

Sayantika Bhowal

Curriculum Vitae

Materials Theory, Department of Materials
ETH Zurich, Wolfgang-Pauli-Strasse 27, 8093 Zürich, Switzerland
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Personal Details

Date of birth: 07/04/1990

Nationality : Indian

Gender: Female

Education and Academic degrees

2012–2017 : **Ph.D degree in Physics (Theoretical)**, *University of Calcutta*, Kolkata.

Theoretical Condensed Matter Physics

Thesis title: First Principles Study of Emergent Phenomena in Strongly Correlated Systems. (Thesis submitted on August 23, 2017; Degree awarded on January 9, 2019).

2010–2012 : **Master of Science in Physics (Specialization: Condensed Matter and Materials Science)**, *University of Calcutta*, Kolkata, (Rank-First).

2008–2010: **Bachelor of Science in Physics (Honours)**, *University of Calcutta*, Kolkata, (Rank-Sixth).

Research Experience

ETH Zurich, Switzerland

September, 2020 – present ***Hidden higher order multipoles and their detection in quantum systems..***

Investigation, tuning, and detection of hidden higher order magnetic and non-magnetic multipoles in ferroelectric and magnetoelectric bulk materials as well as in two-dimensional magnetic skyrmions.

Position : Post-doctoral fellow.

Advisor : **Prof. Nicola A. Spladin**, *Chair, Materials Theory*, ETH Zürich, Wolfgang-Pauli-Strasse 27, 8093 Zurich, Switzerland.

University of Missouri, USA

September, 2017 – August, 2020 ***Charge, spin, and orbital Hall effects in quantum systems..***
Investigation and tuning of Berry curvature driven transport properties involving three fundamental degrees of freedom of an electron, viz., charge (anomalous Hall effect), spin (spin Hall effect), and orbital moment (orbital Hall effect) with an eye towards potential applications in the field of spintronics and orbitronics.

Position : Post-doctoral fellow.

Advisor : **Prof. Sashi Satpathy**, *Curators' Professor*, Department of Physics and Astronomy, University of Missouri, 223 Physics Building, Columbia, MO-65211.

Indian Association for the Cultivation of Science, India

July, 2012 – August, 2017 ***Spin-orbit coupling driven emergent magnetism in 5d transition metal oxides..***
Studying the effect of interplay among different competing energy scales : spin-orbit coupling, Coulomb interaction, Hund's Coupling, crystal field splitting and band width on the electronic and magnetic properties of 5d transition-metal oxides, in particular iridates with different electronic filling of the *d*-orbitals (d^3 , d^4 , $d^{4.5}$, and d^5).

Position : PhD fellow under CSIR fellowship.

Advisor : **Prof. Indra Dasgupta**, *Senior Professor*, Department of Solid State Physics, Indian Association for the Cultivation of Science, Jadavpur, Kolkata-032.

Visiting positions

Institute of Theoretical Physics, TU Bergakademie Freiberg, Germany

Duration: September, 2016 – October, 2016

Position : Visiting fellow under the project Electronic Structure and Transport in Functional Nano-materials funded by DST-DAAD.

Group : **Prof. Jens Kortus**, *Professor*, Institute for Theoretical Physics, TU Bergakademie Freiberg, Germany.

Leibniz Institute for Solid State and Materials Research, Germany

Duration: 13th October, 2016

Position : Visiting the group of Prof. Jeroen van den Brink

Group : **Prof. Jeroen van den Brink**, *Institute Director*, Institute for Theoretical Solid State Physics, Leibniz Institute for Solid State and Materials Research, Dresden, Germany.

Research interests

My research interests focus on the investigation of electronic, magnetic, magnetoelectric, ferroelectric, and Hall transport properties of quantum materials. I am curious to search for hidden entangled order in real materials, leading to diverse quantum phenomena that range from various cross-couplings (such as magnetoelectric effect, piezomagnetic effect, etc.) of strongly correlated systems to the geometric properties of Bloch bands, such as Berry curvature dipole, intriguing momentum space spin texture, which are at the heart of spintronics. Another, complementary area of my current research is in the various Berry curvature-related phenomena, including the anomalous, spin, and orbital Hall effects, with a special emphasis on orbital magnetization in quantum systems and its possible application in the emerging field of orbitronics. I use both *ab-initio* first-principles techniques as well as model Hamiltonian-based analytical and numerical approaches for my research. The outcome of my research is of interest to the people working in the field of strong correlation, ferroelectrics, magnetoelectrics, orbitronics, spintronics, topological effects, magnetic skyrmions, and strong spin-orbit coupled systems.

Selected Publications

- 2022 **Syantika Bhowal**, Stephen P. Collins, and Nicola A. Spaldin. Hidden k -space magnetoelectric multipoles in nonmagnetic ferroelectrics. *Phys. Rev. Lett.*, volume 128, page 116402. American Physical Society, Mar 2022, (**Impact Factor:9.161**).
- 2021 **Syantika Bhowal** and Giovanni Vignale. Orbital hall effect as an alternative to valley hall effect in gapped graphene. *Phys. Rev. B (Editors' suggestion)*, volume 103, page 195309, 2021, (**Impact Factor:4.036**).
- 2020 **Syantika Bhowal** and S. Satpathy. Intrinsic orbital moment and prediction of a large orbital hall effect in two-dimensional transition metal dichalcogenides. *Phys. Rev. B (Rapid Comm.)*, volume 101, page 121112, 2020, (**Impact Factor:5.1**).
- 2019 **Syantika Bhowal** and Sashi Satpathy. Electric field tuning of the anomalous hall effect at oxide interfaces. *npj Computational Materials*, volume 5, page 61, 2019, (**Impact Factor:13.2**).
- 2019 A. Nag, **Syantika Bhowal**, M. Moretti Sala, A. Efimenko, I. Dasgupta, and Sugata Ray. Hopping-induced ground-state magnetism in $6h$ perovskite iridates. *Phys. Rev. Lett.*, volume 123, page 017201, 2019, (**Impact Factor:9.161**).
- 2015 **Syantika Bhowal**, Santu Baidya, Indra Dasgupta, and Tanusri Saha-Dasgupta. Breakdown of $j = 0$ nonmagnetic state in d^4 iridate double perovskites: A first-principles study. *Phys. Rev. B (Rapid Comm.)*, volume 92, page 121113, 2015, (**Impact Factor:5.1**).

Research skills

- Ab-initio* modeling tools: Plane wave based methods-Vienna ab-initio Simulation Package (VASP) and Quantum Espresso. All electron method-Linear Muffin-Tin Orbital (LMTO-ASA) method, Linearized Augmented Planewave (LAPW) Method as implemented in Elk and Wien2k codes. N^{th} -order Muffin-Tin Orbital (NMTO) down-folding technique; Wannier90 code; WannierTools
- Development of codes to model: Berry curvature related phenomena-anomalous, orbital and spin Hall effects; Orbital magnetization, Topological Hall effect. Mean-field study-Hartree-Fock approximation. Two site many-body multi-orbital interacting systems -study of spin-orbit excitons. Skyrmion model-study of magnetoelectric multipoles.
- Languages: Fortran90; Python; Latex

Professional Services

Referee works for Phys. Rev. Lett.; Phys. Rev. B; Phys. Rev. B (Letters); Phys. Rev. Materials; Phys. Rev. Research; Journal of Physics: Condensed Matter; Communication Physics; Journal of Superconductivity and Novel Magnetism; Advanced Materials; and Advanced Electronic Materials.

Teaching Assistantship

Spring semester, 2021 : **Solid State Physics and Chemistry of Materials-II**, *ETH Zürich*, Platform: Zoom.

Spring semester, 2022 : **Solid State Physics and Chemistry of Materials-II**, *ETH Zürich*, (In person).

Mentoring experience

M. Sc. project, 2014: **Amaresh Dey**, *Indian Institute of Technology, Madras, India*.

Project title: **An introductory description to the magnetism.**

Fellowships & Recognitions

- 2016 **Young Physicist award (second)** by Indian Physical Society (IPS).
- 2012 **Gold medal in M. Sc. (Physics)**, *University of Calcutta*.
- 2012 **CSIR fellowship** for PhD from All India National Eligibility Test, **All India Rank-8**.
- 2012 **Qualified All India Graduate Aptitude Test in Engineering (GATE)**.
- 2011-12 **Sujan Kumar Seal Memorial Scholarship in Physics** in *University of Calcutta*.
- 2011 **Sujan Kumar Seal Memorial Studentship in Physics** in *University of Calcutta*.

Full list of publications:

Published articles

- 2022 **Syantika Bhowal**, Stephen P. Collins, and Nicola A. Spaldin. Hidden k -space magnetoelectric multipoles in nonmagnetic ferroelectrics. **Phys. Rev. Lett.**, volume 128, page 116402. American Physical Society, Mar 2022.
- 2022 Manjil Das, **Syantika Bhowal**, Jhuma Sannigrahi, Abhisek Bandyopadhyay, Anupam Banerjee, Giannantonio Cibin, Dmitry Khalyavin, Niladri Banerjee, Devashibhai Adroja, Indra Dasgupta, and Subham Majumdar. Interplay between structural, magnetic, and electronic states in the pyrochlore iridate $\text{Eu}_2\text{Ir}_2\text{O}_7$. **Phys. Rev. B**, volume 105, page 134421. American Physical Society, Apr 2022.

- 2022 Abhisek Bandyopadhyay, A. Chakraborty, **Sayantika Bhowal**, Vinod Kumar, M. M. Sala, A. Efimenko, F. Bert, P. K. Biswas, C. Meneghini, N. Büttgen, I. Dasgupta, T. Saha Dasgupta, A. V. Mahajan, and Sugata Ray. Breakdown of atomic spin-orbit coupling picture in an apparently isolated pseudo-one-dimensional iridate: $\text{Sr}_3\text{NiIrO}_6$. *Phys. Rev. B*, volume 105, page 104431. American Physical Society, Mar 2022.
- 2021 **Sayantika Bhowal** and Giovanni Vignale. Orbital hall effect as an alternative to valley hall effect in gapped graphene. *Phys. Rev. B (Editors' suggestion)*, volume 103, page 195309, 2021.
- 2021 **Sayantika Bhowal**, D O'Neill, M Fechner, NA Spaldin, U Staub, J Duffy, and SP Collins. Anti-symmetric Compton scattering in LiNiPO_4 : Towards a direct probe of the magneto-electric multipole moment. *Open Research Europe*, volume 1, 2021.
- 2021 **Sayantika Bhowal** and Indra Dasgupta. Spin-orbit effects in pentavalent iridates: models and materials. *J. Phys.: Condens. Matter (Topical Review)*, volume 33, page 453001, 2021.
- 2021 **Sayantika Bhowal** and Nicola A. Spaldin. Revealing hidden magnetoelectric multipoles using Compton scattering. *Phys. Rev. Research*, volume 3, page 033185, 2021.
- 2021 Pratik Sahu, **Sayantika Bhowal**, and S. Satpathy. Effect of the inversion symmetry breaking on the orbital hall effect: A model study. *Phys. Rev. B*, volume 103, page 085113, 2021.
- 2020 **Sayantika Bhowal**, S. Satpathy, and P. Sahu. Magnetic Skyrmions in Condensed Matter Physics. *Student Journal of Physics*, volume 8, pages 41–56, 2020.
- 2020 **Sayantika Bhowal** and S. Satpathy. Orbital gyrotropic magnetoelectric effect and its strain engineering in monolayer NbX_2 . *Phys. Rev. B (Rapid Comm.)*, volume 102, page 201403, 2020.
- 2020 **Sayantika Bhowal** and S. Satpathy. Intrinsic orbital moment and prediction of a large orbital hall effect in two-dimensional transition metal dichalcogenides. *Phys. Rev. B (Rapid Comm.)*, volume 101, page 121112, 2020.
- 2020 **Sayantika Bhowal** and S. Satpathy. Intrinsic orbital and spin hall effects in monolayer transition metal dichalcogenides. *Phys. Rev. B*, volume 102, page 035409, 2020.
- 2020 **Sayantika Bhowal** and Indra Dasgupta. Interplay of covalency, non-cubic crystal field, and spin-orbit coupling: A comparative study of d^5 , d^4 , and d^3 double perovskite iridates $\text{Sr}_2\text{MlIrO}_6$ ($\text{M} = \text{Ce, Sc, Ca}$). *J. Magn. Magn. Mater.*, volume 507, page 166827, 2020.
- 2020 Shreemoyee Ganguly and **Sayantika Bhowal**. Study of nontrivial magnetism in $3d - 5d$ transition metal based double perovskites. *Phys. Rev. B*, volume 101, page 085104, 2020.
- 2019 **Sayantika Bhowal** and Sashi Satpathy. Electric field tuning of the anomalous hall effect at oxide interfaces. *npj Computational Materials*, volume 5, page 61, 2019.
- 2019 **Sayantika Bhowal** and S. Satpathy. Electronic structure and anomalous hall effect in the ferromagnetic $3d - 5d$ superlattice $\text{SrMnO}_3/\text{SrIrO}_3$. *Phys. Rev. B*, volume 99, page 245145, 2019.
- 2019 **Sayantika Bhowal** and S. Satpathy. Dirac nodal lines and large spin hall effect in the $6H$ -perovskite iridate $\text{Ba}_3\text{TiIr}_2\text{O}_9$. *Phys. Rev. B*, volume 100, page 115101, 2019.
- 2019 **Sayantika Bhowal**, Shreemoyee Ganguly, and Indra Dasgupta. Spin-orbit coupling driven novel magnetism in d^5 $6H$ -perovskite iridates $\text{Ba}_3\text{IrTi}_2\text{O}_9$ and $\text{Ba}_3\text{TiIr}_2\text{O}_9$. *J. Phys.: Condens. Matter*, volume 31, page 185802, 2019.
- 2019 A. Nag, **Sayantika Bhowal**, M. Moretti Sala, A. Efimenko, I. Dasgupta, and Sugata Ray. Hopping-induced ground-state magnetism in $6h$ perovskite iridates. *Phys. Rev. Lett.*, volume 123, page 017201, 2019.
- 2018 **Sayantika Bhowal** and Sashi Satpathy. Emergent magnetism at the $3d - 5d$ interface: $\text{SrMnO}_3/\text{SrIrO}_3$. *AIP Conference Proceedings*, volume 2005, page 020007, 2018.

- 2018 **Syantika Bhowal**, Subham Majumdar, and Indra Dasgupta. Study of magnetic and multiferroic properties of α -copper pyrovanadate. *AIP Conference Proceedings*, volume 2005, page 020008, 2018.
- 2018 **Syantika Bhowal**, Jamshid Moradi Kurdestany, and Sashi Satpathy. Stability of the antiferromagnetic state in the electron doped iridates. *J. Phys.: Condens. Matter*, volume 30, page 235601. IOP Publishing, 2018.
- 2018 **Syantika Bhowal** and I. Dasgupta. Covalency and spin-orbit coupling driven magnetism in the double-perovskite iridates $\text{Sr}_2\text{MlIrO}_6$ (M= Ca, Mg). *Phys. Rev. B*, volume 97, page 024406, 2018.
- 2018 Abhishek Nag, **Syantika Bhowal**, Atasi Chakraborty, M. M. Sala, A. Efimenko, F. Bert, P. K. Biswas, A. D. Hillier, M. Itoh, S. D. Kaushik, V. Siruguri, C. Meneghini, I. Dasgupta, and Sugata Ray. Origin of magnetic moments and presence of spin-orbit singlets in Ba_2YIrO_6 . *Phys. Rev. B*, volume 98, page 014431, 2018.
- 2018 Abhishek Nag, **Syantika Bhowal**, F. Bert, A. D. Hillier, M. Itoh, Ilaria Carlomagno, C. Meneghini, T. Sarkar, R. Mathieu, I. Dasgupta, and Sugata Ray. $\text{Ba}_3\text{MlIr}_2\text{O}_9$ hexagonal perovskites in the light of spin-orbit coupling and local structural distortions. *Phys. Rev. B*, volume 97, page 064408, 2018.
- 2017 **Syantika Bhowal**, J. Sannigrahi, S. Majumdar, and I. Dasgupta. A comparative study of electronic, structural, and magnetic properties of α -, β -, and γ - $\text{Cu}_2\text{V}_2\text{O}_7$. *Phys. Rev. B*, volume 95, page 075110, 2017.
- 2016 Abhishek Nag, S. Middey, **Syantika Bhowal**, S. K. Panda, Roland Mathieu, J. C. Orain, F. Bert, P. Mendels, P. G. Freeman, M. Mansson, H. M. Ronnow, M. Telling, P. K. Biswas, D. Sheptyakov, S. D. Kaushik, Vasudeva Siruguri, Carlo Meneghini, D. D. Sarma, Indra Dasgupta, and Sugata Ray. Origin of the spin-orbital liquid state in a nearly $j = 0$ iridate $\text{Ba}_3\text{ZnIr}_2\text{O}_9$. *Phys. Rev. Lett.*, volume 116, page 097205, 2016.
- 2016 A. Banerjee, J. Sannigrahi, **Syantika Bhowal**, I. Dasgupta, S. Majumdar, H. C. Walker, A. Bhattacharyya, and D. T. Adroja. Spin wave excitations in the pyrovanadate α - $\text{Cu}_2\text{V}_2\text{O}_7$. *Phys. Rev. B*, volume 94, page 144426, 2016.
- 2015 **Syantika Bhowal**, Santu Baidya, Indra Dasgupta, and Tanusri Saha-Dasgupta. Breakdown of $j = 0$ nonmagnetic state in d^4 iridate double perovskites: A first-principles study. *Phys. Rev. B (Rapid Comm.)*, volume 92, page 121113, 2015.
- 2015 J. Sannigrahi, **Syantika Bhowal**, S. Giri, S. Majumdar, and I. Dasgupta. Exchange-striction induced giant ferroelectric polarization in copper-based multiferroic material α - $\text{Cu}_2\text{V}_2\text{O}_7$. *Phys. Rev. B*, volume 91, page 220407, 2015.
- 2015 S. K. Panda, **Syantika Bhowal**, Ying Li, S. Ganguly, Roser Valentí, L. Nordström, and I. Dasgupta. Electronic structure and spin-orbit driven magnetism in $d^{4.5}$ insulator $\text{Ba}_3\text{YIr}_2\text{O}_9$. *Phys. Rev. B*, volume 92, page 180403, 2015.
- 2014 S. K. Panda, **Syantika Bhowal**, A. Delin, O. Eriksson, and I. Dasgupta. Effect of spin orbit coupling and hubbard u on the electronic structure of IrO_2 . *Phys. Rev. B*, volume 89, page 155102, 2014.
- 2014 B. Koteswararao, R. Kumar, P. Khuntia, **Syantika Bhowal**, S. K. Panda, M. R. Rahman, A. V. Mahajan, I. Dasgupta, M. Baenitz, Kee Hoon Kim, and F. C. Chou. Magnetic properties and heat capacity of the three-dimensional frustrated $s = \frac{1}{2}$ antiferromagnet $\text{PbCuTe}_2\text{O}_6$. *Phys. Rev. B*, volume 90, page 035141, 2014.

Communicated articles

- 2022 **Syantika Bhowal** and Nicola A. Spaldin. Magnetolectric classification of skyrmions. *accepted in Phys. Rev. Lett.*, 2022. arXiv:2201.01667.

- 2022 T. P. Cysne, **Sayantika Bhowal**, G. Vignale, and T. G. Rappoport. Orbital hall effect in bilayer transition metal dichalcogenides: From the intra-atomic approximation to the orbital magnetic moment approach. *accepted in Phys. Rev. B*, 2022. arXiv:2201.03491.
- 2021 A. Bandyopadhyay, A. Chakraborty, **Sayantika Bhowal**, V. Kumar, M. M. Sala, A. Efimenko, F. Bert, P. K. Biswas, C. Meneghini, N. Büttgen, I. Dasgupta, T. Saha Dasgupta, A. V. Mahajan, and S. Ray. Sr₃LiIrO₆: potential quantum spin liquid candidate in the one dimensional d^4 iridate family. 2021. arXiv:2111.00925.

Invited talks

- March, 2021 "Revealing hidden magneto-electric multipoles using Compton scattering", venue: Paul Scherrer Institut, Switzerland (Zoom platform).
- September, 2016 "Spin-orbit driven emergent phases in correlated systems: iridates", venue: Institute of Theoretical Physics, TU Bergakademie Freiberg, Germany.
- October, 2016 "Spin-orbit driven emergent phases in correlated systems: iridates", venue: Leibniz Institute for Solid State and Materials Research, Dresden, Germany.

Contributed talks, conferences and schools

- 2022 Trends in quantum magnetism; International workshop, Ascona, Switzerland. (Presented poster)
- 2021 QMAT2021, Mumbai: National conference on quantum condensed matter. (Presented Talk)
- 2021 QUOROM-5 virtual conference on the cutting edge of oxide research. (Presented poster)
- 2021 MaNEP: Complex Oxide Heterostructures Mini-Workshop. (Contributed Talk)
- 2021 Condensed Matter Seminar Series HS21, ETH Zurich, Switzerland. (Pitch Talk)
- 2021 QUOROM-4 online workshop on oxide electronics. (Presented poster)
- 2021 ICTP virtual conference on "2D Materials for Spin-Orbitronics (smr 3608)".
- 2021 ICTP virtual conference on "20th International Workshop on Computational Physics and Materials Science: Total Energy and Force Methods (smr 3554)."
- 2019 APS March Meeting 2019 (2019), Boston, USA. (Presented Talk)
- 2018 Theoretical Condensed Matter Physics Principal Investigators' Meeting, Materials Sciences and Engineering Division, Office of Basic Energy Science U. S. Department of Energy (2018), Washington DC, USA. (Presented Poster)
- 2018 APS March Meeting 2018 (2018), Los Angeles, USA. (Presented Talk)
- 2017 Indo-US Bilateral workshop on "Physics and Chemistry of Oxides: Theory meets experiment (PCOTE17)", Kolkata, India. (Presented Poster)
- 2016 ICTP conference on "What about U? – Effects of Hubbard Interactions and Hund's Coupling in Solids", Trieste, Italy. (Presented Poster)
- 2016 Autumn School on Correlated Electrons: "Quantum Materials: Experiments and Theory", Forschungszentrum Jülich, Germany. (Presented Poster)
- 2016 Indo-Japan Conference on Emergent phenomena in transition-metal compounds and related materials, Bangalore, India.
- 2015 7th IACS-APCTP-Academy Joint Conference on Emergent Phenomena in Novel Oxide Materials and Low Dimensional Systems, Coorg, India. (Presented Talk)
- 2015 S.N.Bose-JAIST Quantum Monte Carlo School, Kolkata, India.
- 2015 ICTP Workshop on Frustrated Magnetism, JNU, Delhi, India. (Presented poster)
- 2014 ICTP School on Materials Simulation Theory and Numerics, IISER Pune, Pune, India. (Presented Poster)

- 2014 ICTS School and Discussion Meeting on “Strongly Correlated Materials: From Models to Materials”, IISC Bangalore, Bangalore, India.
- 2012 ICTS School on Dirac Material and quantum computation, IISC Bangalore, Bangalore, India.