Strongly Correlated Systems Group

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Our group in theoretical condensed matter physics focus on:

**i) Topological Superconductors-**
they are based on Majorana fermions which are particles that constitute their own antiparticles. Proposed almost a century ago in the field of high energy physics by the physicist Ettore Majorana, in solid state systems, these exotic particles are not fundamental but rise as quasiparticles with zero-energy modes at the edges of the 1D topological Kitaev chain. Their most remarkable feature lies on the possibility of bounding two far apart Majoranas that define an unique nonlocal regular fermion, yielding a qubit decoupled from the surroundings and protected against decoherence. This robust qubit then allows the feasibility of making these blocks as essential for achieving topological quantum computers. In this scenario, this group has made proposals of quantum devices hosting such quasiparticles. Our main papers on the subject are as follows:

*Tuning of heat and charge transport by Majorana fermions*

*Encrypting Majorana fermion qubits as bound states in the continuum*

3) *Phys. Rev. B* 96, 045135 (2017);
*Isolating Majorana fermions with finite Kitaev nanowires and temperature: Universality of the zero-bias conductance*

4) *Phys. Rev. B* 94, 125426 (2016);
*Unveiling Majorana quasiparticles by a quantum phase transition: Proposal of a current switch.*

5) *Phys. Rev. B* 93, 165116 (2016);
*Decay of bound states in the continuum of Majorana fermions induced by vacuum fluctuations: Proposal of qubit technology.*

6) Etc.
ii) 3D and 2D Dirac semimetals-

Three-dimensional Dirac semimetals represent novel class of materials constituting 3D analogous of gapless graphene. Particularly, graphene is a genuine two-dimensional monolayer system formed by carbon atoms packed into a hexagonal honeycomb lattice. A remarkable feature of these semimetals is the presence of Dirac cones in the band structure, similar to those from relativistic dispersion of a massless Dirac particle. Consequently, graphene-like systems provide appropriate conditions for emulation of relativistic effects in the domain of condensed matter physics. Our main papers on this subject are:

1) Phys. Rev. B 96, 041112 (Rapid Communication) (2017);
Antibonding ground state of adatom molecules in bulk Dirac semimetals

2) Phys. Rev. B 94, 205119 (2016);
Realization of anomalous multiferroicity in free-standing graphene with magnetic adatoms

3) Phys. Rev. B 92, 245107 (2015);
Quantum phase transition triggering magnetic bound states in the continuum in graphene

4) Phys. Rev. B 92, 045409 (2015);
Catching the bound states in the continuum of a phantom atom in graphene

5) Etc.
Luciano S. Ricco  
Yuri P. Marques

Willian N. Mizobata  
Renan S. Oliveira

José E. Sanches  
Lucas Buzo

PhD students

Master students

Graduation student:

Master, PhD and Postdoctoral scholarships can be requested via FAPESP.
Interesting links about Physics:

1) Celebrating 125 years of the Physical Review

2) Physical Review B: covering condensed matter and materials physics:

3) arxiv.org/archive/cond-mat

"Science enhances the moral value of life, because it furthers a love of truth and reverence—love of truth displaying itself in the constant endeavor to arrive at a more exact knowledge of the world of mind and matter around us, and reverence, because every advance in knowledge brings us face to face with the mystery of our own being.

- Max Planck"