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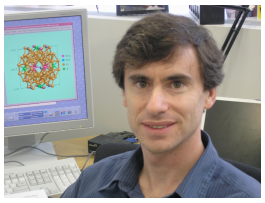

RESEARCH INTERESTS AND SPECTROSCOPIES

Magnetic materials, Interfacial magnetism, Interplay between structure and magnetism, Magnetism at high pressures, Local structure, Phase transitions, Superconductivity, X-ray Magnetic Circular Dichroism (XMCD), X-ray Resonant Magnetic Scattering (XRMS), X-ray Absorption Fine Structure (XAFS).

CURRENT RESEARCH ACTIVITIES

Development of novel polarized x-ray techniques enabling studies of the interplay between structure and magnetism in complex, functional magnetic materials. These include extension of x-ray magnetic circular dichroism (XMCD) and polarized x-ray absorption near-edge/fine structure (XANES/XAFS) techniques to the diamond-anvil cell for high pressure studies of electronic structure and magnetism; Magnetic Reflectivity for studies of interfacial magnetic structure and depth-resolved magnetization profiles in artificial layered nanostructures, and magnetic diffraction anomalous fine structure (MDAFS) for studies of element- and site- specific magnetism in single crystalline bulk and film samples.

EMPLOYMENT/POSITIONS

Adjunct Associate Professor of Physics, Washington University in St. Louis	June 2010-Present
Lead Scientist- Argonne National Lab	May 2006- Present
Physicist –Argonne National Laboratory	May 2005- May 2006
Assistant Physicist –Argonne National Laboratory	May 2001-May 2005
Post-doctoral Research Associate	
Argonne National Laboratory	August 1999- May 2001
University of Washington	March 1998 - July 1999

EDUCATION

Ph.D. in Physics University of Washington 1998

Thesis: *Local structural studies of oriented high temperature superconducting cuprates by polarized XAFS spectroscopy* (Advisor: Edward A. Stern)

M.Sc. in Physics Technion, Israel 1992

Thesis: *Effect of impurities on dynamical properties of dilute metallic binary alloys.* (Advisor: Hanan Shechter)

B.Sc. in Physics Technion, Israel 1989

RESEARCH EXPERIENCE

High pressure XMCD studies in the diamond-anvil cell: Developed a high-pressure (1 Mbar), low-temperature (7 K), high-field (0.7 Tesla) capability for XANES/XMCD-studies of magnetic materials at high pressures. The instrument features a diamond-anvil cell with perforated anvils to minimize anvil's absorption, remote control of piston-motion via a gas membrane allowing *in-situ* pressure control at low temperatures and an online Ruby fluorescence system for *in-situ* pressure calibration at low temperatures. Studied pressure-induced magnetic transitions in a variety of materials including complex oxides, magneto-caloric materials and transition metals. [*Phys. Rev. Lett.* 105, 216407 (2010), *Phys. Rev. Lett.* 100, 045508 (2008); *Physical Review Letters* 102, 237201 (2009); *Physical Review Letters* 102, 057206 (2009), *High Pressure Research* 28, 185 (2008); *Review of Scientific Instruments* 78, 083904 (2007); *Phys. Rev.* B 76, 014411 (2007), *Appl. Phys. Lett*. 90, 042505 (2007)].

X-ray studies of element- and site-specific magnetism in single crystals: Exploited the symmetry properties of crystals in combination with resonant scattering of circularly polarized (CP) x-rays to obtain site-selective magnetic information in single crystals. This technique allowed measuring site-selective magnetization reversals in permanent magnetic materials providing an atomic look at the origins of magneto-crystalline anisotropy in best permanent magnet $Nd_2Fe_{14}B$ [*Phys. Rev. Lett*. **95**, 217207 (2005); *IEEE Transactions on Magnetics* **40**, 2874 (2004); *Phys. Rev. B* **73**, 144416 (2006); *Phys. Rev. B* **74**, 104114 (2006); *Appl. Phys. Lett*. 93, 052504 (2008)]. Developed a digital lock-in detection system for dichroic diffraction of CP x-rays (U.S. Patent 7,403,592 issued July 2008).

X-ray studies of interfacial magnetism: Combined x-ray resonant magnetic scattering and magnetic circular dichroism techniques to measure and quantify the spatial extent and strength of magnetic exchange coupling at buried interfaces of layered structures. These techniques revealed the existence of induced Gd magnetization near the Gd/Fe interface and determined its spatial extent. Generalized computer codes were developed to retrieve magnetization density profiles from layered structures within the first Born approximation, and to obtain anomalous magnetic scattering factors from XMCD measurements [*Phys. Rev. Lett.* 87, 207201 (2001); *Physical Review B* 70, 134420 (2004); *Appl. Phys. Lett*. 91, 022503 (2007); *App. Phys. Lett.* 92, 162502 (2008) Physical Review B 79, 134438 (2009)].

X-ray studies of inhomogeneous magnetic states in artificial nanostructures: Combined x-ray Magnetic Circular Dichroism (XMCD) with penetration depth tunability of x-rays near the critical angle for total external reflection to probe the nucleation of magnetic twisted phases in Gd/Fe multilayers. This method allowed probing near-surface and bulk magnetic states in a single measurement and revealed the nucleation of a spatially inhomogeneous magnetic state at the surface of an artificial Gd/Fe multilayer [*Phys. Rev. B (Rapid Communications)* **67**, 180406(R) (2003); *J. Appl. Phys.* **93**, 6507 (2003); *Phys. Rev. B* **73**, 174401 (2006)].

X-ray absorption studies of local structure of molecular magnets and amorphous magnetic semiconductors: Applied X-ray absorption fine structure (XAFS) and near edge structure (XANES) techniques to determine the chemical oxidation state and local atomic structure around Vanadium in the disordered Vanadium tetracyanoethylene V[TCNE] room-temperature molecule-based magnet and related compounds [*Phys. Rev. B* **70**, 054422 (2004)]. Use XAFS to measure local atomic disorder in amorphous Gd_xSi_{1-x} magnetic semiconductors [*Phys. Rev. B* **67**, 115207 (2003)].

X-ray microscopy studies of magnetic domains: Studied magnetic domain structure in epitaxial bilayers of exchange spring magnet Fe/SmCo. The x-ray microprobe couples phase-retarding optics with K-B mirrors to yield a 1 μm CP x-ray beam with switchable helicity. This tool was used to image domains in the SmCo buried layer and to image biquadratic coupling between layers [*J. App. Phys*. **89**, 7165 (2001)]. The microscope was also used to study magnetization reversal of patterned, sub-micron, pseudo-

spin valve structures [*J. Appl. Phys.* 9**5**, 7028 (2004)]. Added low temperature capability to the magnetic microscope [*Rev. Sci. Instr.* **76**, 063702 (2005)].

XAFS studies of the local structure of high T_c superconductors: Used the orientation dependence of X-ray Absorption Fine Structure (XAFS) in the anisotropic layered structures of high Tc superconductors to measure local atomic arrangements at structural phase transitions and around dopant atoms. Developed methods for preparation of magnetically aligned powders for fluorescence experiments. These measurements revealed, among others, the partial order-disorder nature of the Sr-induced phase transition in $La_{2-x}Sr_xCuO_4$ [*Phys. Rev. Lett.* **76**, 439 (1996)], the polaronic nature of hole carriers doped by Sr in $La_{2-x}Sr_xCuO_4$[*Phys. Rev. B (Rapid Communications)* **56**, R521 (1997)], the high spin non Jahn-Teller state of Ni in $La_{2-x}Sr_xCu_{1-y}Ni_yO_4$[*Phys. Rev. B* **64**, 104510 (2001)] and the large local disorder in tilt angle of CuO_6 octahedra present in $La_{1.875}Ba_{0.125}CuO_4$[*Phys. Rev. B* **61**, 7055 (2000)].

Electron microscopy studies of local atomic structure of materials: Contributed to the development of the EXELFS technique (Extended Energy Loss Fine Structure) as a structural tool with high spatial resolution (50Å -1μm) in the Transmission Electron Microscope (TEM). Main contributions include improvements in data analysis and quantifying the effect of electron radiation damage as a limitation to high spatial resolution [*Micron* **30**, 185-194 (1999), *Ultramicroscopy* **58** n.3-4 p.353 (1995)].

Mössbauer-effect studies of impurities in metals: Used Mössbauer spectroscopy on the ^{119}Sn isotope to study local dynamics and electronic properties of Sn impurities in Ag, Pb and Au metal hosts. Unusually large dynamics of Sn atoms was found at high temperatures, providing new clues into the role of point defects on lowering the melting temperature of dilute binary alloys [*Phys. Rev. B* **47**, 14032 (1993*), J. Phys. Cond. Matt.* **10**, 8573 (1998).

TEACHING EXPERIENCE

Conceived and directed research work of Post-doctoral appointees (3),
Graduate students (3), and visiting scientists (1) 2001-Present

Teaching Assistant, University of Washington 1992-1993
Led problem session of electrodynamics courses for advanced undergraduate students.

Teaching Assistant, Technion 1989-1990
Laboratory instructor for introductory physics courses.

COMPUTER EXPERTISE

Experience in FORTRAN and C scientific programming. Experience with script language programming (PERL, C-shell) as well as working knowledge of UNIX and LINUX operating systems and a variety of software running on these platforms.

SOFTWARE DEVELOPMENTS

- Wrote a generalized code to retrieve magnetization density profiles in multilayers from fits of magnetic reflectivity data using the first Born approximation (1999-2001).
- Wrote a generalized Kramers-Krönig code to obtain accurate charge and magnetic anomalous scattering factors from XANES and XMCD measurements (2000-2001).
- Wrote a generalized code to simulate site-specific x-ray resonant dichroic diffraction of CP x-rays from crystals using ab-initio calculations of resonant scattering factors (2002-2004).
- Wrote a generalized code to correct X-ray Absorption Near Edge Structure (XANES) data for self absorption effects in fluorescence experiments (1998).

LANGUAGES

Fluent in English, Spanish and Hebrew.

AWARDS

International Union of Crystallography Young scientist award	2000

FUNDING

Laboratory Directed Research and Development (LDRD) funding:

Tuning electronic structure at high pressures: towards novel materials discovery from x-ray *science under extreme conditions*	$117K	2010
An Integrated x-ray and neutron approach to magnetic depth-profiling in nanostructures	$60K $110K $80K	2008 2007 2006
Site-specific magnetism in crystals	$96K $100K	2005 2004

PATENTS

Digital Lock-in detection of site-specific magnetism in magnetic materials No. 7,403,592	2008

BOOK Chapters

Hard x-ray resonant techniques for studies of nanomagnetism, G. Srajer, J. C. Lang and D. Haskel, in *Modern Techniques for Characterizing Magnetic Materials* (Y. Zhu, Editor), Kluwer academic publishers, Chapter 5, pp. 201-227 (2005).

OTHER ACTIVITIES

• Member of the Advanced Photon Source Colloquium Committee.	2004-2006
• Neutron and x-ray scattering ANL summer school instructor (XMCD).	2002-present
• XAFS summer school instructor (XAFS and other techniques)	2005-present
• Advisor to the x-ray absorption SR community in Spain on needs and design for XAS/XMCD beamline at ALBA light source.	2004
• Member General User Program spectroscopy panel (Chair 2007).	2006-2008
• Referees papers for physics journals	
• Referees proposals for DOE/NSF.	1996-Present
• Organizer, Workshop on Novel Science with Polarized x-rays	2007
• Chairs sessions at National and International conferences	2005-present
• Served as Scientific Advisory committee member for various conferences	2006-present

PROFESSIONAL ASSOCIATIONS

Member of the American Physical Society
Member of the International XAFS Society

SELECTED PUBLICATIONS (90 publications, 1867 citations, h-index=18)

- *Orbital magnetism and spin-orbit effects in the electronic structure of BaIrO3* Ma. A. Laguna-Marco, **D. Haskel**, N. Souza-Neto, J. Lang, V. Krishnamurthy, S. Chikara, Gang Cao, M. van Veenendaal, *Physical Review Letters*, 105, 216407 (2010)

- *Pressure-induced magnetic transition in Manganite ($La_{0.75}Ca_{0.25}MnO_3$)* Y. Ding, **D. Haskel**, Y.C. Tseng, E. Kaneshita, M. van Veenendaal, J. Mitchell, S. Sinogeikin, V. Prakapenka, H-k. Mao *Physical Review Letters* 102, 237201 (2009)

- *P*ressure induced electronic mixing and enhancement of ferromagnetic order in EuX(X=O,S,Se,Te) magnetic semiconductors N. Souza-Neto, **D. Haskel**, Y.C. Tseng, G. Lapertot, *Physical Review Letters* 102, 057206 (2009).

- *Novel Pressure-Induced Magnetic Transition in Magnetite (Fe_3O_4)* Y. Ding, **D. Haskel**, S. G. Ovchinnikov, Y.C. Tseng, Y. S. Orlov, J. C. Lang and Ho-kwang Mao, *Physical Review Letters* 100, 045508 (2008).

- *Role of Ge in Bridging Ferromagnetism in the Giant Magnetocaloric $Gd_5(Si_xGe_{1-x})_4$ Alloys* **D. Haskel**, Y. B. Lee, B. Harmon, Z. Islam, J. Lang, G. Srajer, Y. Mudryk, K .A. Gschneidner, V. K. Pecharsky, *Physical Review Letters* 98, 247205 (2007).

- *Atomic Origin of Magnetocrystalline anisotropy in $Nd_2Fe_{14}B$* **D. Haskel**, J. Lang, Z. Islam, A. Cady, G. Srajer, M. van Veenendaal, P. Canfield, *Physical Review Letters* 95, 217207 (2005).

- *Four unit-cell superstructure in the optimally doped YBCO spureconductor* Z. Islam, X. Liu, S. Sinha, J. Lang, S. Moss, **D. Haskel**, G. Srajer, P. Wochner, D. Lee, D. Haeffner, U. Welp. *Physical Review Letters* 93, 157008 (2004).

- *Nature of inhomogeneous magnetic state in artificial Fe/Gd ferrimagnetic multilayers* **D. Haskel**, G. Srajer, Y. Choi, D.R. Lee, J. C. Lang, J. Meersschaut, J.S. Jiang, S.D. Bader. *Physical Review B (Rapid Communications)* 67, 180406(R) (2003).

- *Enhanced Interfacial Magnetic Coupling of Gd/Fe Multilayers* **D. Haskel**, G. Srajer, J. Lang, J.Pollmann, C. Nelson, J. Jiang, S. Bader. *Physical Review Letters* 87, 207201 (2001).

- *Altered Sr environment in $La_{2-x}Sr_xCuO_4$* **D. Haskel**, E. A. Stern, D. G. Hinks, A. W. Mitchell and J. Jorgensen. *Physical Review B (Rapid Communications)* 56, R521 (1997) .

- *Dopant and temperature induced phase transitions in LaSrCuO by XAFS* **D. Haskel**, E. A. Stern, D. G. Hinks, A. W. Mitchell, J. Jorgensen and J. Budnick. *Physical Review Letters* 76, 439 (1996).

- *Are Nanophase Grain Boundaries Anomalous?* E. A. Stern, R. W. Siegel, M. Newville, P. G. Sanders and **D. Haskel**. *Physical Review Letters* 75, 3874 (1995).

SELECTED PRESENTATIONS (59 talks, 34 invited)

(Invited) *Probing Magnetism with X-rays: New Tools, New Insights*; Condensed Matter Physics Seminar, Washington University St. Louis, St. Louis, Missouri (April 2010)

(Invited) *Squeezing Magnets- and what can we learn from it* ; Seminar, Department of Materials Physics, Universidad Complutense de Madrid, Madrid, Spain (March 2009)

(Invited) *Site-specific Magnetic Spectroscopy of Functional Materials*; 6th International Conference on Synchrotron Radiation in Materials Science (SRMS-6) Campinas, Brazil (July 2008)

(Invited talk) *The role of Ge in mediating FM interactions in* $Gd_5Si_xGe_{1-x}$ *alloys*; Condensed Matter Physics Seminar, Instituto de Ciencia de Materiales de Aragon, University of Zaragoza, Zaragoza, Spain (March 2007)

(Invited) *New insights into Permanent Magnets*, 53rd Midwest Solid State Conference, Kansas City, USA (October 2006).

(Invited*) Element- and site-specific study of the atomic origin of magnetic hardness in modern magnets,* Symposium on "Combined XAS and XRD techniques in Physics, Chemistry and Materials Science", XX Congress of the Intermational Union of Crystallography (IUCR), Florence, Italy (August 2005)

(Invited*) Hard x-ray magnetic studies at the Advanced Photon Source*. Strategic meeting of users of x-ray absorption spectroscopy at ALBA, Sevilla, Spain (October 2004).

(Invited) *Site-specific magnetism and the spin-reorientation transition in* $Nd_2Fe_{14}B$ *permanent magnet.* Workshop on interplay of Magnetism and Structure in Functional Materials, Benasque Center for Science, Benasque, Spain (February, 2004) .

(Invited) *Element and site-specific magnetism: X-ray studies in the absorption and diffraction channels*. Physics Colloquium, University of Nebraska, NE, USA (January, 2004) .

(Invited) *X-ray studies of Magnetism: Element Specificity and Beyond* BNL/NSLS Symposium Series, Long Island, NY, USA (May, 2003).

(Invited) *Using Circularly Polarized X-rays to study Layered Magnetic Nanostructures* Symposium on Impact of Scattering on Nanoscience and Technology, 2002 ACA Annual Meeting, San Antonio, TX, USA (2002) .

(Invited) *Dopant Structural distortions in High Tc superconductors: Active or Passive Role?* The 11th International XAFS conference (XAFS11), Ako, Japan (2000).

(Invited) *Role of Sr dopants in the inhomogeneous ground state of La(2-x)Sr(x)CuO(4)* Phase transitions and self organization in electronic and molecular networks, Cambridge University, Cambridge, U.K. (2000).