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Research Interests

Low Energy Dynamics in strongly correlated electronic systems.

Magneto-Optical properties of correlated electronic materials.

Far infrared investigation of the fundamental excitations of Multiferroic Materials.

Spin-lattice interaction of frustrated magnetic systems.

Spectroscopy of excitations in graphene.

Education

Ph.D. Physics, University of Maryland, 2008 (Expected).

M.S. Physics, University of Maryland, 2006.

B.S. Engineering Physics, ITESM (Monterrey Tech, Mexico), 2002, *Graduated with Honors.*

Research Experience

Research Assistant — Summer 2005 - current
advisor: Prof. Dennis Drew — University of Maryland

• Origin of electromagnons in $R\mathrm{MnO_3}$ ($\mathbf{H}\|b$).
For magnetic field applied parallel to b, the cycloidal magnetic structure flops together with the static polarization, but the electromagnons do not. This result invalidates proposed theories of the electrodynamics in spiral multiferroics based on the spin-current mechanism. A model based purely on magnetostrictive effects on the Heisenberg interaction between spins has been developed in collaboration with Prof. Maxim Mostovoy. The exchange striction effect is very general and should be applicable to many distinct magnetic materials.

• Far Infrared Spectroscopy of multiferroic $\mathrm{BiFeO_3}$.
A far infrared transmission study of single crystalline $\mathrm{BiFeO_3}$ is being carried out to understand the low frequency magnetoelectric dynamics. Also a study of the phonon dynamics on thin films of $\mathrm{Bi_{1-x}Sm_xFeO_3}$ is underway to understand the morphotropic phase transition at x = 0.14.

• Magnetic field dependence of electromagnon spectra in $R\mathrm{Mn_2O_5}$ ($\mathbf{H}\|a$) and $R\mathrm{MnO_3}$ ($\mathbf{H}\|c$).
The electromagnons behave differently in these two multiferroic families. For the family $R\mathrm{MnO_3}$ the electromagnon excitations do not show any sign of splitting or shift in magnetic field, but they do weaken as the field is increased when applied along the c axis. In a special range of field and temperature the electromagnons reappear giving evidence for reentrant behavior. For the $R\mathrm{Mn_2O_5}$ family, the electromagnons do shift with magnetic field as a consequence of the additional anisotropy energy imposed by the magnetic field. A model for the electromagnons based on Heisenberg interaction was developed for the $R\mathrm{Mn_2O_5}$ family of multiferroics.

• Study of electromagnons in multiferroics $R\mathrm{MnO_3}$.
Clarified the spectrum of electromagnon as being composed of 3 parts: 1) a strongly temperature dependent broad absorption that exists above the Neèl temperature, 2) a well defined electromagnon at low energy that gives the highest contribution to the dielectric constant, and 3) a very strong electromagnon at an energy just below the lowest infrared phonon that couples very strongly to it. This latter electromagnon steals more than half of the intensity from the nearby phonon, which shows that the electromagnon is in fact a mixed magnon-phonon excitation.

• Study of spin-phonon coupling in frustrated magnet $\mathrm{CdCr_2O_4}$.
Demonstrated that the spin-lattice affects the phonon spectrum of the magnetically frustrated chromium spinels. In the case of both $\mathrm{CdCr_2O_4}$ and $\mathrm{ZnCr_2O_4}$, direct exchange dominates the physics. This allows for a phonon that modulates effectively this interaction to split below the ordering temperature. The magnitude of this frequency splitting and the intensity distribution of the resulting phonons is a sensitive probe of the spin-phonon coupling in these systems.

• Evidence for electromagnon excitations in $R\mathrm{Mn_2O_5}$.
Demonstration of the existence of electric dipole active magnetic excitations in $\mathrm{TbMn_2O_5}$ and $\mathrm{YMn_2O_5}$. These excitations are responsible for the step-like anomaly in the dielectric constant at the commensurate–incommensurate (CM–ICM) transition in these multiferroics, and are only due to the Mn spin system. Electromagnons were found as well in the spectrum of $\mathrm{DyMn_2O_5}$ and $\mathrm{EuMn_2O_5}$ but not in $\mathrm{BiMn_2O_5}$ where the CM–ICM transition does not exist.

• Infrared study of multiferroic systems $R\mathrm{Mn_2O_5}$.
Evidence for inversion symmetry breaking at the ferroelectric phase transition was obtained by the appearence of additional phonons (Raman active only in the paraelectric phase) in the infrared spectrum of $\mathrm{TbMn_2O_5}$. Anomalous behavior of the intensity of 2 perpendicularly polarized phonons that exchange spectral weight, possible indication of additional symmetry breaking. Temperature dependent study of the optical gap as well as a high temperature investigation of the phonon dynamics in $\mathrm{TbMn_2O_5}$.

Research Assistant — Summer 2004 - Spring 2005
advisor: Prof. Dennis Drew — University of Maryland
• Investigation of the optical response of silver nanoparticles arrays that show strongly enhanced fluorescence.
Developed a technique to measure the transmission and reflection coefficients of arrays of sizes $\sim$ 300 μm. Wrote a Mathematica program to simulate the results of the spectroscopy using an effective medium model, that takes into account the size and shape of the nanoparticles.

Undergraduate Research Assistant — Fall 2002
advisor: Prof. Genaro Zavala — ITESM
• Design and construction of circuitry for the study of the ferroelectric properties of PZT thin films.
Built a Sawyer-Tower circuit to measure the hysteretic behavior of the polarization as a function of frequency for several compositions of PZT thin films.

Teaching Experience

Teaching Assistant — Spring 2004
Prof. Joe Redish — University of Maryland
PHYS-122. Introductory physics for non-engineering majors. Based on materials prepared by the Physics Education Research Group. Lead discussion and laboratory sections, graded quizzes, laboratory reports and exams.

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Teaching Assistant — Fall 2003
Prof. Nicholas S. Chant — University of Maryland
PHYS-161. Introductory calculus-based physics for engineering majors. Lead discussion sections, prepared and graded quizzes. Graded exams.

Teaching Assistant — Fall 2000 - Fall 2002
M.S. Quetzal Garcia — ITESM
F00811, F00812, F00813. Introductory calculus-based physics for engineering majors. Lead laboratory sections and graded laboratory reports.

Publications

• R. Valdés Aguilar, M. Mostovoy, A.B. Sushkov, S-W. Cheong and H.D. Drew. **Origin of electromagnon excitations in $\boldsymbol{R}\mathbf{MnO_3}$**. In preparation (2008).

• A.B. Sushkov, M. Mostovoy, R. Valdés Aguilar, S-W. Cheong and H.D. Drew. **Electromagnons in multiferroic $\boldsymbol{R}\mathbf{Mn_2O_5}$ compounds and their microscopic origin**. Journal of Physics C. To appear, (2008). Arxiv:0806.1207.

• R. Valdés Aguilar, A.B. Sushkov, Y.J. Choi, S-W. Cheong and H.D. Drew. **Spin phonon coupling in frustrated magnet $\mathbf{CdCr_2O_4}$**. Phys. Rev. B **77**, 092412 (2008).

• R. Valdés Aguilar, A.B. Sushkov, C.L. Zhang, Y.J. Choi, S-W. Cheong and H.D. Drew. **Colossal magnon-phonon coupling in multiferroic $\mathbf{Eu_{0.75}Y_{0.25}MnO_3}$**. Phys. Rev. B **76**, 060404(R) (2007).

• A.B. Sushkov, R. Valdés Aguilar, S. Park, S-W. Cheong and H.D. Drew. **Electromagnons in Multiferroic $\mathbf{YMn_2O_5}$ and $\mathbf{TbMn_2O_5}$**. Phys. Rev. Lett. **98**, 027202 (2007).

• R. Valdés Aguilar, A.B. Sushkov, S. Park, S-W. Cheong and H.D. Drew. **Infrared phonon signatures of multiferroicity in $\mathbf{TbMn_2O_5}$**. Phys. Rev. B **74**, 184404 (2006).

Presentations

• *Electromagnons in Multiferroic Manganites.* International Center for Materials Research, University of California, Santa Barbara, CA. July 2008. Poster

• *Electromagnons in Multiferroic Manganites.* NIST Center for Neutron Research, Gaithersburg, MD. July 2008.

• *Magnetic field phase diagram of electromagnon excitations in multiferroic manganites.* Low Energy Electrodynamics in Solids. Vancouver, BC. July 2008.

• *Electromagnons in Multiferroic Manganites.* The Second Workshop on Novel Electronic Materials. University of Kentucky. Lexington, KY. May 2008.

• *Reentrant electromagnons in multiferroic $Eu_{0.75}Y_{0.25}MnO_3$ in the H-T phase diagram.* APS March Meeting. New Orleans, LA. March 2008.

• *Spin-phonon coupling in frustrated magnet $CdCr_2O_4$.* MRSEC Multiferroics II Workshop, University of Maryland. July 2007.

• *Low energy electrodynamics of frustrated magnetic systems.* The International Conference on Strongly Correlated Electron Systems. Houston, TX. May 2007. Poster.

• *Colossal magnon-phonon coupling in multiferroic $Eu_{0.75}Y_{0.25}MnO_3$.* APS March Meeting. Denver, CO. March 2007.

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• *Spin-Phonon coupling in frustrated magnet* $CdCr_2O_4$. APS March Meeting. Denver, CO. March 2007. Poster.

• *IR phonons induced by the helical magnetic order in multiferroic* $TbMn_2O_5$. APS March Meeting. Baltimore, MD. March 2006.

• *The optical response of crystalline* $TbMn_2O_5$. The Second Canadian-American-Mexican Physics Graduate Student Conference. San Diego, CA. August 2005.

• *Optical studies of plasmon resonances in Ag nanoparticle arrays.* APS March Meeting. Los Angeles, CA. March 2005.

Honors and Awards

Young Investigator Award, The International Conference on Strongly Correlated Electron Systems, Houston, TX. May 2007.

Honors Graduation, ITESM, Mexico. December 2002.

1st. place, National Academic Competition Technical Secondary School, Mexico. June 1993.

Skills

Optics: Michelson and Martin-Puplett polarizing FTIR, grating spectrometer, photoelastic modulator, far IR - UV optical elements, optical quality polishing.

Electronics: Oscilloscope, lock-in amplifier, spectrum analyzer, digital multimeter, JFET preamplifier.

Cryogenics: Liquid nitrogen and helium dewars and transfer lines, He4 cooled cryostats, Oxford Optistat for magneto optical studies, He3 systems.

Detection: He cooled bolometers, MCT, DTGS, Si detectors.

Vacuum Systems: Roughing pump, diffusion pump, ion gauge, helium leak detector.

Mechanical: CAD drawing, lathe, milling machine, drill press.

Data acquisition: Bomem PCDA, Labview.

Data Analysis: Origin, MS Excel, Matlab, Mathematica, Maple, Scion Image.

Operating Systems: MS Windows, basic Linux and MacOS.

Programming: Pascal, C, C++, Matlab, Mathematica, Maple.

Typesetting: LaTeX, HTML.

References

Available upon request.