Physics 583
Spring Semester 2024, Academic Year 2023/2024
List of Suggested Term Papers

Professor Eduardo Fradkin

1. The Coleman-Weinberg Mechanism, Fluctuation Induced First Order Transitions and the Superconductor Phase Transition.
   Reference: S. Coleman and E. Weinberg, *Phys. Rev.* **D7**, 1888 (1973); B. Halperin, T. Lubensky and S-K. Ma, *Phys. Rev.Lett.* **32**, 292 (1974).

2. QCD in the limit of a large number of colors, $N_c \to \infty$.
   Reference: E. Witten, *Nuc. Phys.* **B160**, 57 (1979); S. Coleman, *Aspects of Symmetry*, Chapter 8.

3. Field Theory for the Localization Transition.
   Reference: P. W. Anderson, E. Abrahams, D. C. Licciardello and T. V. Ramakrishnan (The Gang of Four), *Phys. Rev. Lett.* **42**, 673 (1979); F. Wegner, *Phys. Rev.* **B19**, 783 (1979) ; A. McKane and M. Stone, *Ann. Phys.* **131**, 36 (1981); S. Hikami, *Phys. Rev.* **24** , 2671 (1981).

4. Field Theory models of Polyacetylene.
   Reference: R. Jackiw and J. R. Schrieffer, *Nucl. Phys.* **B190** [FS3], 253 (1981); W. P. Su, J. R. Schrieffer and A. J. Heeger, *Phys. Rev.* **B22**, 2099 (1980); H. Takayama, Y. Lin-Liu and K. Maki, *Phys. Rev.* **B21**, 2388 (1980); D. K. Campbell and A. R. Bishop, *Phys. Rev.* **B24**, 4859 (1981); E. Fradkin and J. E. Hirsch, *Phys. Rev.* **B27**, 1680 (1983).

5. Conformal Field Theory and two-dimensional Critical Phenomena.
   Reference: A. A. Belavin, A. M. Polyakov and A. B. Zamolodchikov, *Nucl. Phys.* **B241**, 333 (1984); D. Friedan, Z. Qiu and S. Shenker, *Phys. Rev. Lett.* **52**, 1575 (1984); J. Cardy, *Nucl. Phys.* **B270**[FS16], 186 (1986) .

6. Non-linear Sigma models and quantum spin chains.
   Reference: F. D. M. Haldane, *Phys. Lett.* **A93**, 464 (1983); *Phys. Rev. Lett.* **50**, 1153 (1983).

7. Deconfinement transition of QCD at finite temperature.
   Reference: A. M. Polyakov, *Phys. Lett.* **B72**, 477 (1978); L. Susskind, *Phys. Rev.* **D20**, 2610 (1979); D. Gross, R. Pisarski and L. Yaffe, *Rev. Mod. Phys.* **53**, 43 (1981)

8. Confinement and Lattice Gauge Theory.
   Reference: K. G. Wilson, *Phys. Rev.* **D10**, 2455 (1974); J. Kogut and L. Susskind, *Phys. Rev.* **D11**, 395 (1975); J. Kogut, *Rev. Mod. Phys.* **51**, 659 (1979).

9. Macroscopic Quantum Coherence: the Caldeira-Leggett model.
   Reference: A. Caldeira and A. J. Leggett, *Physica* **A121**, 587 (1983); *Ann. Phys. (NY)* **149**, 374 (1983) ; A. J. Leggett, S. Chakravarty, M. P. A. Fisher, A. Dorsey and W. Zwerger, *Rev. Mod. Phys.* **59**, 1 (1987).

10. Field Theory approaches to the Quantum Hall Effect.
    Reference: S. C. Zhang, T. Hansson and S. Kivelson, *Phys. Rev. Lett.* **62**, 82 (1989)
    A. López and E. Fradkin, *Phys. Rev.* **B44**, 5246 (1991)
    S. C. Zhang, *Int. J. Mod. Phys.* **62**, 25 (1992).

11. Gauge Theories, Chern-Simons actions and the Theory of Knots.
    Reference: E. Witten, *Comm. Math. Phys.* **121**, 351 (1989);

12. Semiclassical theory of Solitons.
    Reference: R. Rajaraman, *Solitons and Instantons*, North-Holland.

13. Renormalization Group approach to Fermi Liquids.
    Reference: R. Shankar, *Rev. Mod. Phys.* **66**, 129 (1994).
    J. Polchinski, 1992 TASI Lectures, arXiv:hep-th/9210046

14. QED in two space-time dimensions.
Reference: J. Schwinger, *Phys. Rev.* **128**, 2425 (1962)
J. Kogut, A. Casher and L. Susskind, *Phys. Rev.* **D10**, 732 (1974).

15. Decay of the False Vacuum.
Reference: S. Coleman, *Aspects of Symmetry*, Chapter 7.

16. Conformal bootstrap
A. M. Polyakov, Soviet Physics JETP **39**, 10 (1974)
D. Simmons-Duffin, 2015 TASI Lectures, arXiv:1602.07982

17. Fermi and Bose Relativistic Strings.
Reference: M. B.Green, J. Schwartz and E.Witten, *Supertstring Theory*; A. M. Polyakov and others in *Fields Strings and Critical Phenomena*, Les Houches Session XLIX (1988), E. Brezin and J. Zinn Justin , Elsevier (1989); D. Friedan in *Recent Advances in Field Theory*, Les Houches Session XXXIX (1982), J. Zuber and R. Stora (1984); A. M. Polyakov , *Gauge Fields and Strings*, Harwood (1987); J. Polchinski, *String Theory*, Cambridge University Press (1998).

18. Bosonization in 1+1-dimensional field theories.
Reference: D. C. Mattis and E. Lieb, *J. Math. Phys.* **6**, 304 (1965); S. Coleman, *Phys. Rev.* **D11**, 2088 (1975); S. Mandelstam, *Phys. Rev.* **D11**, 3026 (1975); F. D. M. Haldane, *J. Phys. C* **14**, 2585 (1981).

19. Non-Abelian Bosonization.
Reference: E. Witten, *Comm. Math. Phys.* **92**, 455 (1984).

20. Path Integrals and Bosonization.
Reference: A. M. Polyakov and P. B. Wiegmann, *Phys. Lett.* **B131**, 121 (1983); A. M. Polyakov in *Fields Strings and Critical Phenomena*, Les Houches Session XLIX (1988), E. Brezin and J. Zinn Justin , Elsevier (1989); R. Gamboa Saravi, M. A. Muschietti, F. A. Schaposnik and J. E. Solomin, *Ann. Phys. (NY)* **157**, 360 (1984); C. M. Naón, *Phys. Rev.* **D31**, 2035 (1985); M. Stone, *Nucl. Phys.* **B327**, 399 (1989).

21. Fractional charge, anomalies and anomaly inflow.
J. Goldstone and F. Wilczek, Physical Review Letters **47**, 986 (1981)
F. Wilczek and A. Zee, Physical Review Letters **51**, 2250 (1983)
C. Callan and J. Harvey, Nuclear Physics B **250**, 427 (1985).

22. The Maldacena Conjecture.
Reference: J. Maldacena , Int. Jour. Theor. Phys. , **38**, 1113 (1999); Phys. Rev. Lett. **80**, 4859 (1998); D. J. Gross, H. Ooguri, Phys. Rev. **D58**, 106002 (1998); N. Drukker, D. J. Gross, H. Ooguri, Phys. Rev. **D60**, 125006 (1999); O. Aharony, S. Gubser, J. Maldacena, H. Ooguri, Y. Oz, JHEP 9812 (1998) 026, hep-th/9812046.

23. Black Holes and String Theory.
A. Strominger, C. Vafa, Phys. Lett. **B379**, 99 (1996); G. Horowitz, A. Strominger,Phys. Rev. Lett. **77**, 2368 (1996); C. G. Callan, J. M. Maldacena, Nucl. Phys. **B472**, 591 (1996); J.M. Maldacena, PhD Thesis, hep-th/9607235.

24. Boundary Conformal Field Theory.
Reference: S. Ghoshal and A. B. Zamolodchikov, *Int. J. Mod. Phys.* **A9**, 3841 (1994); C. Callan, I. Klebanov, A. W. W. Ludwig and J. Maldacena, *Nucl. Phys.* **B422**, 417 (1994).

25. Field Theory of the Kondo Problem.
Reference: P. W. Anderson, *J. Phys.* **C3**, 2436 (1970); P. W. Anderson, G. Yuval and D. R. Hamann, *Phys. Rev.* **B1**, 4464 (1970); N. Read and D. Newns, *J. Phys.* **C16**, 3273 (1983); I. Affleck and A. W. W. Ludwig, *Nucl. Phys.* **B352**, 849 (1991).

26. Bosonization of Fermi Liquids and Coherent States
Reference: A. H. Castro Neto and Eduardo Fradkin, *Phys. Rev.* **B49**, 10877 (1994); *Phys. Rev.* **B51**, 4084 (1995); A. Houghton and J. B. Marston, *Phys. Rev.* **B48**, 7790 (1993).

27. Fractional Statistics and Chern-Simons Theory
References: A. M. Polyakov, Mod. Phys.Lett. A3, 325 (1988)
E. Witten, Comm. Math. Phys. 121, 351 (1989)
E. Fradkin, *Field Theories of Condensed Matter Systems*, Chapter 10.

28. Topological Quantum Computing
References: Alexei Kitaev, Ann. Phys. 303, 2 (2003) and arXiv:quant-ph/9707021
M. H. Freedman, A. Kitaev, and Z. Wang, Comm. Math. Phys. 227, 587 (2002)
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29. Quantum entanglement in 1+1 dimensional CFT
References: C. Callan and F. Wilczek, Phys. Lett. B333, 55 91994)
C. Holzhey, F. Larsen and F. Wilczek, Nucl. Phys. B424, 443 (1994)
P.Calabrese and J. Cardy, J. Stat. Mech. (JSTAT)04, P06002 (2004)
P. Calabrese and J. Cardy, J. Phys. A42, 504005 (2009)

30. Theory of Topological Insulators
References: J. E. Moore, L. Balents, Phys. Rev. B 75, 121306(R) (2007)
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B. Andrei Bernevig, Taylor L. Hughes, Shou-Cheng Zhang, Science, 314, 1757 (2006)
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A. P. Schnyder, S. Ryu, A. Furusaki, and A. W. W. Ludwig, Phys. Rev. B 78, 195125 (2008)
Alexei Kitaev, arXiv:0901.2686

31. Duality and Anomalies in Field Theories
Michael E. Peskin, *Mandelstam-'t Hooft Duality in Abelian Lattice Models*, Ann. Phys (N.Y.) **113**, 122-152 (1978).; C. Dasgupta and B. I. Halperin, *Phase transition in a lattice model of superconductivity*, Phys. Rev. Lett. **47**, 1556-1559 (1981); T. Banks, R. J. Myerson, and J. B. Kogut, *Phase transitions in abelian gauge theories*, Nucl. Phys. B **129**, 493-510 (1977); P. R. Thomas and M. Stone, *Nature of the phase transition in a non-linear $O(2)_3$ model*, Nucl. Phys. B **144**, 513-524 (1978); Eduardo Fradkin and Fidel A. Schaposnik, *The Fermion-Boson Mapping in Three Dimensional Quantum Field Theory*, Phys. Lett. B **338**, 253-258 (1994); C. P. Burgess and F. Quevedo, *Bosonization as duality*, Nucl. Phys. B **421**, 373-387 (1983); C. P. Burgess, C. A. Lütken, and F. Quevedo, *Bosonization in higher dimensions*, Phys. Lett. B **336**, 18-24 (1994)

32. Dualities of fermionic Field Theories
Chong Wang and T. Senthil, *Dual Dirac liquid on the surface of the electron topological insulator*, Phys. Rev. X **5**, 041031/1-7 (2015); Nathan Seiberg and Edward Witten, *Gapped Boundary Phases of Topological Insulators via Weak Coupling*, arXiv:1602.05251; Nathan Seiberg, T. Senthil, Chong Wang, and Edward Witten, *A Duality Web in 2+1 Dimensions and Condensed Matter Physics* , Ann. Phys (N.Y.) **374**, 395-433 (2016); Ofer Aharony, Guy Gur-Ari and Ran Yacoby, *Correlation functions of large N Chern-Simons-Matter theories and bosonization in three dimensions*, J. High Energ. Phys. **2012**, 028/1-37 (2012); Sachin Jain, Shiraz Minwalla and Shuichi Yokoyama, *Chern Simons duality with fundamental boson and fermion*, J. High Energ. Phys. **2013**, 037/1-35 (2013); Andreas Karch and David Tong, *Particle-Vortex Duality from 3d Bosonization*, Phys. Rev. X **6**, 031043/1-11 (2016); Shamit Kachru, Michael Mulligan, Gonzalo Torroba, and Huajia Wang, *Bosonization and Mirror Symmetry*, Phys. Rev. D **94**, 085009/1-15 (2016)

33. Quantum Chaos
S. H. Shenker and D. Stanford, arXiv:1306.0622
J. Maldacena, S. Shenker and D. Stanford, arXiv:1503.01409
Y. Sekino and L. Susskind, arXiv:0808.2096
D. Stanford, arXiv: 1512.07687.

34. SYK and Black Holes
S. Sachdev and J. Ye, Physical Review Letters **70**, 3339 (1993)

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A. Kitaev, http://online.kitp.ucsb.edu/online/entangled15/kitaev/,
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J. Maldacena and D. Stanford, arxiv:1604.07818
E. Witten, arXiv:1610.09758

35. Generalized Global Symmetries
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D. Gaiotto, A. Kapustin, Z. Komargodski and N. Seiberg, Theta, time reversal and temperature, J. High Energy Phys. 05, 091 (2017)
J. McGreevy, Generalized symmetries in condensed matter, Annu. Rev. Condens. Matter Phys. 14 (2022)