Term Paper Guidelines
PHYS 798C
Spring 2022
Prof. Steven Anlage

Format: Follow the format of Physical Review A/B/E articles for references, sections, figures, etc. Include an abstract, introductory section (including a brief outline of the paper), and conclusions. This paper *may* pass as your "scholarly paper" requirement for the Physics Ph.D. program. The paper should be typed in LaTex (or REVTex) and double spaced, 12 pt type or larger. Style and clarity are important in all writing; have a friend proof-read your paper. Please have a native English speaker read and correct the paper. Figures can and should be used, but figures taken from other sources should be referenced. Please include a descriptive figure caption in your own words for all figures. Please have the figures integrated into the text, rather than collected together in a Figure section at the end of the paper. Don't forget to spell check the paper! The length of the paper should be somewhere between 10 and 20 pages.

Plagiarism: You must not steal other people's work. Verbatim copying of passages from other papers, published or unpublished or transparent paraphrasing of other work, is forbidden. You may use the results of other papers, but they must be referenced.

Content: Write an overview of your topic that can be read and understood by the other students in the class. Define terms and acronyms (i.e. SQUID), avoid the use of jargon, and put things in a logical order. Clearly define all quantities that appear in equations! This paper should introduce an intelligent newcomer to the topic. An exhaustive listing of all references in the field, or a repetitive unenlightening summary (in 2014, Smith made wiffnium, with a T_c of 102 K. In 2015, Jones made woofnium, with a T_c of 103 K, etc.) is not desirable. Also please do not choose a topic that is already well documented with wiki pages and review articles, if possible. An understandable discussion of key ideas, simple calculations and quantitative estimates, and anything else which indicates that you understand something about superconductivity and can explain it to beginning researchers in the field is desirable.

It is also important to focus the paper and go into quantitative detail on at least one or two aspects of the subject. For example, one should not simply mention a stream of results without any further discussion. **Something should be discussed in depth, with quantitative and detailed analysis presented**. Also avoid the use of qualitative statements such as "superconducting XYZ devices are clearly superior to normal metal XYZ devices." Give numbers and quantitative justification for all claims. Don't hesitate to introduce equations which illustrate the physics behind your arguments. If you write a paper on an experimental topic, be sure to include a discussion of theory relevant to the experiment. If you write on a theoretical topic, be sure to discuss experimental consequences of the theory.

Please give me three choices of topics in writing by early-March (anlage@umd.edu). To broaden your horizons a bit, choose a paper topic that is not directly related to your research. I will assign topics no later than the end of March. Only one person should write on each topic, so please have more than one choice. If you want to write about a topic not on the list, please discuss it with me.

Bonus points will be awarded for anyone who develops a stand-alone "legacy product" that benefits future students and researchers. This could include, for example, code to calculate surface impedance, tunneling conductance, and other quantities in BCS theory or its generalizations, or numerical solutions to common problems in Eliashberg theory or the Bogoliubov equations, the BTK model, time-dependent Ginzburg-Landau theory, etc. Another possibility is to create a thoughtful PhET-like interactive computer simulation/demonstration related to superconductivity. Consult with your instructor!

Please e-mail your paper by 15 April, 2022. A copy will be returned to you with comments, to be rewritten and returned on 6 May, 2022. The 6 May version will be graded.

Possible Topics

Vortex Glass - Vortex Liquid - Vortex solid phase transitions

Exotic vortex phases - Bose glass, hexatic phase, etc.
Critical behavior of superconductors (heat capacity, thermal expansion, penetration depth, etc.)
p-wave pairing in superconductors and superfluids
SQUID ground state wavefunction pairing symmetry experiments
Spin-charge separation, Charge fractionalization, Visons
Spin fluctuation pairing mechanism in HTS and pnictide superconductors
Andreev reflection, bound states at surfaces of unconventional superconductors
Time-reversal symmetry breaking states in superconductors and their measurement
Nonlinear Meissner effect
Pseudogap phenomenon in HTS - stripe phase
Neutron spectroscopy of collective modes in HTS
The Electron-Phonon mechanism in superconductors (including the isotope effect)
Hydride superconductivity
Coexistence of antiferromagnetism and superconductivity in HTS and other superconductors
Coexistence of ferromagnetic and superconducting order
S/F/S Josephson junctions, spin-triplet proximity effect
The Proximity Effect, superconductor/ferromagnet proximity coupling
Multi-terminal Josephson junctions
C_{60} superconductors, field-effect in C_{60} films
Superconductivity in carbon nanotubes, graphene and doped diamond
Topological superconductivity and Majorana Fermions
Nano-scale superconductivity, proximity effect
Mesoscopic superconductors - Andreev scattering, Andreev billiards
MgB_2 superconducting properties and/or applications
Leggett mode in multi-band superconductors
Kosterlitz-Thouless transition in superconducting thin films
Quasi-1D superconducting films grown on carbon nanotubes
Hubbard model and HTS pairing mechanism
SO(5) theory of antiferromagnetism and HTS
Superconducting X-ray detectors
Superconducting single photon detectors
Superconducting microwave kinetic inductance detectors
Transition edge sensors
Superconducting detectors used in astronomical observations
Infrared and Optical properties of superconductors - The sum rule in HTS
Rotating superconductors and the London moment
The Bernoulli Effect in superconductors
Electric Field Effect in superconductors
High Field (>30 T) properties of superconductors. Fulde-Ferrell-Larkin-Ovchinikov State
HTS and MgB_2 wire production
HTS Tape coating methods (Rabits, IBAD, etc.)
Vortex imaging techniques (neutrons, magnetic force microscopes, SQUID microscopes, etc.)
Classical superconducting digital computers
Quantum superconducting computers (choose a focused topic)
NMR measurements in superconductors
Ultrasonic attenuation in unconventional superconductors
Magnetic and non-Magnetic impurities in HTS
Angle-Resolved Photoemission spectroscopy (ARPES) of the Fermi surface and energy gap in HTS
High-field quantum oscillation measurements in cuprates and other superconductors
STM and tunneling spectroscopy of superconductors
Marginal Fermi Liquid theory of HTS
Organic superconductors
Transport properties of HTS with $H > H_{c2}$
Hall Effect in LTS and HTS
Nernst Effect above T_c in the pseudogap region
Fluctuation diamagnetism above T_c in the pseudogap region

Theory of and Evidence for a Quantum Critical Point in the HTS phase diagram
Room temperature superconductivity – where is it? What would it look like? Do we already have it?
Practical utility, or lack thereof, of room temperature superconductors
Extremely low-level measurements using SQUIDs
Superconductivity in the presence of spin imbalance
Non-equilibrium superconductivity
Superconducting experiments and detectors operating in earth orbit and beyond.
Superconductivity in the Gravity-Probe B experiment
Using metamaterial structures to modify the superconducting pairing interaction
What lies beyond BCS theory?

Some Previous Term Paper Titles:
Transport Properties of the Electron-doped Superconducting Cuprates
Superconductors for Wireless Applications
Imaging Techniques for Vortices in Superconductors
Scanning Tunneling Microscopy and Scanning Tunneling Spectroscopy on Superconductors
Extremely Low-Level Measurements Using DC SQUID
Report on Rapid Single Flux Quantum (RSFQ) Logic
Proximity Effects of Superconductors
Infrared and Optical Properties of Superconductors
Extremely Low Level Measurements Using SQUIDs
Kosterlitz-Thouless Transition in Two-Dimensional Superconductors
Manifestations of the Casimir effect in superconductors

Superconductors in Rotation
Superconductors in the presence of weak inertial and gravitational fields
The pseudogap of the angle resolved photoemission spectroscopy and the resonating valence bond model in high temperature superconductors
Thermally-Driven Melting of the Vortex Lattice
Quantum phase transition: in cuprate superconductors
High-T_c Superconductors and the Hubbard Model
Models for the proximity effect
Chaos and Nonlinear Dynamics in Josephson Junctions
Vortex Imaging Techniques
Magnetic Levitation with Superconductors
Andreev Reflection