Physics 598 PTD
Physics of two-dimensional systems
Fall 2013

Time:	Tuesday/Thursday 2:00 - 3:20pm
Place	158 Loomis Lab of Physics (LLP)
Instructor:	Tony Leggett
Office:	2113 Engineering Sciences Building (ESB)
Office Hour:	Monday 4:00
TA:	Jitong Yu, 4119 ESB [office hour: Thursday 4:00]

TOPICS: The course will concentrate on those aspects of the physics of 2 D systems that have no obvious analogs in 3 D. (e.g. absence of long-range order, the (supposed) universality of localization, the quantum Hall effect, topological protection). It will emphasize the comparison of theory and experiment, particularly in areas where there is currently substantial discrepancy.

A tentative lecture schedule for the first half of the course is attached; a schedule for the second half will be distributed later.

BOOKS: I have not found a single book that adequately covers all the material of the course, though there are some that give excellent treatments of particular topics (see below). A useful if somewhat "random" reference for the general subject of (one- and) two-dimensional systems is section E of the journal *Physica*, which was introduced in 1997 specifically to cover this area.

Other suggestions:

D. J. Thouless, in P.C.W. Davies (ed.), *The New Physics*, Cambridge University Press, 1989, 530 N 422. A good introduction to 2D physics at the Scientific American level, with special emphasis on phase transitions.

J. Wosnitza, Fermi Surfaces of low-dimensional organic metals and superconductors, Springer Tracts in Modern Physics, v. 134 508ER38

Y. Imry, *Introduction to Mesoscopic Physics*, 2nd ed. (Oxford University Press, 2002). As the name implies, this book covers a wider area than 1- and 2-D systems, but it is quite useful for its treatment of weak localization (where, however, it ignores the developments of the last few years). 537.6 Im 8i2002.

S. Girvin and R.E. Prange (eds.) *The Quantum Hall Effect*, 2nd ed. (Springer, Berlin 1990). A very useful collection of reviews on various aspects of both the integral and the fractional effects.537.6Q R51990 (Res)

B.A. Bernevig, *Topological Insulators and Topological Superconductors*, Princeton University Press, 2013. (ordered for library)

ASSESSMENT: assuming departmental approval, by homework assignments and a project.

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Tentative lecture syllabus for first half of course

Lecture	Date	Topic
1	Tu 27 Aug	General introduction:what is special about two dimensions?
2	Th 29 Aug	Some important experimental systems
3	Tu 3 Sept	Experimental systems (cont.): Single-particle quantum mechanics in two dimensions
4	Th 5 Sept	Weak localization I: General considerations, one-parameter scaling
5	Tu 10 Sept	Weak localization II: Quantitative treatment
6	Th 12 Sept	Weak localization III: The effects of spin
7	Tu 17 Sept	Weak localization IV: Interaction effects, the pre-1995 experimental situation
8	Th 19 Sept	Ginzburg-Landau theory
9	Tu 24 Sept	Long-range order in 2D systems
10	Th 26 Sept	The Kosterlitz-Thouless transition
11	Tu 1 Oct	Dynamics of superfluid films: The superconducting analogy
12	Th 3 Oct	The experimental situation: 2D magnetism
13	Tu 8 Oct	The experimental situation: Superconducting films
14	Th 10 Oct	The experimental situation: Si MOSFETs
15	Tu 15 Oct	Some aspects of two-dimensionality in the cuprates

Second half of the course

16	Th 17 Oct	Quantum Hall effect: general considerations
17	Tu 22 Oct	The integral QHE: topological considerations, edge states
18	Th 24 Oct	The fractional QHE: Laughlin wave function, fractional charge and statistics
19	Tu 29 Oct	Composite fermions: experimental evidence for fractional charge and statistics
20	Th 31 Oct	The quantum Hall effect: miscellaneous topics
21	Tu 5 Nov	Topological insulators: general preliminaries
22	Th 7 Nov	Topological insulators: a simple example
23	Tu 12 Nov	Topological insulators: further topics, the experimental situation
24	Th 14* Nov	Topological superconductors, Majorana fermions
25	Tu 19 Nov	Topological quantum computation: the general idea
26	Th 21 Nov	The Kitaev models
27	Tu 3 Dec	The nu=5/2 quantum Hall state
28	Th 5 Dec	($p+ip$) Fermi superfluids; strontium ruthenate
29	Tu 10 Dec	Review and overview

Lectures 21-28 are self-contained and can be followed without having absorbed the material on the quantum Hall effect in lectures 16-20.

*will have to be rescheduled.