

# Marco Beleggia

Born 9/7/1972 (Italy) - MSc (Physics) 1996 - PhD (Physics) 2001

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Google Scholar public profile: <http://scholar.google.com/citations?user=vEqtF2MAAAAJ>

## EDUCATION

- **Ph.D. Physics**, University of Bologna, Italy (23/2/2001). Thesis title: *Transmission electron microscopy observation of electromagnetic fields*. Advisor: Prof. Giulio Pozzi. My PhD project was partially carried at the Hitachi Advanced Research Lab. (Japan). Supervisor: A. Tonomura.
- **M.Sc. Physics** (graduated *cum laude*) University of Bologna, Italy (14/6/1996). Thesis title: *Simulations of Foucault images of superconducting fluxons*. Advisor: Prof. Giulio Pozzi.

## RESEARCH INTERESTS - KEYWORDS

- Electron-matter interactions
- Nanoscale and quantum physics: spin, charge and their dynamics
- Electron holography and interferometry; phase contrast and phase retrieval
- Advanced electron microscopy and spectroscopy: Lorentz, EELS, STEM, HRTEM, in-situ/environmental, cryo-TEM, phase plate imaging
- Shape- and finite-size effects in electronic and magnetic nanomaterials
- Dipolar interactions in colloidal systems, self-assembly
- Magnetic nanoparticles for biomedical applications
- Ferroelectrics, multiferroics, interfaces, complex oxides
- Interface between physical, chemical, and life sciences
- Nanotechnology: fabrication — functionalization — characterization — application
- Synergy between electron-probe and photon-probe imaging techniques
- Aharonov-Bohm effect and quantized vortices in superconductors
- Single-molecule and radiation-sensitive materials imaging
- Semiconductor devices for energy harvesting and photonic applications

## SCIENTIFIC EXPERTISE - KEYWORDS

- Magnetism: analytical and numerical micromagnetism, magnetic nanostructures, local hysteresis, nanoscale interactions, shape anisotropy, finite-size effects, colloidal systems, magnetic phase diagrams, nanostructured arrays, multilayers and heterostructures
- Superconductivity: vortices, flux pinning, flux-line-lattice dynamics, field topography
- Semiconductors: p-n junctions, doping profiling, electric field topography, surface effects
- Electron optics, electron microscopy, electron holography, image formation theory, light optics
- Modelling of electromagnetic fields and simulation of electron microscopy images/signals
- Magnetic and ferroelectric nanostructures, multiferroics, strongly correlated electron systems
- Single-molecule imaging with electrons, radiation sensitive materials, electron phase plates
- Liquid-cell in-situ electron microscopy and holography
- Organic ice resist electron beam lithography
- Hands-on experience with various Transmission Electron Microscopes (Philips CM30 and CM200, FEI Tecnai and Titan, Jeol 3000F, Jeol 2100F, Hitachi HF 3300, etc.).

## SCIENTIFIC PRODUCTION – METRIC

Sources: Google/Scopus/WoS; last update: Dec 2018

- Peer-reviewed articles: **96** Conf. Proc. & Misc.: **100+** Total citations: **2414/1702/1584**
- Review articles: **2** Book Chapters: **6** 5 year avg: **79.20** cit/yr (WoS)
- Invited talks: **35** Current *h-index*: **25/22/21** Most cited paper: **149/104/104** cit

## EMPLOYMENT HISTORY

- 2009-curr. Technical University of Denmark, Center for Electron Nanoscopy** **DK**  
*Associate Professor (tenured), head of the "Electron Matter Interaction" research group*  
**Focus:** Modelling and image interpretation for the quantitative measurement of physical properties of magnetic and electronic nanomaterials. Teaching (course responsible for 10250, lecturer in other DTU/KU courses). Supervising B.Sc, M.Sc, Ph.D students and post-docs.  
**Achievements:** Developed an algorithm to measure magnetic moments and charges from holographic phase images with a sensitivity approaching a single Bohr magneton and a tiny fraction of the electron charge, respectively. Shape effects in nanomagnetism. Self-assembled dipolar ferromagnetism in magnetic colloids. Ferroelectricity in confined structures. Remote manipulation of magnetic nanoparticles for a novel non-invasive cancer therapy. Organic Ice Resists for the nanofabrication of quantum nanodevices and bio-hybrid structures.
- 2014-2015 Helmholtz Zentrum Berlin for Energy and Materials** **DE**  
*Senior Scientist – at 50% with DTU from 01.03.2014 to 29.02.2016*  
**Focus:** Development of models for the interactions between the electron beam and the sample and simulations of images/signals in the TEM/STEM-EELS/SEM aimed at extracting quantitative information from the experimental data. Image contrast mechanisms in He/Ne ion microscopes.  
**Achievements:** Formulated a description for beam-induced charging of a finite object with neutralizing tunneling currents. Developed a model for beam-induced plasma effects in the ETEM.
- 2007-2008 University of Leeds, Institute for Materials Research** **UK**  
*Royal Society Fellow in the group of R. Brydson*  
**Focus:** Establishment of Electron Holography in Leeds as a complementary (to EELS, Lorentz-TEM, HRTEM, STEM, etc.) tool for nanoscale characterization of advanced materials.  
**Achievements:** Procured and installed a custom-made electron biprism on the local Philips CM 200 FEG TEM. Initiated collaborative efforts with Physics (C. Marrows) on spintronics and development of tunable magnetic phase plates (Zernike phase contrast with electrons).
- 2004-2007 Brookhaven National Lab., Center for Functional Nanomaterials** **USA**  
*Associate scientist (tenure-track) with Y. Zhu and in the nanomagnetism group (L. H. Lewis)*  
**Focus:** TEM observation and characterization of magnetic and electronic nanomaterials. Charge distributions and material defects at grain boundaries in superconductors. Ferroelectrics and multiferroic materials. Analytical and numerical micro-/nano-magnetism.  
**Achievements:** Development of magnetic phase diagrams for nano-rings, and of an analytical shape-shape magnetostatic interaction expression. Description of interfacial ferromagnetism in LaMnO-SrMnO multilayers. Interplay between dipolar and exchange couplings in ECC media.
- 2002-2003 Brookhaven National Laboratory, Materials Science Department** **USA**  
*Research associate (post-doc) in the Nanoscale Structure of Advanced Materials group of Y. Zhu.*  
**Focus:** TEM observation and characterization of nanostructures.  
**Achievements:** Effect of shape anisotropy in phase computations and energetics of magnetic nanoparticles. Quantitative magnetization mapping of nanostructures by electron holography and micromagnetic simulations. Discovery and description of shape-induced ferromagnetic ordering in dipolar-dominated nanostructured systems.
- 2001 INFN – National Institute for the Physics of Matter** **Italy**  
*Research fellow (post-doc) under the supervision of Prof. G. Pozzi.*  
**Focus:** Phase computations for superconducting vortices and p-n junctions.  
**Achievements:** Direct visualization of vortex pinning at columnar defects in high- $T_c$  superconductors by phase-contrast methods. Electron-optical description of pancake vortices.
- 1996-2000 University of Bologna, Department of Physics** **Italy**  
*Graduate student of Prof. G. Pozzi.*  
**Focus:** Phase contrast techniques for transmission electron microscopy and electron holography.

**Achievements:** Development of a phase computation method for TEM observations. Applications to TEM image interpretation of superconducting vortices and p-n junctions.

## GUEST OR VISITING SCIENTIST APPOINTMENTS

**2006-curr. NINT – National Institute for Nanotechnology** **Canada**

*Visiting scientist in the group of M. Malac*

**Focus:** Electron imaging of radiation sensitive materials and single molecules.

**Achievements:** Assessed the benefits of Zernike-type phase plates in single-molecule imaging with Cs-corrected TEMs. Evaluated doses with bright-field, holography, Zernike, and electron nanodiffraction imaging modes. Invented and patented the "Hole free phase plate" device.

**2012-2014 Technical University in Berlin, Inst. of Optics and Atomic Physics** **Germany**

*Guest scientist in the group of Prof. Dr. Michael Lehmann*

**Focus:** Electron holography of nanoscale charge distributions and electric fields. Confined nanostructured p-n junctions. Beam-induced potentials.

**Achievements:** Extended the phase Laplacian approach for measuring charges to high-resolution Electron Holography for model-independent holographic chemical mapping.

**2007-2009 Brookhaven Nat. Lab., Cond. Matter Physics and Mat. Sci. Dept.** **USA**

*Guest scientist in the group of Y. Zhu*

**Focus:** Magnetodynamics and interactions in nanostructured magnetic arrays.

**Achievements:** Generalization of magnetic phase diagrams. Structure of magnetic vortex cores.

**1999-2000 Hitachi Advanced Research Laboratory** **Japan**

*Visiting scientist in the group of Dr. A. Tonomura.*

**Focus:** Electron holography of superconducting materials. Vortex dynamics.

**Achievements:** Development and application of a reconstruction system for electron holography. Measurement of penetration depth in high- $T_c$  superconductors by EH.

## TRAINING, PROFESSIONAL DEVELOPMENT

- **Habilitation to Full Professor**, Italy, Apr 2017.
- **Course** *How to prepare a successful proposal for Horizon 2020*, DTU, Oct 21, 2014.
- **Course** *The good application for the DFF (Danish Research Council)*, DTU, Sep 19, 2013.
- **Course** *UDTU*, Education in University Teaching, graduated in Aug 2011. UDTU is an 18 months program (250 h. workload) that included a project on my own teaching development.
- **Course** *Leadership Development for Principal Investigators*, U. Leeds, UK, Dec 4, 2007.
- **Course** *People Management for Postdoctoral Staff*, Faculty of Engineering, University of Leeds, Leeds, UK, Nov. 29-30, 2007.
- **International School** *Advances in Electron Microscopy in Materials Science*, organized by University of Lecce and ISUFI, Lecce, Italy, Sep. 10-20, 2001.
- **Summer School** *National School on Condensed Matter Physics*, organized by ISI Foundation and INFM, Villa Gualino, Torino, Italy, Sep. 4-15, 2000.
- **Course** *Quantitative High-Resolution Electron Microscopy and Electron Diffraction*, EUREM 2000 conference, Brno, Czech Republic, July 9-14, 2000.
- **International School** *Superconducting Materials: Advances in Technology and Applications*, International Advanced School "Leonardo da Vinci", Bologna, Italy, June 29–July 10, 1998.
- **Course** *Digital Imaging, Microscopy and Microanalysis '97*, Cleveland OH, Aug. 10-14, 1997.
- **Course** *Modern Developments of Electron Microscopy in Material Science*, XX Conference of the Italian Society of Electron Microscopy (SIME), Rimini, Italy, Sep. 11-14, 1995.

## GRANTS, FUNDING HISTORY, AWARDS

- **EUROSTARS SuperPower** (2018), co-PI and WP leader, €300k (total budget €1.25M).
- **H.C. Ørsted Fellowship** *Nanoscale interactions between electrons and ice: towards the ultimate resolution of ice lithography* (2017) for Ding Zhao, co-supervised with A. Han (DTU).

- **VILLUM Blocstipend** (2016) to support the 2-year project "Ice lithography and electron holography" with the full-time employment of Dr. Anna Elsukova 01/01/2017-31/12/2018.
- **Otto Mønsted Guest Professorship** (~€28k, 2015) to support a 3-month visit and collaboration activities with Prof. R. Budhani, summer 2018.
- **Otto Mønsted Guest Professorship** (~€28k, 2015) to support a 3-month visit and collaboration activities with Prof. M. Lehmann, Jan-Mar 2014.
- **H.C. Ørsted Fellowship** *Self-assembly dynamics of ferromagnetic nanoparticles in evaporating fluid* (2012) for Jelena Jordanovic, co-supervised with C. Frandsen (DTU Physics).
- **Otto Mønsted Guest Professorship** (~€25k, 2010) to support a 3-month visit and collaboration activities with Prof. G. Pozzi, Mar-May 2011.
- **Royal Society Fellowship Relocation Grant** (~£190k, 2007). Supported my research activities for two years (July 1<sup>st</sup>, 2007 to June 30<sup>th</sup>, 2009) at the University of Leeds, UK.
- Instrumental in acquiring and renewing a **Grant, U.S. Department of Energy** (*DOE FWP MA-015-MACA*), ~\$2M/year, open ended. Supported my research at Brookhaven National Laboratory during 2002-2007 (Basic Energy Sciences, contract No. DE-AC02-98CH10886).
- **Early Career Award** (€1000, 2006), from Italian Society of Microscopy Sciences (SISM).
- **Prize Carla Milanese**, from Italian Society of Electron Microscopy (SIME), for the outstanding contribution presented at the MCEM 5th conference (March 1<sup>st</sup>, 2002).
- **Grant Young Researcher Project** from University of Bologna (€2500, year 2001) to support collaboration with HARL group of Dr. A. Tonomura, Japan.
- **Scholarship** from INFM on "Phase contrast electron microscopy techniques for the observation of quantized flux lines", Feb. 1997 (refused due to incompatibility with Ph.D. project).
- Other grant or fellowship applications with good results:
  - 2012 **ERC Starting Grant** (€1.4M budget). Proposal ranked "B" (passed 1<sup>st</sup> threshold).
  - 2006 **EPSRC ARF Advanced Research Fellowship** (£778k budget). Proposal ranked 11 (after being interviewed in Swindon, UK), with 10 projects funded.
  - 2005 **EURYI European Young Investigator Awards** (€1.25M budget) Proposal ranked amongst the best 6 in Italy (across all scientific disciplines), with only the first 3 funded.

## INNOVATION – PATENTS

- "Charging of a hole-free thin film phase plate". Patent US8785850-B2 (granted 2014-07-22); also submitted in Japan JP2011151019-A. M. Malac, M. Beleggia, M. Kawasaki, R. Egerton.
- "Quiet magnetic Velcro fastener". D. Vokoun, M. Beleggia. CZ26401 (U1), 2014-02-12.
- "A method for creating structures or devices using an organic ice resist". A. Han, M. Beleggia, W. Tiddi. Patent application WO2017191079 (priority# EP20160167903), 9 Nov 2017.

## TEACHING ACTIVITIES

- **Course responsible and lecturer** *Transmission Electron Microscopy for the characterization of advanced materials* (5 ECTS) M.Sc., 2014-ongoing.
- **Co-lecturer** *Magnetism and Magnetic Materials* (10 ECTS, B.Sc. and M.Sc.), 2011-ongoing. Course shared between DTU and KU (Copenhagen University).
- **Course responsible and lecturer** *Transmission Electron Microscopy for Nanoscience* (5 ECTS, Ph.D. open to final year M.Sc.), 2010-2013.
- **Organized and co-lectured** the *Basic and Advanced Transmission Electron Microscopy* special course at DTU Cen, 2009.
- **Co-lectured** *Processing and Properties of Inorganic Nanomaterials*, Nanotechnology M.Sc., University of Leeds, UK, 2007.
- **Instructor** for the tutorial workshop on *Electron Holography* at the Microscopical Society of Canada Annual Meeting, University of Alberta, Edmonton, Canada, 2007.
- **Instructor** for the pre-congress workshop/tutorial *Electron holography in Materials and Life Sciences* at the SCANDEM conference, Copenhagen, Denmark, 2013.
- **Instructor** for the pre-congress tutorial *Imaging magnetism with electrons* at the MRS fall meeting, Boston, USA, 2013.



- **Guest-lecturer** for a yearly short course (10 hours) on *Advanced electron microscopy techniques applied to nanoscience* to graduate students, U. Bologna (Italy), (2006-2009).
- **Lectured** to 4<sup>th</sup>-year physics undergraduate students on *Advanced calculus applied to electron-optics, phase retrieval and phase contrast techniques*. U. Bologna, Italy, 1999-2001.
- **Teaching Assistant** for courses *Electron Optics* and *Electron Microscopy*. Physics Department, University of Bologna, Italy, 1999-2001.
- **Taught** a 4<sup>th</sup>-yr physics undergrad. *Electron Microscopy Laboratory* course. U. Bologna, 2000.

## ACADEMIC and PROFESSIONAL ACTIVITIES

- **Conference vice-chair**, European Microscopy Conference 2020, Copenhagen, Denmark.
- **Chaired** several sessions at workshops and international conferences worldwide, on topics involving electron holography, magnetism and magnetic materials, advanced electron microscopy and materials characterization.
- **Member** (substitute) of COST action RADIOMAG TD1402, representing Denmark, 2014-curr
- **Editorial Board Senior Member**, IEEE Magnetics Letters, 2012-curr.
- **Committee chair**, Ph.D. A. Insinga, DTU Risø, DK, 2016.
- **External committee member**, Ph.D. Ioanna Antypas, U. Cambridge, UK, 2007.
- **Committee member**, Ph.D. S. Tandon, Carnegie Mellon University, USA, 2004.
- **Peer reviewer** for many high-profile scientific journals (including Phys. Rev. Lett., Nature Materials/Nanotech, Nanoletters, Nature). I review on average a paper per month at least.
- **Member** (or former member) of professional societies: Italian Society Microscopy Sciences (SISM), Microscopy Society of America (MSA), Materials Research Society (MRS), Royal Microscopical Society (RMS), Royal Society, IoM<sup>3</sup>, IEEE.
- **Panel member** of the Center for Functional Nanomaterials (Brookhaven National Laboratory, USA) Proposal Review Panel (PRP), 2008-2010.
- **Panel member** of the Royal Society International Travel Grant Panel, 2008-2013.

## SUPERVISORY ACTIVITIES

- **Supervised or co-supervised** undergraduate and graduate students in their Bachelor, Master or PhD projects, and post-docs in their research activities.
  - *F. Ubaldi*: TEM and modeling of p-n junctions, PhD Bologna University, Italy.
  - *S. Tandon*: Lorentz-TEM and phase simulations, PhD Carnegie Mellon University, USA.
  - *J. Lau*: Barrier energetics, reversal and magnetodynamics in patterned magnetic arrays. Columbia University (PhD project carried out at Brookhaven National Laboratory).
  - *H. Lei*: TEM of shape-controlled nanopatterned arrays and magnetic dots. Stony Brook University (PhD project carried out at Brookhaven National Laboratory).
  - *M.K. Hari*: Numerical micro- and nano-magnetism of spintronic circuits. MSc U. Leeds.
  - *Ó.D. Jóhannsson*: LLG-based micromagnetism of dipolar chains. Proj. DTU.
  - *N. Torstensson*: Magnetic steering of catalytic etching. BSc DTU.
  - *A.F. Pedersen*: Micromagnetic simulations of planar Hall effect bridge. Proj. DTU.
  - *J. Jordanovic*: Self-assembly dynamics of ferromagnetic nanoparticles in evaporating fluid. Postdoc DTU.
  - *B.S. Baekke*: Polarization enhancement of ferroic NPs embedded in a matrix. BSc DTU.
  - *T. Jahuo and E. Fogh*: Demagnetization factors for non-trivial shapes. Project, DTU.
  - *N. Torstensson*: Timescale separation between spin relaxation and NP rotation. Proj. DTU.
  - *B.S. Baekke*: Polarization profile in ferroelectric needles. Proj. DTU.
  - *A. Insinga and D. Cadario*: Neodymium magnetic systems optimization with a variational approach. Proj. DTU.
  - *M.R. Almind and N.Ø. Langemark*: Visualizing magnetic fields of magnetite nanoparticles with off-axis electron holography. BSc DTU.
  - *M.S. Yekta*: Nanowires for LEDs: characterization with Electron Holography. MSc DTU.
  - *W. Tiddi*: Ice lithography for large-scale sub-10 nm patterning. PhD DTU.
  - *B.S. Baekke*: Demagnetization effects in NiMnGa shape memory alloys. MSc DTU.

- *M.R. Almind and N.Ø. Langemark*: Micromagnetic simulations of magnetite octahedra. Project, DTU
- *A. Bay Andersen*: Quantitative characterization of magnetic vortex cores in magnetite nanoparticles using off-axis electron holography. BSc DTU.
- *M. Kure*: Dipolar ferromagnetism and ferrotoroidicity in nanoclusters. PhD DTU.
- *A. Elsukova*: Ice lithography and electron holography. Postdoc DTU.
- *F. Durhus, M. Boisen, L. Wandall*: Simulations of magnetic particle aggregation. Proj. DTU.
- *Z. Abachri*: Imaging Skyrmion materials. MSc DTU
- **Managed** (interim) the Nanomagnetism research theme at Brookhaven National Laboratory, including supervision of a post-doc (Yi Ding) and coordination of scientific staff activity (D. Arena, M.A. Schofield, Y. Zhu), after the group leader (L.H. Lewis) accepted her current position as Head of the Chemistry Department, Northeastern University, Boston, USA.
- **Chair** of DTU Cen's Teaching Panel, coordinating the departments' efforts in "teaching according to our needs" (as per DTU mandate), training and outreach, and overseeing supervision of PhD students and making sure that their projects achieve a steady progress.
- **Head of research group** *Electron Matter Interaction*: scientific management of 8 researchers at various stages of their career (PhD's, postdocs, junior and senior scientists).

## INTERNATIONAL COLLABORATORS

- G. Pozzi: phase contrast and phase retrieval microscopy techniques, optics
- Y. Zhu: electron diffraction, nanoscale characterization of advanced materials
- M. De Graef: electron crystallography, Lorentz-TEM, micromagnetism, phase retrieval
- M. Malac: nanolithography, EELS, Zernike phase plates for electrons
- R. Egerton: EELS, low-dose imaging of radiation sensitive materials
- G. Rowlands: fundamentals of micromagnetism, energetics of nanomagnets
- Y. Millev: spin reorientation transitions, renormalization group theory
- M. Freeman: time-resolved magneto-optical techniques
- R. Klie: STEM and atomic-resolved EELS, grain boundaries
- L. Lewis: magnetic materials, magnetic phase transitions, nanomagnetism
- D. Arena: synchrotron, element-specific time-res. X-ray spectroscopy and magnetic dichroism
- G. Matteucci: electron holography, foundations of quantum mechanics, Aharonov-Bohm effect
- L. Ferrari: phase transitions, statistical mechanics
- J. Davenport: first-principle calculations, Heisenberg models
- D. Vokoun: exchange-coupled composite media, magnetometry, magnetic forces
- J. Lau: magnetodynamics in shape-controlled nanostructured materials
- M. Schofield: electron holography, spin and charge distributions in materials
- Ch. Jooss: manganites, multiferroics, magneto-optical techniques, electrochemistry
- C.H. Marrows: spintronic, MBE sample growth, nanomagnetism, domain wall resistance
- R. Dunin-Borkowski: electron holography, magnetic vortices, phase retrieval
- R.M. Brydson: EELS, HR-TEM, nanomaterials, nanotechnology
- T. Kasama: electron holography, magnetotactic bacteria, physics of rocks and minerals
- C. Frandsen: self-assembled magnetic nanoparticles, Mossbauer spectroscopy
- R. Budhani: superconductivity, proximity effects, interplay with magnetism, Skyrmions
- E. Renstroem: life sciences, cellular biology, translational science
- A. Maigne: cryo-EM, e-beam/ice interactions
- S. Hettler: charge based phase plates

## LANGUAGE SKILLS

- Italian (native)      English (fluent)      German, Danish, Spanish, Japanese, French (beginner)

# LIST OF PUBLICATIONS

## PEER-REVIEWED JOURNALS

1. "Foucault imaging of superconducting fluxons". T. Yoshida, M. Beleggia, J. Endo, K. Harada, H. Kasai, T. Matsuda, G. Pozzi, A. Tonomura. *J. Appl. Phys.* **85**, 4096-4103 (1999).
2. "Recent results in the interpretation of Interference and Lorentz images of vortices in superconductors". M. Beleggia, S. Fanesi, R. Patti, G. Pozzi. *Mater. Charact.* **42**, 209-220 (1999).
3. "A model for the interpretation of holographic and Lorentz images of tilted reverse biased p-n junctions in a finite specimen". M. Beleggia, R. Capelli, G. Pozzi. *Philos. Mag. B* **80**, 1071-1082 (2000).
4. "Electron microscopy of reverse biased p-n junctions". M. Beleggia, D. Cristofori, P.G. Merli, G. Pozzi. *Micron* **31**, 231-236 (2000).
5. "Observation of superconducting vortices using advanced electron microscopy techniques". M. Beleggia, R. Patti, G. Pozzi, in *Superconducting materials, Advances in Technology and Applications*, World Scientific Press, Ed. A. Tampieri, G. Celotti (2000).
6. "On the calculation of the phase shift of superconducting fluxons: from the isolated to the lattice case". M. Beleggia and G. Pozzi. *Ultramicroscopy* **84**, 171-183 (2000).
7. "Observation of superconducting fluxons by transmission electron microscopy: a new Fourier space approach for calculating the electron optical phase shift". M. Beleggia and G. Pozzi. *Phys. Rev. B* **63**, 054507 (2001).
8. "Influence of the specimen surfaces on TEM images of reverse-biased p-n junctions". M. Beleggia, G.C. Cardinali, P.F. Fazzini, P.G. Merli, G. Pozzi. *Inst. Phys. Conf. Ser.* **169**, 427-430 (2001).
9. "Phase shift and phase-contrast images of pancake superconducting vortices". M. Beleggia and G. Pozzi. *J. Electron Microsc.* **51**, S73 (2002).
10. "Direct Evidence of the Anisotropic Structure of Vortices Interacting with Columnar Defects in High-Temperature Superconductors through the Analysis of Lorentz Images". O. Kamimura, H. Kasai, T. Akashi, T. Matsuda, K. Harada, J. Masuko, T. Yoshida, N. Osakabe, A. Tonomura, M. Beleggia, G. Pozzi, Y. Nakayama, J. Shimoyama, K. Kishio, T. Hanaguri, K. Kitazawa, M. Sasase, S. Okayasu. *J. Phys. Soc. Jpn.* **71**, 1840-1843 (2002).
11. "TEM phase contrast images of reverse-biased p-n junctions: the effect of charged oxide layers". M. Beleggia, P.F. Fazzini, P.G. Merli, G. Pozzi. *Microscopia elettronica* **23(2)**, 37-42 (2002).
12. "Interpretation of experimental Lorentz microscopy observations of superconducting vortices in high-temperature superconductors with columnar defects". M. Beleggia, G. Pozzi, J. Masuko, N. Osakabe, K. Harada, T. Yoshida, O. Kamimura, H. Kasai, T. Matsuda, A. Tonomura. *Phys. Rev. B* **66**, 174518 (2002).
13. "A Fourier approach to fields and electron optical phase shifts calculations". M. Beleggia, P.F. Fazzini, G. Pozzi. *Ultramicroscopy* **96**, 93-103 (2003).
14. "Influence of charged oxide layers on TEM imaging of reverse biased p-n junctions". M. Beleggia, P.F. Fazzini, P.G. Merli, G. Pozzi. *Phys. Rev. B* **67**, 045328 (2003).
15. "Electron-optical phase shift of magnetic nanoparticles, part I: basic concepts". M. Beleggia and Y. Zhu. *Philos. Mag.* **83**, 1045-1055 (2003).
16. "Electron-optical phase shift of magnetic nanoparticles, part II: polyhedral particles". M. Beleggia, Y. Zhu, S. Tandon, M. De Graef. *Philos. Mag.* **83**, 1143-1161 (2003).
17. "Profile structure of magnetic flux lines in type-II superconductor from a rectangular electron hologram". K. Harada, M. Beleggia, J. Endo, H. Kasai, Y. Togawa, T. Matsuda, A. Tonomura. *J. Electron Microsc.* **52(4)**, 369-373 (2003).
18. "Quantitative study of magnetic field distribution by electron holography and micromagnetic simulations". M. Beleggia, M.A. Schofield, Y. Zhu, M. Malac, Z. Liu, M. Freeman. *Appl. Phys. Lett.* **83**, 1435-1437 (2003).
19. "On the computation of the Demagnetization Tensor Field for an arbitrary particle shape using a Fourier space approach". M. Beleggia and M. De Graef. *J. Magn. Magn. Mater.* **263**, L1-L9 (2003).
20. "Atomic scale model of the grain boundary potential in Perovskite Oxides". R.F. Klie, M. Beleggia, Y. Zhu, J.P. Buban, N.D. Browning. *Phys. Rev. B* **68**, 214101 (2003).

21. "On the computation of the demagnetization tensor for uniformly magnetized particles of arbitrary shape. Part I: analytical approach". S. Tandon, M. Beleggia, Y. Zhu, M. De Graef. *J. Magn. Magn. Mater.* **271**, 9-26 (2004).
22. "On the computation of the demagnetization tensor for uniformly magnetized particles of arbitrary shape. Part II: numerical approach". S. Tandon, M. Beleggia, Y. Zhu, M. De Graef. *J. Magn. Magn. Mater.* **271**, 27-38 (2004).
23. "Modeling Superconducting vortices in High- $T_c$  materials for TEM observations". M. Beleggia, G. Pozzi, A. Tonomura. *J. Magn. Magn. Mater.* **272-276**, E143-E144 (2004).
24. "Electron optical phase shift of a Josephson vortex". M. Beleggia. *Phys. Rev. B* **69**, 014518 (2004).
25. "Direct evidence of negative grain boundary potential in Ca-doped and undoped  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ ". M.A. Schofield, M. Beleggia, Y. Zhu, K. Guth, C. Jooss. *Phys. Rev. Lett.* **92**, 195502 (2004).
26. "On the magnetostatic interactions between nanoparticles of arbitrary shape". M. Beleggia, S. Tandon, Y. Zhu, M. De Graef. *J. Magn. Magn. Mater.* **278**, 270-284 (2004).
27. "On the computation of the demagnetization tensor for particles of arbitrary shape". M. Beleggia, S. Tandon, Y. Zhu, M. De Graef. *J. Magn. Magn. Mater.* **272-276**, E1197-E1199 (2004).
28. "A Fourier Space Approach to the Computation of Magnetostatic Interactions between Arbitrarily Shaped Particles". M. Beleggia. *IEEE Trans. Mag.* **40**, 2149-2151 (2004).
29. "Direct measurements of electrostatic potentials at grain boundaries: mechanism for current improvement in high- $T_c$  superconductors". Ch. Joos, K. Guth, M.A. Schofield, M. Beleggia, Y. Zhu, *Phys. C* **408-410**, 443-444 (2004).
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40. "Demagnetization factors of the general ellipsoid: An alternative to the Maxwell approach". M. Beleggia, M. De Graef and Y.T. Millev. *Philos. Mag.* **86**, 2451-2466 (2006).
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83. "Environmental TEM study of electron beam induced electro-chemistry of Pr<sub>0.64</sub>Ca<sub>0.36</sub>MnO<sub>3</sub> catalyst for oxygen evolution". S. Mildner, M. Beleggia, D. Mierwaldt, T.W. Hansen, J.B. Wagner, S. Yazdi, T. Kasama, J. Ciston, Y. Zhu, Ch. Jooss. *J. Phys. Chem. C* **119**, 5301-5310 (2015).
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86. "Effect of magnetostatic interactions on the twin boundary motion in Ni-Mn-Ga magnetic shape memory alloys". V Kopecky, D. Vokoun, O. Heczko, M. Beleggia. *IEEE Mag. Lett.* **6**, 10002014 (2015).
87. "Local charge measurements with Electron Holography". M. Beleggia, L. Gontard, R.E. Dunin-Borkowski. *J. Phys. D: Appl. Phys.* **49**, 294003 (2016).
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89. "Computer simulations analysis for determining the polarity of charge generated by high energy electron irradiation of a thin film". M. Malac, S. Hettler, M. Hayashida, M. Kawasaki, Y. Konyuba, Y. Okura, H. Ijima, I. Ishikawa, M. Beleggia". *Micron* **100**, 10-22 (2017).
90. "Magnetic dipolar ordering and hysteresis of geometrically defined nanoparticle clusters", M. Kure, M. Beleggia, C. Frandsen. *J. Appl. Phys.* **122**, 133902 (2017).

91. "Organic ice resists". W. Tiddi, A. Elsukova, P. Liu, H. Thanh Le, M. Beleggia, A. Han. *Nanoletters* **17**, 7886-7891 (2017).
92. "Charging of carbon thin films in scanning and phase-plate transmission electron microscopy". S. Hettler, E. Kano, M. Dries, D. Gerthsen, L. Pfaffmann, M. Bruns, M. Beleggia, M. Malac. *Ultramicroscopy* **184**, 252 (2018).
93. "Organic ice resists for 3D electron-beam processing: instrumentation and operation". W. Tiddi, A. Elsukova, M. Beleggia, A. Han. *Microel. Eng.* **192**, 38-43 (2018).
94. "Tunable Ampere phase plate for low-dose imaging of biomolecular complexes", A. H. Tavabi, M. Beleggia, V. Migunov, A. Savenko, O. Oktem, R.E. Dunin-Borkowski, G. Pozzi. *Scientific Reports* **8**, 5592 (2018).
95. "Strategies of phase resolution improvement and artifact removal in measurements of projected charge distribution by off-axis electron holography". F. Zheng, V. Migunov, M. Beleggia, U. Ramsperfer, D. Pescia, R.E. Dunin-Borkowski. *Ultramicroscopy*, submitted (2018).
96. "Effect of molecular weight on the feature size in organic ice resists". A. Elsukova, D. Zhao, A. Han, M. Beleggia. *Nanoletters* **18**, 7576-7582 (2018).
97. "Improved measurement scheme for mapping nanoscale charge distributions by off-axis electron holography". F. Zheng, V. Migunov, M. Beleggia, U. Ramsperger, D. Pescia, R.E. Dunin-Borkowski. *Ultramicroscopy*, submitted (2018).
98. "Quantification of mixed Bloch/Neel topological spin textures stabilized by the Dzyaloshinskii-Moriya interaction in Co/Pd multilayers". J.A. Garlow, S.D. Pollard, M. Beleggia, T. Dutta, H. Yang, Y. Zhu. *Phys. Rev. Lett.* submitted (2018).
99. "Optical property – composition correlation in noble metal alloy nanoparticles studies with EELS". S. Kadkhodazadeh, F.A.A. Nugroho, C. Langhammer, M. Beleggia, J.B. Wagner. *ACS Photonics*, submitted (2018).
100. "The mean inner potential of liquid water". M.N. Yesibolati, S. Lagana, H. Sun, M. Beleggia, S.M. Kathmann, T. Kasama, K. Mølhav. *Science Advances*, in preparation (2019).
101. "Intracellular manipulation of magnetic nanoparticles with Low frequency dynamic fields", M. Beleggia, K. Heussen, M. Koch, E. Zhang, M. Kircher, E. Renstroem. *J. Appl. Phys.*, in preparation (2019).

### **BOOKS – BOOK CHAPTERS – INVITED REVIEW ARTICLES – Ph.D THESIS**

102. "Transmission Electron Microscopy observation of Electromagnetic fields". M. Beleggia. *Ph.D. thesis*. University of Bologna, Italy (2001).
103. "Magnetic phase imaging with transmission electron microscopy". M. Beleggia and Y. Zhu. Chapter 7 in *Modern techniques for characterizing magnetic materials*, Y. Zhu (Editor), Kluwer academic, 2005.
104. "Electron holography of electromagnetic fields: recent theoretical advances". M. Beleggia, G. Pozzi, A. Tonomura. Chapter (TBD) in *Introduction to Electron Holography, Vol. 2*, E. Voelkl (Editor), submitted for publication in 2010 (publication of this book is currently on hold).
105. "Electron Holography of magnetic materials". T. Kasama, M. Beleggia, R.E. Dunin-Borkowski. Chapter 3 in *Holography – Different Fields of Application*, F.A. Monroy Ramirez (Editor), Intech, 2011.
106. "Lorentz microscopy and electron holography of magnetic materials". R.E. Dunin-Borkowski, T. Kasama, M. Beleggia, G. Pozzi. Chapter 6 in *Handbook of Nanoscopy*, pp 221-251, G. van Tendeloo, D. van Dyck, S. Pennycook (Editors), Wiley-VCH, 2012.
107. "Phase computations for Electron Holography of nanostructured magnetic materials". M. Beleggia. *Microscopie*, Anno IV - n. 1 (7), 37-47 (2007).
108. "Characterization of the JEM-2100F-LM TEM for Electron Holography and Magnetic Imaging". M.A. Schofield, M. Beleggia, J.W. Lau, Y. Zhu. *JEOL News* **42**, 2-7 (2007).
109. "The Physics of Shape". M. De Graef and M. Beleggia. Contract signed with World Scientific Publishing. Book in progress. Deadline: Apr 2021.
110. "ETEM studies of electrodes and electrocatalysts". Ch. Jooss, S. Mildner, M. Beleggia, D. Mierwaldt, V. Roddatis. Chapter 11 in *Controlled Atmosphere Transmission Electron Microscopy*, J.B. Wagner and T.W. Hansen (Eds.), Springer (2016).
111. "Gas-electron Interaction in the ETEM". J.B. Wagner, M. Beleggia. Chapter 3 in *Controlled Atmosphere Transmission Electron Microscopy*, J.B. Wagner and T.W. Hansen (Eds.), Springer (2016).

## INVITED TALKS and SEMINARS

- t1. "Dipolar Interactions and Shape Anisotropy in Magnetic Nanoparticles". M. Beleggia. Physics Department and National Institute for Nanotechnology, University of Alberta, Edmonton, Canada. August 8, 2003, [invited seminar](#) (hosts: Prof. M. Freeman and Dr. M. Malac).
- t2. "Dipolar Interactions and Shape Anisotropy in Magnetic Nanoparticles. Recent Developments of the Fourier-space approach for phase computations". M. Beleggia. Physics Department, University of Bologna, Italy, December 12, 2003, [invited seminar](#) (host: Prof. G. Pozzi).
- t3. "Observation of Dipolar Ferromagnetism by TEM techniques". M. Beleggia, S. Tandon, Y. Zhu and M. De Graef. Conf. of the Microscopy Society of America, Savannah, GA, Aug. 1-5, 2004, [invited talk](#).
- t4. "Characterization of artificially patterned arrays of magnetic elements by Transmission Electron Microscopy", M. Beleggia, Meeting of the National Institute for the Physics of Matter, Genova, Italy, June 8-10, 2004, [invited talk](#).
- t5. "Transmission Electron Microscopy of Vortices in Superconducting Materials". M. Beleggia. Iowa State University, Physics Department, April 15<sup>th</sup>, 2005, [invited seminar](#) (host: Prof. J.R. Clem).
- t6. "The phase diagram for magnetic nano-rings". M. Beleggia, J.W. Lau, M.A. Schofield, Y. Zhu, S. Tandon and M. De Graef. The Min., Met. & Mat. Society Annual Meeting, San Francisco, CA, Feb. 13-17, 2005, [invited talk](#).
- t7. "Electron Holography of magnetic nanostructures", M. Beleggia, J.W. Lau, M.A. Schofield and Y. Zhu. Microscopy Conference 2005, Davos, Switzerland, Aug 28-Sep 2, 2005, [invited talk](#).
- t8. "Electron Holography: how to explore the nanoworld with coherent electrons". M. Beleggia. National Institute for Nanotechnology, Edmonton, Canada. July 29, 2006, [invited seminar](#) (host: Dr. M. Malac).
- t9. "Magnetic phenomena at the nanoscale revealed by Electron Holography". M. Beleggia. Hitachi Advanced Research Laboratory, Hatoyama, Saitama, Japan. August 31, 2006, [invited talk](#) (host: Dr. K. Harada).
- t10. "Observing nanoscale phenomena with coherent electrons". M. Beleggia. University of Göttingen, Germany. December 18, 2006, [invited seminar](#) (host: Prof. Dr. Schönhammer).
- t11. "Electron Holography: a technique to explore the nanoworld". M. Beleggia. University of Leeds, UK. May 9, 2007, [invited seminar](#) (host: Prof. R. Brydson).
- t12. "Advanced Electron Microscopy and Holography: coherent electrons as a quantitative link to the physics of nanomaterials". M. Beleggia. U. of Antwerp, Belgium. Aug 28, 2007, [invited seminar](#) (host: Prof. G. Van Tendeloo).
- t13. "Electron phase retrieval with application to nanomaterials". M. Beleggia. University of Oxford, UK. Jan 21, 2008, [invited seminar](#) (host: Dr. A. Kohn).
- t14. "Phase contrast/retrieval as a quantitative link to the physics of nanomaterials". M. Beleggia. U. of Cambridge, UK. Feb 19, 2008, [invited seminar](#) (host: Dr. J. Barnard).
- t15. "Modelling the electron-optical phase shift: a quantitative link to the physics of nanomaterials". Denmark Technical University, Copenhagen, Denmark. Apr 14, 2008, [invited seminar](#) (host: Dr. R.E. Dunin-Borkowski).
- t16. "The electron phase and the physics of nanomaterials". INT-Karlsruhe, Germany, Apr 24, 2008, [invited seminar](#) (host: Prof. Dr. H. Hahn).
- t17. "Imaging shape effects in nanomagnetism with electrons". Risø DTU, Denmark, May 25, 2010, [invited seminar](#) (host: Dr. N. Pryds).
- t18. "Electron holography of magnetic nanostructures". U. Hamburg, Germany, Nov 2, 2010, [invited physics colloquium](#) (host: Prof. Dr. R. Wiesendanger).
- t19. "Electron holography: an extra set of eyes to probe the physics of nanomaterials". Humboldt University, Berlin, Germany, June 20, 2011, [invited seminar](#) (host: Prof. Dr. S. Fischer).
- t20. "Quantitative electron imaging of nanoscale potentials". Humboldt University, Berlin, Germany, June 8, 2012, [invited seminar](#) (host: Prof. Dr. J.P. Rabe).
- t21. "Practical hole-free phase plate imaging: advantages and pitfalls". M. Malac, M. Bergen, M. Kawasaki, M. Beleggia, R. Egerton, M. Shimizu, H. Furukawa. M&M meeting 2012, Phoenix AZ, USA, Aug 2, 2012, [invited talk](#).
- t22. "Electron holography of magnetic materials: state-of-the-art and future perspectives". M. Beleggia. MC 2013 conference, Regensburg, Germany, Aug 28, 2013, [invited talk](#).

- t23. "Quantitative mapping of nanoscale charge distributions in electronic nanostructures with advanced electron microscopy". M. Beleggia, Helmholtz Zentrum Berlin, Germany, Nov 28, 2013, [invited seminar](#) (host: Dr. S. Christensen).
- t24. "Dipolar ordering in self-assembled nanoparticle magnets revealed by electron holography". M. Beleggia, M. Varon, T. Kasama, V. Puentes, R.E. Dunin-Borkowski, R.J. Harrison, C. Frandsen. MRS Fall meeting 2013, Boston, USA, Dec 2, 2013, [invited talk](#).
- t25. "Quantitative mapping of nanoscale charge distributions in electronic nanostructures with advanced electron microscopy". M. Beleggia, HZB, Berlin, Germany, Nov 28, 2013, [invited seminar](#) (host: Prof. Dr. S. Christensen).
- t26. "Measuring nanoscale charge and spin distributions with electron holography: the quantitative link between structure and functionality". M. Beleggia, LMU, Munich, Germany, Dec 9, 2013, [invited seminar](#) (host: Prof. Dr. T. Bein)
- t27. "Interpretation of holographic phase shifts from polar interfaces, ferroelectric nanostructures and charged materials". M. Beleggia, Microscopy Conference, Goettingen, Sep 2015, [invited talk](#).
- t28. "Modelling holographic signals from ferroelectric nanostructures and polar interfaces". M. Beleggia, FEMMS conference, Lake Tahoe, Sep 2015, [invited talk](#).
- t29. "Measuring nanoscale charge and spin distributions with electron holography: the quantitative link between structure and functionality". M. Beleggia, University of Wuerzburg, Germany, Jan 13, 2016, [invited seminar](#) (host: Prof. Dr. M. Bode)
- t30. "Dember potentials on e-beam irradiated thin-films". M. Beleggia, AMTC5 conference, Nagoya, Japan, May 11-13, 2016, [invited talk](#).
- t31. "Phase plates: new designs and concepts". M. Beleggia, WE-Heraeus workshop, Bonn, Germany, Jun 19-23, 2016, [invited talk](#).
- t32. "Remote manipulation of intracellular magnetic nanoparticles for biomedical applications". M. Beleggia, IMFUFA seminar, Roskilde University, Denmark, Nov 23, 2016, [invited physics colloquium](#) (host: Dr. N. Bailey).
- t33. "Model independent measurement of multipole fields". M. Beleggia, Electron Holography Workshop, Feb 13-15, 2017, Saitama, Japan, [invited talk](#).
- t34. "Electron holography measurements of magnetic multipole and toroidal moments". Electronic phenomena studied in the nordic countries, Jul 3-5, 2017, Lund, Sweden, [invited talk](#).
- t35. "Magnetism of nanoparticle superstructures revealed by electron holography". NIST, USA, Dec 10, 2018, [invited seminar](#) (host: Dr. J. Lau).

### CONFERENCE PROCEEDINGS

- c1. "Experiments on Foucault images of superconducting fluxons". T. Yoshida, J. Endo, K. Harada, H. Kasai, T. Matsuda, M. Beleggia, G. Pozzi, A. Tonomura. *Microsc. Microanal.* **3**, Suppl. 2, 507-508 (1997).
- c2. "Theoretical Foucault images of superconducting fluxons". M. Beleggia, G. Pozzi, K. Harada, H. Kasai, T. Matsuda, T. Yoshida, A. Tonomura. *Microsc. Microanal.* **3**, Suppl. 2, 509-511 (1997).
- c3. "One-dimensional theoretical Foucault images of superconducting fluxons". M. Beleggia, G. Pozzi, J. E. Bonevich, K. Harada, H. Kasai, T. Matsuda, T. Yoshida, A. Tonomura, Proc. 11th Eur. Congr. on El. Micr., Electron Microscopy **96(2)**, Comm. of Eur. Soc. of Micr. Publ. - Brussels, 105-106 (1998).
- c4. "Theoretical coherent Foucault images of fluxon lattice", M. Beleggia, G. Pozzi, K. Harada, H. Kasai, T. Matsuda, T. Yoshida. A. Tonomura. *Electron Microscopy 1998*, vol 2, Mat. Science 1, 531-532 (1998).
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