Synthesis and unconventional properties of novel oxides, intermetallic compounds, magnetic nanoparticles, and borides

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CDMF
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~ 12 Laboratories

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Outline

1 – Magnetic Nanoparticles NPs
2 – Superconducting Oxides for Practical Applications
3 – Geometrically Frustrated Magnets
4 – Superconductivity in Borides and Intermetallic Compounds
1 - Magnetic Nanoparticles NPs

Research Interests

1- Dipolar Interaction between NPs

Disclosing the Effect of Dipolar Interactions Between Magnetic NPs

Synthesis
Characterization
Monte Carlo Simulations

2- Magnetic Separation in Liquid-Phase Catalysis

Magnetic separation is a very promising technique to improve recovery of metal-based catalysts in liquid-phase reactions

ACS Catalysis 2, 925 (2012).

2 - Superconducting Oxides for Practical Applications

Bulk materials for Electric Power Applications – Low-loss Power Cables & Fast Current Limiters (dense, textured, and carrying high current density (J))

<table>
<thead>
<tr>
<th></th>
<th>D  (g/cm³)</th>
<th>ρwl (mΩcm)</th>
<th>γ (Jab/Jc)</th>
<th>Jab (10⁸ A/cm²) @ 5 K</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPS</td>
<td>5.7</td>
<td>0.45</td>
<td>19</td>
<td>0.26</td>
</tr>
<tr>
<td>SPT</td>
<td>6.3</td>
<td>0.31</td>
<td>2</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Very Large Value of Jab

Increase in Jab of ~ 5 x!

~ 97 % of the Theoretical Value!


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3 - Geometrically Frustrated Magnets

Magnetic properties of quantum spins with AFM coupling on frustrating lattices

Widespread interest due to the occurrence of new types of complex quantum ground states

Double Perovskite Sr$_2$YRuO$_6$ with fcc lattice of Ru moments
The simplest three-dimensional frustrated magnet model system

Square Lattice
Unfrustrated

Triangular Lattice
Frustrated

6 Possible Configurations
With Equivalent Energy

PRB Rapid Commun., in press (2016);
“Disorder and Geometric Frustration in the Shastry-Sutherland Lattice: (R$_{1-x}$Y$_x$)B$_4$”
4 – Superconductivity in Borides and Intermetallic Compounds

Revisiting some Families of Superconducting Materials

Borides of Transition Metals TM and Their Solid Solutions
(TM)B; TM = Nb, Ta, W, Mo

Intermetallic Compounds
The case of Re₃(TM); TM = Nb, Ta, W, Mo

Series of Nb₁₋ₓZrₓB
20 % Increase in Tᵥ for x ~ 0.05

At Least two Issues of Interest
1. - Multiband Superconductivity
2. - Superconductivity in noncentrosymmetric Crystal Structures

JAP; under review (2016).
JAL; under review (2016).
Scientific Collaborations

Brazil
Prof. L. Rossi – Institute of Chemistry, University of Sao Paulo
Prof. E. Granado – Institute of Physics, State University of Campinas
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Ongoing Research Projects

1 – Geometrically Frustrated Magnetic Oxides and Borides
- “Two-Dimensional Magnetic Correlations and Partial Long-Range Order in Sr$_2$YRuO$_6$”; (PRL 110, 017202 (2013))
- “Spin Dynamics and Two-Dimensional Correlations in the FCC Antiferromagnetic Sr$_2$YRuO$_6$” (PRB Rapid Commun., in press (2016));
- “Spectroscopy and Electronic Structure of Sr$_2$YRuO$_6$ and Sr$_2$YRu$_{0.75}$Ir$_{0.25}$O$_6$” (Submitted to PRB (2016));
- “Disorder and Geometric Frustration in the Shastry-Sutherland Lattice: (Gd$_{1-x}$Y$_x$)B$_4$”.

2 – Metal-Insulator Transition in Nickelates and their Solid Solutions
- “Entropy change and electronic delocalization in Nd$_{1-x}$Eu$_x$NiO$_3$”; (JAP 117, 17C105 (2015)).

3 – New Superconducting Borides
- “Superconductivity and electron-phonon coupling in some TM borides”; (Submitted to JAP (2016)).

4 – New Superconducting Intermetallic Compounds
- “Superconductivity in non-centrosymmetric Re$_3$(TM); TM = W, Mo, Ta, Nb; compounds”; (currently under investigation).
A magnetic material in which all of the pairwise magnetic interactions can not be simultaneously satisfied