motions and Collisions of Perfectly Elastic Spheres"

7. Maxwell (1860b), "Illustrations of the Dynamical Theory of Gases.—Part II. On the Process of Diffusion of Two or More Kinds of Moving Particles among One Another"
8. Maxwell (1867), "On the Dynamical Theory of Gases"
9. Maxwell (1871), *The Theory of Heat*: ch. XXII
10. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. III, §§22–23, pp. 169–181; ch. IV, §§28–30, pp. 207–227
11. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §§3–4
12. Werndl and Frigg (2015), "Reconceptualising Equilibrium in Boltzmannian Statistical Mechanics and Characterising Its Existence"

Week 7: Statistical Mechanics II — Gibbsian Picture (29. Nov)

Required Reading

1. Frigg (2008), "A Field Guide to Recent Work on the Foundations of Statistical Mechanics": §§3.1–3.3 (pp. 55–60 in the arXiv preprint)
2. Schrödinger (1960), *Statistical Thermodynamics*: ch. I; ch. II, pp. 5–7
3. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §3, pp.48–59; ch. 2, §4.2, pp.67–71
4. Wallace (2015), "The Quantitative Content of Statistical Mechanics"

Suggested Reading

1. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*: ch. III
2. Fowler (1955), *Statistical Mechanics: The Theory of the Properties of Matter in Equilibrium*
3. Frigg and Werndl (2018), "Equilibrium in Gibbsian Statistical Mechanics"
4. Gibbs (1902), *Elementary Principles of Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics*
5. Jaynes (1965), "Gibbs vs Boltzmann Entropies"
6. Malament and Zabell (1980), "Why Gibbs Phase Averages Work—The Role of Ergodic Theory"
7. Schrödinger (1960), *Statistical Thermodynamics*: chs. II–III
8. Tolman (1938), *The Principles of Statistical Mechanics*
9. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §5
10. Werndl and Frigg (2017), "Mind the Gap: Boltzmannian versus Gibbsian Equilibrium"

Weeks 8–15: The Contemporary Debates (06. Dec – 31. Jan)

Week 8: Equilibrium and Thermodynamical Processes (06. Dec)

Required Reading

1. Norton (2016), "The Impossible Process: Thermodynamic Reversibility"
2. Valente (2017), "On the Paradox of Reversible Processes in Thermodynamics"

Suggested Reading

1. Brown and Uffink (2001), "The Origins of Time-Asymmetry in Thermodynamics: The Minus First Law"
2. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*
3. Ehrenfest-Afanassjewa (1956), *Die Grundlagen der Thermodynamik*: ch. I, ch. VI
4. Norton (2017), "Thermodynamically Reversible Processes in Statistical Physics"

Week 9: Probability in Statistical Mechanics (13. Dec)

Required Reading

1. Jaynes (1967), "Foundations of Probability and Statistical Mechanics"

Suggested Reading

1. Callender (2011a), "The Past Histories of Molecules"
2. Frigg (2010), "Probability in Boltzmannian Statistical Mechanics"
3. Gillies (2000), *Philosophical Theories of Probability*
4. Hacking (1975), *The Emergence of Probability*
5. Hacking (1990), *The Taming of Chance*
6. Jaynes (1957a), "Information Theory and Statistical Mechanics"
7. Jaynes (1957b), "Information Theory and Statistical Mechanics. II"
8. Jaynes (1963), "Information Theory and Statistical Mechanics (Brandeis Lectures 1962)"
9. Lavis (2011), "An Objectivist Account of Probabilities in Statistical Mechanics"
10. Myrvold (2011), "Statistical Mechanics and Thermodynamics: A Maxwellian View"
11. Uffink (2011), "Subjective Probability and Statistical Physics"
12. Wallace (2018), "Probability and Irreversibility in Modern Statistical Mechanics: Classical and Quantum"

Week 10: Thermodynamics and Statistical Mechanics: Reduction, Emergence, or What? (20. Dec)

Required Reading

1. Butterfield (2011b), "Less is Different: Emergence and Reduction Reconciled": §§1–3 (pp. 1065–1082); §7 (pp. 1123–1132)

Suggested Reading

1. Batterman (2001), *The Devil in the Details: Asymptotic Reasoning in Explanation, Reduction, and Emergence*
2. Butterfield (2011a), "Emergence, Reduction and Supervenience: A Varied Landscape"
3. Callender (1999), "Reducing Thermodynamics to Statistical Mechanics: The Case of Entropy"
4. Callender (2001), "Taking Thermodynamics Too Seriously"

5. Knox (2016), "Abstraction and Its Limits: Finding Space for Novel Explanation"
6. [*** Patricia ***]
7. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: [***]
8. Sklar (1999), "The Reduction(?) of Thermodynamics to Statistical Mechanics"
9. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. IV, §30, pp. 221–227; ch. V, §§41–43, pp. 293–323
10. Wallace (2015), "The Quantitative Content of Statistical Mechanics"

Week 11: The Nature of Entropy (10. Jan)

Required Reading

1. Frigg and Werndl (2011), "Entropy: A Guide for the Perplexed"

Suggested Reading

1. Callender (1999), "Reducing Thermodynamics to Statistical Mechanics: The Case of Entropy"
2. Carnap (1977), *Two Essays on Entropy*: Essay I
3. [*** Greven, Keller, and (pp. 121-146). Princeton N.J: . (2003)? ***]
4. Jaynes (1965), "Gibbs vs Boltzmann Entropies"
5. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: [***]
6. Werndl and Frigg (2017), "Mind the Gap: Boltzmannian versus Gibbsian Equilibrium"

Week 12: The Second Law and Irreversibility (17. Jan)

Required Reading

1. Uffink (2001), "Bluff Your Way in the Second Law of Thermodynamics"

Suggested Reading

1. Albert (2000), *Time and Chance*
2. Earman and Norton (1998), "Exorcist XIV: The Wrath of Maxwell's Demon. Part I. From Maxwell to Szilard"
3. Earman and Norton (1999), "Exorcist XIV: The Wrath of Maxwell's Demon. Part II. From Szilard to Landauer and Beyond"
4. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*
5. Jaynes (1957b), "Information Theory and Statistical Mechanics. II"
6. Lebowitz (1999), "Statistical Mechanics: A Selective Review of Two Central Issues"
7. Lebowitz (2007), "From Time-symmetric Microscopic Dynamics to Time-asymmetric Macroscopic Behavior: An Overview"
8. Lieb and Yngvason (1999), "The Physics and Mathematics of the Second Law of Thermodynamics"

9. Reichenbach (1956), *The Direction of Time*: [***]
10. Schrödinger (1951), "Irreversibility"
11. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: [***]
12. Uffink (2003), "Irreversibility and the Second Law of Thermodynamics"
13. Wallace (2011), "The Logic of the Past Hypothesis"
14. Wallace (2017), "The Nature of the Past Hypothesis"
15. Wallace (2018), "Probability and Irreversibility in Modern Statistical Mechanics: Classical and Quantum"

Week 13: The Arrows of Time (24. Jan)

Required Reading

1. Reichenbach (1956), *The Direction of Time*: [***]
2. Wallace (2013), "The Arrow of Time in Physics"

Suggested Reading

1. Brown and Uffink (2001), "The Origins of Time-Asymmetry in Thermodynamics: The Minus First Law"
2. Callender (2011b), "Thermodynamical Asymmetry in Time"
3. Feynman (1965), *The Character of Physical Law*: ch. 5
4. Lebowitz (2007), "From Time-symmetric Microscopic Dynamics to Time-asymmetric Macroscopic Behavior: An Overview"
5. Penrose (2001), "The Direction of Time"
6. Price (1996), *Time's Arrow and Archimedes' Point: New Directions for the Physics of Time*
7. Penrose and Percival (1962), "The Direction of Time"
8. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: [***]
9. Zeh (2007), *The Physical Basis of the Direction of Time*

Week 14: Cosmology (31. Jan)

Required Reading

1. Wallace (2010), "Gravity, Entropy, and Cosmology: In Search of Clarity"

Suggested Reading

1. Albert (2000), *Time and Chance*
2. Callender (2010), "The Past Hypothesis Meets Gravity"
3. Feynman (1965), *The Character of Physical Law*: ch. 5
4. Reichenbach (1956), *The Direction of Time*
5. [*** Katie ***]
6. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: [***]
7. Wallace (2011), "The Logic of the Past Hypothesis"
8. Wallace (2017), "The Nature of the Past Hypothesis"

Week 15: Black Holes (extra session, date TBD)

Required Reading

1. Curiel (2015), "Are Classical Black Holes Hot or Cold?"

Suggested Reading

1. [*** Callender and Dougherty ***]
2. Curiel (2016), "Black Holes Really Are Thermodynamical Objects"
3. Wald (2001), "The Thermodynamics of Black Holes"

FEBRUARY: NO LECTURES, DR. CURIEL OUT OF TOWN (07.–14. Feb)

FINAL PAPER DUE: 19. MAR

References

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Bricmont, J., G. Ghirardi, D. Dürr, F. Petruccione, M. Galavotti, and N. Zanghi (Eds.) (2001). *Chance in Physics*, Volume 574 of *Lecture Notes in Physics*. Berlin: Springer. doi:10.1007/3-540-44966-3.

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Butterfield, J. (2011a, June). Emergence, reduction and supervenience: A varied landscape. *Foundations of Physics 41*(41), 920–959. doi:10.1007/s10701-011-9549-0.

Butterfield, J. (2011b). Less is different: Emergence and reduction reconciled. *Foundations of Physics 41*(6), 1065–1135. doi:10.1007/s10701-010-9516-1.

Callender, C. (1999, July). Reducing thermodynamics to statistical mechanics: The case of entropy. *Journal of Philosophy 96*(7), 348–373. doi:10.5840/jphil199996733.

Callender, C. (2001, December). Taking thermodynamics too seriously. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 32*(4), 539–553. doi:10.1016/S1355-2198(01)00025-9.

Callender, C. (2010). The Past Hypothesis meets gravity. See Ernst and Hüttemann (2010), Chapter 3, pp. 34–58. doi:10.1017/CBO9780511770777.003.

Callender, C. (2011a). The past histories of molecules. See Beisbart and Hartmann (2011), Chapter 4, pp. 83–114. doi:10.1093/acprof:oso/9780199577439.003.0004.

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Carnot, S. (1824). *Réflexions sur la Puissance Motrice du Feu et sur les Machines Propres á Développer Cette Puissance*. Paris: Chez Bachelier, Libraire. For an English translation, see *Reflections on the Motive Power of Fire, and on Machines Fitted to Develop That Power*, E. Mendoza (trans., ed.), Dover Publications: New York, 1960, an emended version of *Reflections on the Motive Power of Heat*, R. Thurston (trans.), Macmillan: New York, 1890.

Chang, H. (2008). *Inventing Temperature: Measurement and Scientific Progress*. Oxford: Oxford University Press. doi:10.1093/0195171276.001.0001.

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Ernst, G. and A. Hüttemann (Eds.) (2010). *Time, Chance, and Reduction: Philosophical Aspects of Statistical Mechanics*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511770777.

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Fowler, R. (1955). *Statistical Mechanics: The Theory of the Properties of Matter in Equilibrium* (2nd ed.). Cambridge: Cambridge University Press.

Frigg, R. (2008). A field guide to recent work on the foundations of statistical mechanics. In D. Rickles (Ed.), *The Ashgate Companion to Contemporary Philosophy of Physics*, Chapter 3, pp. 99–196. London: Ashgate. Preprint: arXiv:0804.0399 [cond-mat.stat-mech].

Frigg, R. (2010). Probability in Boltzmannian statistical mechanics. See Ernst and Hüttemann (2010), Chapter 6, pp. 92–118. doi:10.1017/CBO9780511770777.006.

Frigg, R. and C. Werndl (2011). Entropy: A guide for the perplexed. See Beisbart and Hartmann (2011), Chapter 5, pp. 115–142. doi:10.1093/acprof:oso/9780199577439.003.0005.

Frigg, R. and C. Werndl (2018). Equilibrium in gibbsian statistical mechanics. In E. Knox and A. Wilson (Eds.), *Routledge Companion to Philosophy of Physics*. London: Routledge. Forthcoming. Preprint available at <http://www.romanfrigg.org/writings/gibbs_equ_routledge.pdf>.

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Lieb, E. and J. Yngvason (1999, March). The physics and mathematics of the second law of thermodynamics. *Physics Reports 310*(1), 1–96. doi:10.1016/S0370-1573(98)00082-9. Preprint: arXiv:cond-mat/9708200 [cond-mat.soft].

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Maxwell, J. C. (1860b). Illustrations of the dynamical theory of gases.—Part II. On the process of diffusion of two or more kinds of moving particles among one another. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, Series 4 20*(130), 21–37. Reprinted in *The Scientific Papers of J. C. Maxwell* (2 volumes printed as one), Volume I, W. Niven (Ed.). New York: Dover Publications, Inc., 1965, 392–409.

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