

APS March Meeting 2015

San Antonio, Texas

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10:48AM L2.00013 Excitonic and marginal Fermi liquid instabilities in 2D and 3D Dirac semimetals, JOSE GONZALEZ, Instituto de Estructura de la Materia (CSIC), Madrid, Spain — We study the quantum electrodynamics of 2D and 3D Dirac semimetals by means of a self-consistent resolution of the Schwinger-Dyson equations, aiming to obtain the respective phase diagrams in terms of the relative strength of the Coulomb interaction and the number N of Dirac fermions. In this framework, 2D Dirac semimetals have just a strong-coupling instability characterized by exciton condensation (and dynamical generation of mass) that we find at a critical coupling well above the estimates made with RPA screening (large- N approximation), thus explaining the absence of that instability in free-standing graphene samples. On the other hand, we show that 3D Dirac semimetals have a richer phase diagram, with a strong-coupling instability leading to dynamical mass generation up to $N = 4$ and a line of critical points for larger values of N characterized by the vanishing of the electron quasiparticle weight in the low-energy limit. Such a marginal Fermi liquid boundary marks the transition to a kind of strange metal that can still be defined in terms of electron quasiparticles, but with parameters that have large imaginary parts implying an increasing deviation at strong coupling from the conventional Fermi liquid picture.

Wednesday, March 4, 2015 8:00AM - 11:00AM —
Session L3 GSNP: Topics in Statistical Physics II 002AB - Marco Mazza, Max Planck Institute for Dynamics and Self-Organization

8:00AM L3.00001 Concept of Linear Thermal Circulator Based on Coriolis forces¹, HUANAN LI, TSAMPIKOS KOTTOS, Wesleyan University — Directional transport and the creation of non-reciprocal devices that control the flow of energy and/or mass at predefined directions have been posing always fascinating challenges. In this contribution, we show that the presence of a Coriolis force in a rotating linear lattice imposes a non-reciprocal propagation of the phononic heat carriers. Using this effect we propose the concept of Coriolis linear thermal circulator which can control the circulation of a heat current. A simple model of three coupled harmonic masses on a rotating platform allow us to demonstrate giant circulating rectification effects for moderate values of the angular velocities of the platform.

¹This work was partly sponsored by a NSF DMR-1306984 grant and by an AFOSR MURI grant FA9550-14-1-0037.

8:12AM L3.00002 Magnetically driven quantum heat engine¹, ENRIQUE MUNOZ, Pontificia Universidad Catolica de Chile, FRANCISCO PENA, Pontificia Universidad Catolica de Valparaiso — In analogy with classical thermodynamics, a quantum heat engine generates useful mechanical work from heat, by means of a reversible sequence of transformations (trajectories), where the “working substance” is of quantum mechanical nature. Several theoretical implementations for a quantum heat engine have been discussed in the literature, such as entangled states in a qubit, quantum mechanical versions of the Otto cycle, and photocells. In this work [1], we propose yet a different alternative by introducing the concept of a magnetically driven quantum heat engine. We studied the efficiency of such system, by considering as the “working substance” a single nonrelativistic particle trapped in a cylindrical potential well, as a model for a semiconductor quantum dot, in the presence of an external magnetic field. The trajectories are driven by a quasistatic modulation of the external magnetic-field intensity, while the system is in contact with macroscopic thermostats. The external magnetic field modulation allows to modify the effective geometric confinement, in analogy with a piston in a classical gas.

[1] E. Munoz and F. J. Pena, Physical Review E 89, 052107 (2014).

¹E. Munoz acknowledges financial support from Fondecyt under contract 1141146

8:24AM L3.00003 ABSTRACT WITHDRAWN —

8:36AM L3.00004 Why are all dualities conformal? Theory and practical consequences, SEYYED MOHAMMAD SADEGH VAEZI, ZOHARN NUSSINOV, Washington University, GERARDO ORTIZ, Indiana University, Bloomington — We relate duality mappings to the “Babbage equation” $F(F(z)) = z$ with F a map linking weak to strong coupling theories. Under fairly general conditions F may only be a specific conformal transformation of the fractional linear type. This deep general result has enormous practical consequences. For example, one can establish that weak and strong coupling expansions are trivially related, i.e., one needs to generate only one of them while the other is automatically determined through a set of linear constraints. The latter partially solve or, equivalently, localize the computational complexity to a simple fraction of the coefficients, and as a bonus those relations encode non-trivial equalities between different geometric constructions. We illustrate our findings by examining various models including, but not limited to, ferromagnetic and spin-glass type Ising models on hypercubic lattices.

8:48AM L3.00005 ABSTRACT WITHDRAWN —

9:00AM L3.00006 Quantifying the Effects of Noise on Diffuse Interface Models: Cahn-Hilliard-Cook equations, SPENCER PFEIFER, BASKAR GANAPATHYSUBRAMANIAN, Iowa State Univ — We present an investigation into the dynamics of phase separation through numerical simulations of the Cahn-Hilliard-Cook (CHC) equation. This model is an extension of the well-known Cahn-Hilliard equation, perturbed by an additive white noise. Studies have shown that random fluctuations are critical for proper resolution of physical phenomena. This is especially true for phase critical systems. We explore the transient behavior of the solution space for varying levels of noise. This is enabled by our massively scalable finite element-based numerical framework. We briefly examine the interplay between noise level and discretization (spatial and temporal) in obtaining statistically consistent solutions. We show that the added noise accelerates progress towards phase separation, but retards dynamics throughout subsequent coarsening. We identify a scaling exponent relating morphology metrics with the level of noise. We observe a very clear scaling effect of finite domain size, which is observed to be offset by increasing levels of noise. Domain scaling reveals a clear microstructural asymmetry at various stages of the evolution for lower noise levels. In contrast, higher noise levels tend to produce more uniform morphologies.



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APS March Meeting 2015

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Monday–Friday, March 2–6, 2015; San Antonio, Texas

Session L2: Focus Session: Beyond Graphene - Spin and Magnetic Properties

8:00 AM–11:00 AM, Wednesday, March 4, 2015
Room: 001B

Sponsoring Unit: DMP
Chair: Jun Zhu, Pennsylvania State University

Abstract ID: BAPS.2015.MAR.L2.13

Abstract: L2.00013 : Excitonic and marginal Fermi liquid instabilities in 2D and 3D Dirac semimetals

10:48 AM–11:00 AM

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We study the quantum electrodynamics of 2D and 3D Dirac semimetals by means of a self-consistent resolution of the Schwinger-Dyson equation aiming to obtain the respective phase diagrams in terms of the relative strength of the Coulomb interaction and the number N of Dirac fermion: framework, 2D Dirac semimetals have just a strong-coupling instability characterized by exciton condensation (and dynamical generation of m that we find at a critical coupling well above the estimates made with RPA screening (large- N approximation), thus explaining the absence of tl instability in free-standing graphene samples. On the other hand, we show that 3D Dirac semimetals have a richer phase diagram, with a strong coupling instability leading to dynamical mass generation up to $N = 4$ and a line of critical points for larger values of N characterized by the variation of the electron quasiparticle weight in the low-energy limit. Such a marginal Fermi liquid boundary marks the transition to a kind of strange metal that can still be defined in terms of electron quasiparticles, but with parameters that have large imaginary parts implying an increasing deviation at coupling from the conventional Fermi liquid picture.

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