

# Curriculum Vitae

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## Andrea Urru

### General information

**Born:** Carbonia, Italy, October 2<sup>nd</sup> 1992

**Citizenship:** Italian

**Civil state:** Single

**Current employment:** Abrahams Fellow, Postdoctoral Researcher, Rutgers University, Center for Materials Theory

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### Research activity general description

My research activity is focused on the realistic theoretical modeling of the structural, electronic, vibrational, and magnetic properties of solid state materials, mainly by means of *ab initio* techniques. I am mainly interested in the understanding and prediction, by means of symmetry analysis and first-principles techniques (density-functional theory and Wannier interpolation), of effects originating from the cross-coupling of magnetism with other (e.g., electric, lattice) degrees of freedom and the effects generated by the breaking of inversion and time-reversal symmetries. Examples of such physical effects include, but are not limited to: ferroelectricity, multiferroicity,

magnetoelectricity, altermagnetism, flexomagnetism, natural optical activity, and non-reciprocal directional dichroism.

Keywords: *Magnetoelectricity, Multiferroicity, Hidden orders, Multipolar magnetism, Altermagnetism, Spatial dispersion, Symmetry and group theory.*

## Employment History

Sep. 2023 – present	Abrahams fellow, Postdoctoral Researcher, Rutgers University, Center for Materials Theory PIs: Prof. David Vanderbilt and Prof. Karin M. Rabe
Jan. 2021 – Aug. 2023	Postdoctoral Researcher, ETH Zürich, Materials Theory PI: Prof. Nicola A. Spaldin

## Education

Oct. 2016 – Nov. 2020	Ph.D. <i>magna cum laude</i> , Theory and Numerical Simulation of Condensed Matter, International School for Advanced Studies (SISSA) Advisor: Prof. Andrea Dal Corso
Oct. 2014 – Jul. 2016	M. Sc., Physics, University of Cagliari, grade: 110/110 <i>cum laude</i> Advisor: Prof. Vincenzo Fiorentini
Oct. 2011 – Jul. 2014	B. Sc., Physics, University of Cagliari, grade: 110/110 <i>cum laude</i> Advisor: Prof. Vincenzo Fiorentini

## Teaching activity

- Sep. 2022 – Jan. 2023 Teaching Assistant, Solid State Physics and Chemistry of Materials I for the Master Degree in Materials Science, ETH Zürich. Total duration: 30 hours.
- Sep. 2021 – Jan. 2022 Teaching Assistant, Solid State Physics and Chemistry of Materials I for the Master Degree in Materials Science, ETH Zürich. Total duration: 30 hours.
- Oct. 2019 – Feb. 2020 Teaching Assistant, Basic and Advanced Problems in Solid States Physics for the Condensed Matter PhD program, International School for Advanced Studies (SISSA). Total duration: 20 hours.
- Oct. 2018 – Feb. 2019 Teaching Assistant, Basic and Advanced Problems in Solid States Physics for the Condensed Matter PhD program, International School for Advanced Studies (SISSA). Total duration: 20 hours.
- Sep. 2019 – Sep. 2019 Teaching Assistant, Summer School *Advanced Materials and Molecular Modelling with Quantum ESPRESSO*, September 16<sup>th</sup>-20<sup>th</sup> 2019, Ljubljana, Slovenia. Total duration: approximately 10 hours.
- Mar. 2016 – Jul. 2016 Teaching Assistant, General Physics II Laboratory (Electromagnetism) for the Bachelor Degree in Physics, University of Cagliari. Total duration: 20 hours.
- Oct. 2015 – Feb. 2016 Teaching Assistant, General Physics I (Mechanics and Thermodynamics) for the Bachelor Degree in Engineering, University of Cagliari. Total duration: 40 hours.
- Mar. 2015 – Jul. 2015 Teaching Assistant, General Physics I Laboratory (Mechanics and Thermodynamics) for the Bachelor Degree in Physics, University of Cagliari. Total duration: 40 hours.
- Mar. 2015 – Jul. 2015 Teaching Assistant, General Physics II (Electromagnetism) for the Bachelor Degree in Mathematics, University of Cagliari. Total duration: 20 hours.
- Oct. 2014 – Feb. 2015 Teaching Assistant, General Physics I (Mechanics and Thermodynamics) for the Bachelor Degree in Engineering, University of Cagliari. Total duration: 40 hours.

## Mentoring and supervision activity

Supervisor of two master projects for M. Sc. students at ETH Zürich.

## Honours and Awards

- 2025 Best Poster Award, The 37<sup>th</sup> Annual Workshop on Recent Developments in Electronic Structure Methods (ESW2025), awarded by the University of Texas, El Paso.
- 2024 Young Scientist Prize, Shanghai International Crystallographic School and Workshop on chirality in solid state physics and quantum materials, awarded by the International Union of Crystallography (IUCr).
- 2024 Student/Postdoc Presentation Award, The 35<sup>th</sup> Annual Workshop 2024 Fundamental Physics of Ferroelectrics, awarded by the Center for Materials by Design LLC, Carnegie Institution for Science.
- 2017 Best M. Sc. graduate students award, awarded by the University of Cagliari.
- 2015 “Franco Meloni prize” for best Bachelor theses in Physics, University of Cagliari, awarded by Prof. Franco Meloni.

## Publications

### Peer-reviewed journals

- [1] A. Urru, A. Filippetti, J. Íñiguez-González, and V. Fiorentini. *Trilinear coupling and toroidicity in multiferroics*. Phys. Rev. B **112**, 104422 (2025). DOI: [10.1103/x23m-vk2j](https://doi.org/10.1103/x23m-vk2j)
- [2] A. Urru, D. Seleznev, Y. Teng, S. Y. Park, S. E. Reyes-Lillo, and K. M. Rabe. *G-type antiferromagnetic BiFeO<sub>3</sub> is a multiferroic g-wave altermagnet*. Phys. Rev. B **112**, 104411 (2025). DOI: [10.1103/v3fg-6smc](https://doi.org/10.1103/v3fg-6smc). Editors’ suggestion.
- [3] A. Urru, I. Souza, O. Pozo Ocaña, S. S. Tsirkin, and D. Vanderbilt. *Optical spatial dispersion via Wannier interpolation*. Phys. Rev. B **112**, 045201 (2025). DOI: [10.1103/56cw-5h19](https://doi.org/10.1103/56cw-5h19).
- [4] S. F. Weber, A. Urru, and N. A. Spaldin. *Local magnetoelectric effects as predictors of surface magnetic order*. Phys. Rev. X **15**, 021094 (2025). DOI: [10.1103/7brd-lynv](https://doi.org/10.1103/7brd-lynv).
- [5] S. Bhowal, A. Urru, S. F. Weber, and N. A. Spaldin. *Emergent surface multiferroicity*. Phys. Rev. Lett. **134**, 146703 (2025). DOI: [10.1103/PhysRevLett.134.146703](https://doi.org/10.1103/PhysRevLett.134.146703).
- [6] J.-R. Soh, M. E. Merkel, L. Pourovskii, I. Živković, O. Malanyuk, J. Pásztorová, S. Francoual, D. Hirai, A. Urru, D. Tolj, D. Fiore-Mosca, O. Yazyev, N. A. Spaldin, C. Ederer, and H. M. Rønnow. *Spectroscopic signatures and origin of hidden order in Ba<sub>2</sub>MgReO<sub>6</sub>*. Nat. Commun. **15**, 10383 (2024). DOI: [10.1038/s41467-024-53893-z](https://doi.org/10.1038/s41467-024-53893-z).
- [7] M. Braun, B. Guster, A. Urru, H. Kabbour, and E. Bousquet. *Large dynamical magnetic effective charges and antimagnetolectricity from spin and orbital origin in multiferroic BiCoO<sub>3</sub>*. Phys. Rev. B **110**, 144442 (2024). DOI: [10.1103/PhysRevB.110.144442](https://doi.org/10.1103/PhysRevB.110.144442).
- [8] S. F. Weber, A. Urru, S. Bhowal, C. Ederer, and N. A. Spaldin. *Surface Magnetization in Antiferromagnets: Classification, example materials, and relation to magnetoelectric responses*. Phys. Rev. X **14**, 021033 (2024). DOI: [10.1103/PhysRevX.14.021033](https://doi.org/10.1103/PhysRevX.14.021033). Featured in Physics by the American Physical Society, see [here](#).
- [9] E. Bousquet, E. Lelièvre-Berna, N. Qureshi, J.-R. Soh, N. A. Spaldin, A. Urru, X. H. Verbeek, and S. F. Weber. *On the sign of the linear magnetoelectric coefficient in Cr<sub>2</sub>O<sub>3</sub>*. J. Phys.: Condens. Matter **36**, 155701 (2024). DOI: [10.1088/1361-648X/ad1a59](https://doi.org/10.1088/1361-648X/ad1a59).

- [10] X. H. Verbeek, A. Urru, and N. A. Spaldin. *Hidden orders and (anti-) Magnetoelectric effects in  $Cr_2O_3$  and  $\alpha-Fe_2O_3$* . Phys. Rev. Research **5**, L042018 (2023). DOI: [10.1103/PhysRevResearch.5.L042018](https://doi.org/10.1103/PhysRevResearch.5.L042018).
- [11] A. Urru, J.-R. Soh, N. Qureshi, A. Stunault, B. Rössli, H. M. Rønnow, and N. A. Spaldin. *Neutron scattering from local magnetoelectric multipoles: A combined theoretical, computational, and experimental perspective*. Phys. Rev. Research **5**, 033147 (2023). DOI: [10.1103/PhysRevResearch.5.033147](https://doi.org/10.1103/PhysRevResearch.5.033147).
- [12] A. Urru and N. A. Spaldin. *Magnetic octupole tensor decomposition and second-order magnetoelectric effect*. Annals of Physics **447**, 168964 (2022). DOI: [10.1016/j.aop.2022.168964](https://doi.org/10.1016/j.aop.2022.168964).
- [13] A. Urru, F. Ricci, A. Filippetti, J. Íñiguez, and V. Fiorentini. *A three-order-parameter bistable magnetoelectric multiferroic metal*. Nat. Commun. **11**, 4922 (2020). DOI: [10.1038/s41467-020-18664-6](https://doi.org/10.1038/s41467-020-18664-6).
- [14] A. Urru and A. Dal Corso. *Lattice dynamics effects on the magnetocrystalline anisotropy energy: Application to MnBi*. Phys. Rev. B **102**, 115126 (2020). DOI: [10.1103/PhysRevB.102.115126](https://doi.org/10.1103/PhysRevB.102.115126).
- [15] P. Giannozzi, O. Baseggio, P. Bonfà, R. Car, I. Carnimeo, C. Cavazzoni, S. de Gironcoli, P. Delugas, F. Ferrari Ruffino, A. Ferretti, T. Gorni, N. Marzari, I. Timrov, A. Urru, and S. Baroni. *Quantum ESPRESSO toward the exascale*. J. Chem. Phys. **152**, 154105 (2020). DOI: [10.1063/5.0005082](https://doi.org/10.1063/5.0005082).
- [16] F. Belviso, V. E. P. Claerbout, A. Comas-Vives, N. S. Dalal, F. Fan, A. Filippetti, V. Fiorentini, L. Foppa, C. Franchini, B. Geisler, L. M. Ghiringhelli, A. Groß, S. Hu, J. Íñiguez, S. K. Kauwe, J. L. Musfeldt, P. Nicolini, R. Pentcheva, T. Polcar, W. Ren, Fa. Ricci, Fr. Ricci, H. S. Sen, J. M. Skelton, T. D. Sparks, A. Stroppa, A. Urru, M. Vandichel, P. Vavassori, H. Wu, K. Yang, H. J. Zhao, D. Puggioni, R. Cortese, and A. Cammarata. *Viewpoint: Atomic-Scale Design Protocols toward Energy, Electronic, Catalysis, and Sensing Applications*. Inorg. Chem. 2019, **58**, 22, 14939-14980 (2019). DOI: [10.1021/acs.inorgchem.9b01785](https://doi.org/10.1021/acs.inorgchem.9b01785).
- [17] A. Urru and A. Dal Corso. *Density functional perturbation theory for lattice dynamics with fully relativistic ultrasoft pseudopotentials: The magnetic case*. Phys. Rev. B **100**, 045115 (2019). DOI: [10.1103/PhysRevB.100.045115](https://doi.org/10.1103/PhysRevB.100.045115).
- [18] A. Urru and A. Dal Corso. *Spin-polarized electronic surface states of Re(0001): An ab-initio investigation*. Surf. Science **686**, 22-29 (2019). DOI: [10.1016/j.susc.2019.03.008](https://doi.org/10.1016/j.susc.2019.03.008).
- [19] A. Urru and A. Dal Corso. *Clean Os(0001) electronic surface states: A first-principle fully relativistic investigation*. Surf. Science **671**, 17-26 (2018). DOI: [10.1016/j.susc.2018.01.006](https://doi.org/10.1016/j.susc.2018.01.006).

## Submitted

- [1] P. A. Gigon, A. Urru, D. Prabhakaran, B. Rössli, A. Turrini, J. Lass, D. G. Mazzone, P. C. Forino, C. Niedermayer, N. A. Spaldin, H. M. Rønnow, and J.-R. Soh. *Local non-centrosymmetric magneto-electric multipoles in  $CoWO_4$* .

## Non-peer-reviewed journals

- [1] A. Urru, G. Cocco, and V. Fiorentini (2015). *Tunability of the Berry phase in gapped graphene*. [arXiv:1511.01341](https://arxiv.org/abs/1511.01341)

## In preparation

- [1] A. Urru, K. Roy, R. Rao, and K. M. Rabe. *Magnetic space groups of nonmagnetic crystals: beyond the Herring test.*
- [2] J. Tosado, A. Urru, N. Sharma, N. Qureshi, C. Stock, and E. Rodriguez. *Ferrotoroidic order through spherical neutron polarimetry.*

## Seminars and contributions to conferences and workshops

### Invited seminars and lectures

- [1] [A. Urru](#) (2025). *Universal description of surface magnetism via bulk magnetoelectric effects.* Nanoseminar, TU Dresden, Dresden, Germany.
- [2] [A. Urru](#) (2025). *Hidden magnetoelectric multipoles and their detection via neutron diffraction.* MLZ (FRM-II/TUM) seminar series “Neutrons in Science and Industry”, TU München, München, Germany.
- [3] [A. Urru](#) (2024). *Breaking time-reversal in centrosymmetric antiferromagnets: magnetic octupoles and their link to magnetoelectric effects and surface magnetization.* Materials Colloquium, ETH Zürich, Zürich, Switzerland.

### Invited talks at international conferences

- [1] [A. Urru](#), I. Souza, S. S. Tsirkin, O. Pozo Ocaña, and D. Vanderbilt (2025). *Natural optical activity in solids: an ab initio approach based on Wannier interpolation.* 22nd International Workshop on Computational Physics and Material Science: Total Energy and Force Methods, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.

### Contributed talks at international conferences

- [1] [A. Urru](#), I. Souza, O. Pozo Ocaña, S. S. Tsirkin, and D. Vanderbilt (2025). *Natural optical activity in solids from Wannier interpolation.* 2025 APS Global Physics Summit, Anaheim (CA), USA.
- [2] [A. Urru](#), D. Seleznev, Y. Teng, S. Y. Park, S. E. Reyes-Lillo, and K. M. Rabe (2025). *G-type antiferromagnetic  $\text{BiFeO}_3$  is an altermagnet.* The 36th Annual Workshop 2025 Fundamental Physics of Ferroelectrics, Annapolis (MD), USA.
- [3] [A. Urru](#), S. F. Weber, S. Bhowal, C. Ederer, and N. A. Spaldin (2024). *Symmetry-guided analogy between bulk magnetoelectric responses and surface magnetization in antiferromagnets.* 2024 APS March Meeting, Minneapolis (MN), USA.
- [4] [A. Urru](#), F. Ricci, A. Filippetti, J. Íñiguez, and V. Fiorentini (2024). *A three-order parameter bistable magnetoelectric multiferroic metal.* The 35th Annual Workshop 2024 Fundamental Physics of Ferroelectrics, Washington (DC), USA.
- [5] [A. Urru](#) and N. A. Spaldin (2023). *Hidden magnetic octupoles: tensor decomposition and second-order magnetoelectric effect.* 2023 APS March Meeting, Las Vegas (NV), USA.

- [6] [A. Urru](#) and A. Dal Corso (2020). *Density functional perturbation theory for lattice dynamics with fully relativistic ultrasoft pseudopotentials: the magnetic case*. 2020 APS March Meeting, Denver (CO), USA. <sup>1</sup>
- [7] [A. Urru](#) and A. Dal Corso (2019). *Density Functional Perturbation Theory for lattice dynamics with Fully Relativistic Ultrasoft Pseudopotentials: the magnetic case*. 2019 FisMat Conference, University of Catania, Catania (CT), Italy.
- [8] [A. Urru](#) and V. Fiorentini (2015). *Behavior of the Berry phase in gapped graphene*. 2015 FisMat Conference, University of Palermo (PA), Italy.

## Posters presented at international conferences

- [1] [A. Urru](#), I. Souza, O. Pozo Ocaña, S. S. Tsirkin, and D. Vanderbilt (2025). *Optical activity in solids: an ab initio approach based on Wannier interpolation*. 37<sup>th</sup> Workshop on Recent Developments in Electronic Structure Methods, University of Texas El Paso, El Paso (TX), USA.
- [2] [A. Urru](#), O. Pozo Ocaña, S. S. Tsirkin, I. Souza, and D. Vanderbilt (2024). *Spatial-dispersive optical phenomena in crystalline solids: an ab initio approach based on Wannier interpolation*. 36<sup>th</sup> Workshop on Recent Developments in Electronic Structure Methods, Boston University, Boston (MA), USA.
- [3] [A. Urru](#), S. F. Weber, S. Bhowal, C. Ederer, and N. A. Spaldin (2023). *Surface Magnetization in Antiferromagnets: Classification and relationship to Magnetoelectric Responses*. QUOROM-9 Virtual Conference, ETH Zürich, Zürich, Switzerland.
- [4] [A. Urru](#), J.-R. Soh, N. Qureshi, A. Stunault, B. Rössli, H. M. Rønnow, and N. A. Spaldin (2023). *Neutron scattering from local magnetoelectric multipoles: A combined theoretical, computational, and experimental perspective*. QUOROM-8 Virtual Conference, ETH Zürich, Zürich, Switzerland.
- [5] X. H. Verbeek, [A. Urru](#), and N. A. Spaldin (2023). *Hidden Magnetoelectric Multipoles, and anti-Magnetoelectric Effect in  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>*. 21st International Workshop on Computational Physics and Material Science: Total Energy and Force Methods, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.
- [6] [A. Urru](#) and N. A. Spaldin (2022). *Hidden magnetic octupoles and second-order magnetoelectric effect*. Theoretical Physics Symposium "Beyond Multiferroics", DESY Hamburg, Germany.
- [7] [A. Urru](#) and N. A. Spaldin (2022). *Hidden magnetic octupoles and second-order magnetoelectric effect*. Workshop Trends in the Theory of Quantum Materials 2022, ETH Zürich, Zürich, Switzerland.
- [8] [A. Urru](#) and N. A. Spaldin (2022). *Hidden magnetic octupoles: tensor decomposition and second-order magnetoelectric effect*. Psi-k 2022 Conference, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland.
- [9] [A. Urru](#), J.-R. Soh, N. Qureshi, A. Stunault, B. Roessli, H. M. Rønnow, and N. A. Spaldin (2022). *Hidden magnetoelectric multipoles and their detection via neutron diffraction: the*

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<sup>1</sup>The 2020 APS March Meeting was canceled due to the health emergency raised by Covid-19. Under request of the APS, the oral presentation was recorded and made publicly available through the APS website. The relevant material can be found [here](#).

*CuO case*. Trends in Quantum Magnetism International Workshop, Congressi Stefano Franscini, Ascona, Switzerland.

- [10] [A. Urru](#) and A. Dal Corso (2019). *Density Functional Perturbation Theory with Fully Relativistic pseudopotentials: the magnetic case*. 19th International Workshop on Computational Physics and Material Science: Total Energy and Force Methods, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.
- [11] [A. Urru](#) and A. Dal Corso (2019). *Spin-polarized electronic surface states of Re(0001): an ab-initio investigation*. 19th International Workshop on Computational Physics and Material Science: Total Energy and Force Methods, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.
- [12] [A. Urru](#) and A. Dal Corso (2018). *Clean Os(0001) electronic surface states: a first-principle fully relativistic investigation*. 2018 MAX Conference, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.
- [13] [A. Urru](#) and A. Dal Corso (2017). *Electronic surface states of Os(0001)*. 2017 FisMat Conference, International Center for Theoretical Physics (ICTP), Trieste (TS), Italy.

## Referee activity

Referee for the following journals:

- npj Computational Materials;
- Physical Review X;
- Physical Review B;
- Newton.

## Programming languages

- Coding: Fortran, Python;
- Command-line interface: Bash;
- Text processing: awk, sed;
- Typesetting: LaTeX;
- *Ab initio* software: Quantum Espresso, VASP, Elk.

## Languages

- Italian (mother tongue);
- English (fluent);
- French (reading: intermediate, writing: basic, spoken: basic).