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

Lecture 1: Introduction (18. Oct)

Required Reading

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

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

Lecture 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. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, ch. 1
6. Gibbs (1876), "On the Equilibrium of Heterogeneous Substances. I"
7. Gibbs (1878), "On the Equilibrium of Heterogeneous Substances. II"
8. Maxwell (1871), *The Theory of Heat*: ch. I; ch.II, pp. 32–40; ch. III, pp. 54–58; ch. IV, pp. 83–93; ch. IV, pp. 108–117
9. Planck (1926), *Treatise on Thermodynamics*: Prefaces to the first through fifth editions, pp. VII–XII; Parts I–II, pp. 1–77
10. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §I, pp. 14–27
11. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: Author's Preface, pp. V–VII; ch. 1, §§1–5, pp. 1–25
12. Truesdell (1980), *The Tragicomical History of Thermodynamics: 1822–1854*
13. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §2
14. Wallace (2014), "Thermodynamics as Control Theory"

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

Lectures 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. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, ch. 1
5. Gibbs (1876), "On the Equilibrium of Heterogeneous Substances. I"
6. Gibbs (1878), "On the Equilibrium of Heterogeneous Substances. II"
7. Maxwell (1871), *The Theory of Heat*: chs. VII–VIII; ch. XII, pp. 185–195
8. Planck (1926), *Treatise on Thermodynamics*: Part III, pp. 78–124
9. Planck (1915), *Eight Lectures on Theoretical Physics, Delivered at Columbia University in 1909*: Lecture 1
10. Prigogine (1967), *Introduction to Thermodynamics of Irreversible Processes*
11. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 2, §I, pp. 14–27
12. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. I, §§6–8, pp. 26–54; ch. 1, §11, pp. 68–71
13. Truesdell (1980), *The Tragicomical History of Thermodynamics: 1822–1854*
14. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §2
15. Wallace (2014), "Thermodynamics as Control Theory"

Lecture 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 (1877), "Über die Beziehung zwischen dem zweiten Hauptsatze der mechanischen Wärmetheorie und der Wahrscheinlichkeitsrechnung resp. den Sätzen über das Wärmegleichgewicht"
2. Boltzmann (1871), "Einige allgemeine Sätze über Wärmegleichgewicht"

3. 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
4. Brown, Myrvold, and Uffink (2009), "Boltzmann's H-Theorem, Its Discontents, and the Birth of Statistical Mechanics"
5. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*: chs. I–II
6. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, ch. 2
7. Goldstein (2001), "Boltzmann's Approach to Statistical Mechanics"
8. Jaynes (1965), "Gibbs vs Boltzmann Entropies"
9. Lavis (2005), "Boltzmann and Gibbs: An Attempted Reconciliation"
10. Lavis (2008), "Boltzmann, Gibbs, and the Concept of Equilibrium"
11. Maxwell (1860a), "Illustrations of the Dynamical Theory of Gases.—Part I. On the Motions and Collisions of Perfectly Elastic Spheres"
12. 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"
13. Maxwell (1867), "On the Dynamical Theory of Gases"
14. Maxwell (1871), *The Theory of Heat*: ch. XXII
15. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. III, §§22–23, pp. 169–181; ch. IV, §§28–30, pp. 207–227
16. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §§3–4
17. Werndl and Frigg (2015), "Reconceptualising Equilibrium in Boltzmannian Statistical Mechanics and Characterising Its Existence"

Lecture 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. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, ch. 8
3. Fowler (1955), *Statistical Mechanics: The Theory of the Properties of Matter in Equilibrium*
4. Frigg and Werndl (2018), "Equilibrium in Gibbsian Statistical Mechanics"
5. Gibbs (1902), *Elementary Principles of Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics*
6. Jaynes (1965), "Gibbs vs Boltzmann Entropies"

7. Lavis (2005), "Boltzmann and Gibbs: An Attempted Reconciliation"
8. Lavis (2008), "Boltzmann, Gibbs, and the Concept of Equilibrium"
9. Malament and Zabell (1980), "Why Gibbs Phase Averages Work—The Role of Ergodic Theory"
10. Schrödinger (1960), *Statistical Thermodynamics*: chs. II–III
11. Tolman (1938), *The Principles of Statistical Mechanics*
12. Uffink (2007), "Compendium of the Foundations of Classical Statistical Physics": §5
13. Werndl and Frigg (2017), "Mind the Gap: Boltzmannian versus Gibbsian Equilibrium"

Lectures 8–15: The Contemporary Debates (20. Dec – 31. Jan)

Lecture 8: Equilibrium and Thermodynamical Processes (20. 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. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, ch. 1
5. Lavis (2008), "Boltzmann, Gibbs, and the Concept of Equilibrium"
6. Norton (2012), "Idealization and Approximation"
7. Norton (2017), "Thermodynamically Reversible Processes in Statistical Physics"
8. Pitowsky (2001), "Local Fluctuations and Local Observers in Equilibrium Statistical Mechanics"
9. Pitowsky (2006), "On the Definition of Equilibrium"
10. Rechel (1947), "The Reversible Process in Thermodynamics"
11. Uffink (2003), "Three Concepts of Irreversibility and Three Versions of the Second Law"

Lectures 9–10: Probability in Statistical Mechanics (10. Jan, regular time, 12:00–14:00; 10. Jan, special time, 14:00–16:00, Ludwigstr. 31/028 (normal room))

Required Reading

1. Frigg (2008), "A Field Guide to Recent Work on the Foundations of Statistical Mechanics": §2.3.2 (pp. 22–25 in the arXiv preprint); §2.4 (pp. 30–37 in the arXiv preprint); §2.6 (pp. 43–47 in the arXiv preprint); §§3.2.1–3.2.2 (pp. 59–60 in the arXiv preprint); §§3.2.1–3.2.2 (pp. 59–60 in the arXiv preprint); §§3.3–3.4 (pp. 62–74 in the arXiv preprint); §3.6 (pp. 89–96 in the arXiv preprint)
2. Jaynes (1967), "Foundations of Probability and Statistical Mechanics"
3. Uffink (2011), "Subjective Probability and Statistical Physics"

Suggested Reading

1. Arnold and Avez (1968), *Ergodic Problems of Classical Mechanics*
2. Bricmont (2001), "Bayes, Boltzmann, and Bohm: Probabilities in Physics"
3. Callender (2011b), "The Past Histories of Molecules"
4. Carnap (1962), *Logical Foundations of Probability*
5. Earman and Rédei (1996), "Why Ergodic Theory Does Not Explain the Success of Equilibrium Statistical Mechanics"
6. Emch and Liu (2002), *The Logic of Thermostatistical Physics*, chs. 3–7
7. de Finetti (1972), *Probability, Induction and Statistics*
8. Frigg (2009), "Typicality and the Approach to Equilibrium in Boltzmannian Statistical Mechanics"
9. Frigg (2010), "Probability in Boltzmannian Statistical Mechanics"
10. Gillies (2000), *Philosophical Theories of Probability*
11. Good (1971), "46656 Varieties of Bayesians"
12. Hacking (1975), *The Emergence of Probability*
13. Hacking (1990), *The Taming of Chance*
14. Hájek (2009), "Fifteen Arguments Against Hypothetical Frequentism"
15. Howson and Urbach (1993), *Scientific Reasoning: The Bayesian Approach (2nd ed.)*: especially pp. 276–288.
16. Howson and Urbach (2005), *Scientific Reasoning: The Bayesian Approach (3rd ed.)*
17. Jaynes (1957a), "Information Theory and Statistical Mechanics"
18. Jaynes (1957b), "Information Theory and Statistical Mechanics. II"
19. Jaynes (1963), "Information Theory and Statistical Mechanics (Brandeis Lectures 1962)"
20. Jaynes (1968), "Prior Probabilities"
21. Jaynes (1989), *E. T. Jaynes: Papers on Probability, Statistics, and Statistical Physics*
22. Jaynes (2003), *Probability Theory: The Logic of Science*
23. Khinchin (2013), *Mathematical Foundations of Statistical Mechanics*
24. Lavis (2011), "An Objectivist Account of Probabilities in Statistical Mechanics"
25. Lewis (1981), "A Subjectivist's Guide to Objective Chance"
26. von Mises (1957), *Probability, Statistics and Truth*

27. Myrvold (2011), "Statistical Mechanics and Thermodynamics: A Maxwellian View"
28. Peirce (1878), "The Doctrine of Chances"
29. Ramsey (1931), "Truth and Probability"
30. Shannon (1948a), "A Mathematical Theory of Communication"
31. Shannon (1948b), "A Mathematical Theory of Communication (Part III)"
32. Shimony (1985), "The Status of the Principle of Maximum Entropy"
33. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 4; ch. 5, §III (pp. 175–194); ch. 7, §IV (pp. 279–295)
34. Wallace (2018), "Probability and Irreversibility in Modern Statistical Mechanics: Classical and Quantum"

Lecture 11: Thermodynamics and Statistical Mechanics: Reduction, Emergence, or What? (15. Jan, Monday, 12:00–14:00, Ludwigstr. 28, RG/503)

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. Batterman (2010), "On the Explanatory Role of Mathematics in Empirical Science"
3. Belot (2005), "Whose Devil? Which Details?"
4. Butterfield (2011a), "Emergence, Reduction and Supervenience: A Varied Landscape"
5. Callender (1999), "Reducing Thermodynamics to Statistical Mechanics: The Case of Entropy"
6. Callender (2001), "Taking Thermodynamics Too Seriously"
7. Dizadji-Bahmani, Frigg, and Hartmann (2010), "Who's Afraid of Nagelian Reduction?"
8. Gibbs (1902), *Elementary Principles of Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics*: chs. XIII-XIV
9. Hellman (1999), "Reduction(?) to What? Comments on L. Sklar's "The Reduction (?) of Thermodynamics to Statistical Mechanics""
10. Kadanoff (2009), "More Is the Same: Phase Transitions and Mean Field Theories"
11. Kadanoff (2013), "Theories of Matter: Infinities and Renormalization"
12. Knox (2016), "Abstraction and Its Limits: Finding Space for Novel Explanation"
13. Morrison (2006), "Emergence, Reduction, and Theoretical Principles: Rethinking Fundamentalism"
14. Morrison (2012), "Emergent Physics and Micro-Ontology"
15. Morrison (2015), "Why Is More Different?"
16. Myrvold (2011), "Statistical Mechanics and Thermodynamics: A Maxwellian View"
17. Palacios (2017), "Phase Transitions: A Challenge for Reductionism?"
18. Pincock (2012), *Mathematics and Scientific Representation*

19. Pincock (2007), "Mathematical Idealization"
20. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 9
21. Sklar (1999), "The Reduction(?) of Thermodynamics to Statistical Mechanics"
22. Sommerfeld (1964), *Thermodynamics and Statistical Mechanics*: ch. IV, §30, pp. 221–227; ch. V, §§41–43, pp. 293–323
23. Wallace (2015), "The Quantitative Content of Statistical Mechanics"

Lecture 12: The Nature of Entropy (17. Jan)

Required Reading

1. Frigg and Werndl (2011), "Entropy: A Guide for the Perplexed": §§1–4; §7

Suggested Reading

1. Barrett. and Sober (1992), "Is Entropy Relevant to the Asymmetry Between Retrodiction and Prediction?"
2. Callender (1999), "Reducing Thermodynamics to Statistical Mechanics: The Case of Entropy"
3. Carathéodory (1909), "Untersuchungen über die Grundlagen der Thermodynamik"
4. Carnap (1977), *Two Essays on Entropy*: Essay I
5. Gibbs (1876), "On the Equilibrium of Heterogeneous Substances. I"
6. Gibbs (1878), "On the Equilibrium of Heterogeneous Substances. II"
7. Gibbs (1902), *Elementary Principles of Statistical Mechanics, Developed with Especial Reference to the Rational Foundation of Thermodynamics*: chs. XII-XIV
8. Grad (1961), "The Many Faces of Entropy"
9. Greven, Keller, and Warnecke (2003), *Entropy*
10. Jaynes (1965), "Gibbs vs Boltzmann Entropies"
11. Maxwell (1871), *The Theory of Heat*: chs. VII–VIII; ch. XII, pp. 185–195
12. Myrvold (2011), "Statistical Mechanics and Thermodynamics: A Maxwellian View"
13. Reichenbach (1956), *The Direction of Time*: part III, ch. 8; part IV, ch. 20
14. Schrödinger (1992), *What Is Life? The Physical Aspect of the Living Cell, with Mind and Matter, and Autobiographical Sketches*
15. Werndl and Frigg (2017), "Mind the Gap: Boltzmannian versus Gibbsian Equilibrium"
16. Thomson (Lord Kelvin) (1852), "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy"

Lecture 13: The Second Law and Irreversibility (23. Jan, Tuesday, 12:00–14:00, Amalienstr. 73A/106)

Required Reading

1. Frigg (2008), "A Field Guide to Recent Work on the Foundations of Statistical Mechanics": §2.3.2, from p. 24 (arXiv version; "Micro-Probabilities" onward); §§2.3.3–2.3.4 (pp. 26–27 in arXiv version); §2.6.3 (pp. 46–47 in arXiv version)

2. Uffink (2003), "Three Concepts of Irreversibility and Three Versions of the Second Law"

Suggested Reading

1. Albert (2000), *Time and Chance*
2. Brown and Uffink (2001), "The Origins of Time-Asymmetry in Thermodynamics: The Minus First Law"
3. Carathéodory (1909), "Untersuchungen über die Grundlagen der Thermodynamik"
4. Earman and Norton (1998), "Exorcist XIV: The Wrath of Maxwell's Demon. Part I. From Maxwell to Szilard"
5. Earman and Norton (1999), "Exorcist XIV: The Wrath of Maxwell's Demon. Part II. From Szilard to Landauer and Beyond"
6. Ehrenfest and Ehrenfest (1959), *The Conceptual Foundations of the Statistical Approach in Mechanics*
7. Frigg (2009), "Typicality and the Approach to Equilibrium in Boltzmannian Statistical Mechanics"
8. Gibbs (1876), "On the Equilibrium of Heterogeneous Substances. I"
9. Gibbs (1878), "On the Equilibrium of Heterogeneous Substances. II"
10. Jaynes (1957b), "Information Theory and Statistical Mechanics. II"
11. Lebowitz (1999), "Statistical Mechanics: A Selective Review of Two Central Issues"
12. Lebowitz (2007), "From Time-symmetric Microscopic Dynamics to Time-asymmetric Macroscopic Behavior: An Overview"
13. Lieb and Yngvason (1999), "The Physics and Mathematics of the Second Law of Thermodynamics"
14. Lieb and Yngvason (2000), "A Fresh Look at Entropy and the Second Law of Thermodynamics"
15. Maxwell (1871), *The Theory of Heat*: chs. VII–VIII; ch. XII, pp. 185–195
16. Myrvold (2011), "Statistical Mechanics and Thermodynamics: A Maxwellian View"
17. Planck (1926), *Treatise on Thermodynamics*: Prefaces to the first through fifth editions, pp. VII–XII; Part III
18. Price (2002), "Boltzmann's Time Bomb"
19. Prigogine (1947), *Étude Thermodynamique des Phénomènes Irréversibles*
20. Prigogine (1967), *Introduction to Thermodynamics of Irreversible Processes*
21. Reichenbach (1956), *The Direction of Time*: part III, chs. 7–16
22. Schrödinger (1951), "Irreversibility"
23. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 7, §III (pp. 246–278)
24. Thomson (Lord Kelvin) (1852), "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy"
25. Uffink (2001), "Bluff Your Way in the Second Law of Thermodynamics"
26. Uffink and Valente (2015), "Lanford's Theorem and the Emergence of Irreversibility"
27. Wallace (2011), "The Logic of the Past Hypothesis"
28. Wallace (2017b), "The Nature of the Past Hypothesis"
29. Wallace (2018), "Probability and Irreversibility in Modern Statistical Mechanics: Classical and Quantum"

Lecture 14: The Arrows of Time (24. Jan)

Required Reading

1. Uffink (2001), "Bluff Your Way in the Second Law of Thermodynamics": §12, pp. 384–389
2. Wallace (2013), "The Arrow of Time in Physics"

Suggested Reading

1. Albert (2000), *Time and Chance*
2. Brown and Uffink (2001), "The Origins of Time-Asymmetry in Thermodynamics: The Minus First Law"
3. Callender (2004), "There is No Puzzle about the Low Entropy Past"
4. Davies (1977), *The Physics of Time Asymmetry*
5. Davies (1994), "Stirring Up Trouble"
6. Earman (1969), "The Anisotropy of Time"
7. Earman (2002), "What Time Reversal Invariance Is and Why It Matters"
8. Earman (2011), "Sharpening the Electromagnetic Arrow(s) of Time"
9. Eddington (1935), *The Nature of the Physical World*
10. Feynman (1965), *The Character of Physical Law*: ch. 5
11. Frisch (2006), "A Tale of Two Arrows"
12. Gold (1962), "The Arrow of Time"
13. Goldstein, Tumulka, and Zanghi (2016), "Is the Hypothesis About a Low Entropy Initial State of the Universe Necessary for Explaining the Arrow of Time?"
14. Lebowitz (1993), "Boltzmann's Entropy and Time's Arrow"
15. Lebowitz (1994), "Time's Arrow and Boltzmann's Entropy"
16. Lebowitz (2007), "From Time-Symmetric Microscopic Dynamics to Time-Asymmetric Macroscopic Behavior: An Overview"
17. Lewis (1986a), "Counterfactual Dependence and Time's Arrow"
18. Lewis (1986c), "Postscripts to "Counterfactual Dependence and Time's Arrow""
19. McTaggart (1908), "The Unreality of Time"
20. Mersini-Houghton and Vaas (2012), *The Arrows of Time: A Debate in Cosmology*
21. Penrose (2001), "The Direction of Time"
22. Penrose and Percival (1962), "The Direction of Time"
23. Penrose (1979), "Singularities and Time-Asymmetry"
24. Popper (1956), "The Arrow of Time"
25. Popper (1965), "Time's Arrow and Entropy"
26. Price (1996), *Time's Arrow and Archimedes' Point: New Directions for the Physics of Time*
27. Price (2002), "Boltzmann's Time Bomb"
28. Reichenbach (1956), *The Direction of Time*: part II–IV, chs. 2–23
29. Sklar (1993), *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*: ch. 10
30. Uffink (2001), "Bluff Your Way in the Second Law of Thermodynamics"
31. Uffink and Valente (2015), "Lanford's Theorem and the Emergence of Irreversibility"
32. Wald (2006), "The Arrow of Time and the Initial Conditions of the Universe"
33. Zeh (2007), *The Physical Basis of the Direction of Time*

Lecture 15: Black Holes (31. Jan)

Required Reading

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

Suggested Reading

1. Callender and Dougherty (2017), "Black-Hole Thermodynamics: More Than an Analogy?"
2. Curiel (2016), "Black Holes Really Are Thermodynamical Objects"
3. Prunkl and Timpson (2017), "Black Hole Entropy Is Entropy and Not (Necessarily) Information"
4. Wald (2001), "The Thermodynamics of Black Holes"
5. Wallace (2017a), "The Case for Black Hole Thermodynamics, Part I – Phenomenological Thermodynamics"
6. Wüthrich (2017), "Are Black Holes about Information?"

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

FINAL PAPER DUE: 19. MAR

References

Albert, D. (2000). *Time and Chance*. Cambridge, MA: Harvard University Press.

Arnold, V. and A. Avez (1968). *Ergodic Problems of Classical Mechanics*. Number IX in The Mathematical Physics Monograph Series. New York: W. A. Benjamin, Inc.

Barrett., M. and E. Sober (1992, June). Is entropy relevant to the asymmetry between retrodiction and prediction? *British Journal for the Philosophy of Science 43*(3), 141–160. doi:10.1093/bjps/43.2.141.

Batterman, R. (2001). *The Devil in the Details: Asymptotic Reasoning in Explanation, Reduction, and Emergence*. Oxford: Oxford University Press. doi:10.1093/0195146476.001.0001.

Batterman, R. (2010, March). On the explanatory role of mathematics in empirical science. *British Journal for the Philosophy of Science 61*(1), 1–25. doi:10.1093/bjps/axp018.

Beisbart, C. and S. Hartmann (Eds.) (2011). *Probabilities in Physics*. Oxford: Oxford University Press. doi:10.1093/acprof:oso/9780199577439.001.0001.

Belot, G. (2005, January). Whose devil? Which details? *Philosophy of Science 72*(1), 128–153. doi:10.1086/428072. A fuller version can be found at <http://philsci-archive.pitt.edu/archive/00001515/>.

Benedict, R. (1969). *Fundamentals of Temperature, Pressure and Flow Measurements*. New York: John Wiley & Sons, Inc.

Boltzmann, L. (1871). Einige allgemeine Sätze über Wärmegleichgewicht. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien – mathematisch-naturwissenschaftliche Classe 63-2*, 679–711.

Boltzmann, L. (1877). über die Beziehung zwischen dem zweiten Hauptsatze der mechanischen Wärmetheorie und der Wahrscheinlichkeitsrechnung resp. den Sätzen über das Wärmegleichgewicht. *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften in Wien – mathematisch-naturwissenschaftliche Classe 76*, 373–435.

Boltzmann, L. (1896). *Vorlesungen über Gastheorie*, Volume I. Leipzig: J. A. Barth.

Boltzmann, L. (1898). *Vorlesungen über Gastheorie*, Volume II. Leipzig: J. A. Barth.

Boltzmann, L. (1964). *Lectures on Gas Theory*. Cambridge: Cambridge University Press. Translation by S. Brush of *Vorlesungen über Gastheorie* (2 volumes, 1896 and 1898).

Bricmont, J. (2001). Bayes, Boltzmann, and Bohm: Probabilities in physics. See Bricmont, Ghirardi, Dürr, Petruccione, Galavotti, and Zanghi (2001), Chapter 1, pp. 3–21. doi:10.1007/3-540-44966-3_1.

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

Brown, H., W. Myrvold, and J. Uffink (2009). Boltzmann's H-theorem, its discontents, and the birth of statistical mechanics. *Studies in History and Philosophy of Science Part A 40*(2), 174–191. doi:10.1016/j.shpsb.2009.03.003.

Brown, H. and J. Uffink (2001, December). The origins of time-asymmetry in thermodynamics: The minus first law. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 32*(4), 525–538. doi:10.1016/S1355-2198(01)00021-1.

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