

Curriculum Vitae:

Andreas J. Heinrich

Heinrich is a world-leading researcher in the field of atomic-scale science in solids. He pioneered spin excitation spectroscopy with scanning tunneling microscopes – a method that has provided high-resolution access to the quantum states of atoms and nanostructures on surfaces. He has a track record of outstanding publications and invited talks and has established a strong network of global collaborations. Through Heinrich's leadership role in IBM Research he is uniquely positioned to bridge the needs of industrial research and the academic world. Heinrich is a frequent presenter to corporate and political leaders, such as the president of Israel, top US and European government officials as well as top corporate leaders including the IBM Board of Directors. Heinrich's work has received extensive media coverage worldwide.

Academic Degrees

1998	PhD Physics, University of Göttingen, Germany
1994	Masters (Diplom), University of Göttingen, Germany

Employment

2016-present	Distinguished Professor at Ewha Womans University Director of the Institute of Basic Science Center for Quantum Nanoscience
2004 – 2016	Research Staff Member at IBM Almaden
Since 2005	Group leader on scanning probe microscopy and magnetic nanostructures on surfaces. Kavli Prize laureate D.M. Eigler transferred leadership of the STM lab to Heinrich in January 2005.
2001 - 2004	Researcher / Engineer at IBM Almaden
1998 – 2001	Postdoc at IBM Almaden with D.M. Eigler
1994 – 1998	Research Assistant, University of Göttingen (R.G. Ulbrich, Supervisor)

I. Scientific Impact

Spin excitation spectroscopy

In 2004, Heinrich created the field of atomic scale spectroscopy of magnetic atoms on surfaces and has grown it to international prominence in the following decade.

Key milestones:

- Design and construction of a novel scanning tunneling microscope for temperatures below 1 Kelvin and high magnetic fields – specifically built to investigate single-atom electron loss spectroscopy on magnetic atoms. This microscope was the first of its kind in the world.
- First to achieve single atom spin-excitation spectroscopy with his STM measurement of the Zeeman splitting of individual atoms on surfaces (*Science* 2004).
- Groundbreaking achievements with spin excitation spectroscopy include the measurement of single atom magnetic anisotropy (*Science* 2007), spin-spin coupling in engineered chains (*Science* 2006), and the Kondo effect (*Nature Physics* 2008).
- Developed nanosecond scanning tunneling microscopy (STM) (*Science* 2010), an improvement in time resolution of 100,000 times.
- Demonstrated atomic-scale magnetic data storage (*Science* 2012), which led to world-wide coverage in scientific and general media.
- Combined spin excitation spectroscopy with x-ray absorption spectroscopy (*Science* 2014).
- Following these publications, prominent international groups have utilized spin excitation spectroscopy as a major part of their efforts, including the Xue group in Beijing, the Kawai group in Tokyo, and the Wiesendanger group in Germany.
- Heinrich has given 10 plenary lecture and over 65 invited talks at major international conferences. He has given more than 80 seminar and colloquium talks at universities and international research institutions.

Precise atom manipulation

In addition to these groundbreaking accomplishments, Heinrich has built on the pioneering achievements of his predecessor, Dr. D.M. Eigler, in the area of precise atom manipulation on surfaces by constructing model devices for possible future applications in data storage and computation.

Precise atom manipulation (continued)

Key milestones:

- Development of a technique to control the motion of CO molecules on surfaces. Application of such processes to perform arbitrary logic operations via mechanical computations (*Science* 2002).
- Construction of a state-of-the-art low-temperature atomic force microscope in close collaboration with Professor Franz Giessibl (Regensburg) with atomic resolution.
- Published a fundamentally new technique for measuring the atomic forces that act on atoms and molecules on surfaces. Applied of this technique to measure the force it takes to move atoms and molecules on surfaces (*Science* 2008).
- Construction of complex nanostructures for atomic-scale magnetic data storage.
- Creation of the World's smallest movie 'A Boy and His Atom' with about 10,000 precise atom moves (YouTube 2013).

Selected Publications - Spin excitation spectroscopy

- Ileana G. Rau, Susanne Baumann, ... , Barbara Jones, Pietro Gambardella, Andreas J. Heinrich, and Harald Brune, "Reaching the Magnetic Anisotropy Limit of a 3d Metal Atom", ***Science*** 344, 988 (2014).
- Sebastian Loth, Susanne Baumann, Christopher P. Lutz, D. M. Eigler, and Andreas J. Heinrich, "Bistability in Atomic-Scale Antiferromagnets", ***Science*** 335, 196 (2012).
- S. Loth, M. Etzkorn, C.P. Lutz, D.M. Eigler, A.J. Heinrich, "Measurement of Fast Electron Spin Relaxation Times with Atomic Resolution", ***Science*** 329,1628 (2010).
- S. Loth, K. von Bergmann, M. Ternes, C.P. Lutz, A.J. Heinrich, "Quantized spin momentum transfer in atomic-scale magnetic devices", ***Nature Physics*** 6, 340 (2010).
- A.F. Otte, M. Ternes, K. von Bergmann, S. Loth, H. Brune, C.P. Lutz, C.F. Hirjibehedin, A.J. Heinrich, "The role of magnetic anisotropy in the Kondo effect", ***Nature Physics*** 4, 847 (2008).
- C.F. Hirjibehedin, C.-Y. Lin, A.F. Otte, M. Ternes, C.P. Lutz, B.A. Jones, A.J. Heinrich, "Large Magnetic Anisotropy of a Single Atomic Spin Embedded in a Surface Molecular Network", ***Science*** 317, 1199 (2007).
- C.F. Hirjibehedin, C.P. Lutz, A.J. Heinrich, "Spin-coupling in engineered atomic structures", ***Science*** 312, 1021 (2006).
- A.J. Heinrich, J.A. Gupta, C.P. Lutz, and D.M. Eigler, "Single-atom spin-flip spectroscopy", ***Science*** 306, 466 (2004).

Selected Publications – Precise atom manipulation

- Markus Ternes, Cesar Gonzalez, Christopher P. Lutz, Prokop Hapala, Franz J. Giessibl, Pavel Jelinek, and Andreas J. Heinrich, "Interplay of Conductance, Force, and Structural Change in Metallic Point Contacts", ***Phys. Rev. Lett.*** 106, 016802 (2011).
- M. Ternes, C.P. Lutz, C.F. Hirjibehedin, F.J. Giessibl, A.J. Heinrich, "The Force Needed to Move an Atom on a Surface", ***Science*** 319, 1066 (2008).
- A.J. Heinrich, J.A. Gupta, C.P. Lutz, and D.M. Eigler, "Molecule cascades", ***Science*** 298, 1381 (2002).

II. Recognition

Awards and plenary lectures

- 2014 Outstanding Technical Achievement Award, IBM:
For the creation of the scientific movie 'A Boy and his Atom' and the resulting public engagement with IBM basic science research.
- 2014 Plenary lecture at Dutch Physical Society Meeting, Veldhoven, The Netherlands:
'A Brief History of Atom Manipulation'.
- 2012 Fellow of the American Physics Society:
For the development of spin excitation spectroscopy and nanosecond STM.
- 2012 Plenary lecture at International Conference on Nanoscale Science and Technology (ICNT 2012), Paris, France:
'Quantum or Classic: An atomic-scale perspective on magnetism on surfaces'.
- 2011 Best of IBM Award (top 100 annual contributors out of 430,000 employees):
For Atomic Scale Manipulation and Chemistry on Surfaces.
- 2011 Corporate Award, IBM:
For Atomic Scale Manipulation and Chemistry on Surfaces.
- 2011 Plenary lecture at German Physical Society Meeting, Dresden, Germany:
'Probing the energetics and dynamics of individual atomic spins on surfaces'.
- 2010 Outstanding Technical Achievement Award, IBM:
For the development of a technique for measuring atomic forces during the manipulation of atoms on surfaces.
- 2010 Plenary lecture at International Vacuum Congress (IVC 18), Beijing, China:
'Nanosecond STM and quantum tunneling of magnetization'.
- 2009 Zhong-Guan Cun Forum at Institute of Physics, Chinese Academy of Sciences:
'An atomic-scale look at magnetic nanostructures on surfaces'.
- 2007 Outstanding Innovation Award, IBM:
For the development of a scanning tunneling microscope for the investigation and atomic-scale construction of magnetic nanostructures.
- 2006 Plenary lecture at California Section of the American Physical Society, Long Beach, CA, USA:
'Magnetism Revisited on the Atomic Scale'.

Recognition (continued)

- 2003 Research Division Award, IBM:
For the development of molecule cascades, a novel concept for information processing on the atomic scale.
- 2005 Plenary lecture at International Conference on Scanning Probe Microscopy and Related Techniques (SPM'13), Sapporo, Japan: 'Inelastic STM spectroscopy at Low Temperatures'.
- 2005 Plenary lecture at 32nd Annual Meeting of Canadian Microscopy Society, Hamilton, Canada: 'Scanning Tunneling Microscopy'.
- 2003 Plenary lecture at International Conference on Scanning Probe Microscopy and Related Techniques (SPM'12), Eindhoven, The Netherlands: 'Molecule Cascades: Concepts and Applications'.
- 2003 Plenary lecture at Spring Meeting of German Physical Society, Dresden, Germany: 'The STM as a Hand in the Nanoworld'.
- 1998 Feodor Lynen scholarship, the Alexander von Humboldt-Foundation, Germany:
Funded postdoctoral research at IBM.

Scientific Advisory Boards

- 2012 - 2016 Scientific Advisory Board of Max Planck Institute for Solid State Research, Stuttgart, Germany.

World-wide collaborations

Heinrich has established a reputation as a world-class destination for top scientists to perform research on magnetic nanostructures. He receives many more requests for postdoc positions than he has openings. Examples of senior collaborators include:

- Prof. Harald Brune, EPF Lausanne, Switzerland (6 month stay)
- Prof. Franz Giessibl, U. Regensburg, Germany (6 month stay)
- Dr. Kirstin v. Bergmann, U. of Hamburg, Germany (6 month stay)
- Dr. Karl-Heinz Ernst, EMPA Zurich, Switzerland (6 month stay)
- Prof. Sander Otte, Delft U., The Netherlands (6 month stay)
- Prof. Thomas Greber, U. of Zurich, Switzerland (1 month stay)

Teaching experience

- Master's student Sunday lecture at Dutch Physical Society Meeting "Spins on surfaces: a Master Class", Veldhoven, The Netherlands, January 2014.
- Invited lecturer at Heini Rohrer Memorial Symposium "A Brief History of Atom Manipulation", Zurich, Switzerland, November 2013.
- Invited lecturer at Nanoscience Summer School "An atomic-scale view of spins on surfaces", Montreal, Canada, May 2012.
- Visiting Professor at Physics Department, Tsinghua University, Beijing, China, June –July 2011.
- Invited lecturer at Quantum Nanoscience Winterschool "Energetics and dynamics of spins on surfaces", Crans Montana, Switzerland, March 2011.
- Invited Lecturer at Advanced Study Institute (ASI) "Advanced Microscopies", Hong Kong, December 2008.
- Invited Lecturer at 5th International Wilhelm and Else Heraeus Summer School „Molecules: Building Blocks for Future Nanoelectronics“, Wittenberg, Germany, August 2004.

International placement of former apprentices

Many former team members of Heinrich's team have moved to leadership positions in academic research, including:

- Independent group leader at Max Planck Society in Hamburg, Germany
- Associate professor at Ohio State University, USA
- Reader at University College London and London Center for Nanotechnology, Great Britain
- Researcher at Max Planck Society in Stuttgart, Germany
- Assistant professor in Delft, The Netherlands

III. Global leadership

Heinrich has built an extensive network of international collaborators through his work and high-level presentations. International political and business leaders seek his insight on creativity and the future of basic and applied research.

Leadership within IBM Research

Heinrich has taken an active role in developing the research strategy of IBM in the areas of nanoscience and magnetic data storage.

- 2012: participant in task force for the future of magnetic data storage and application of advanced research results.
- 2013: driver of IBM engagement with Ogilvy&Mather (PR and marketing firm) for the corporate promotion of the movie 'A Boy and his Atom', which resulted in a Gold Lion Award for marketing excellence.

Engagements with global political leaders

Heinrich has been approached on multiple occasions by global political leaders for his input on the future applications of basic science research. Examples include:

- 2012: Visit by the president of Israel, Shimon Peres, to IBM Almaden with his stated goal of learning about atomic-level magnetic data storage. This visit was requested of Heinrich by the Israeli consulate after officials there read coverage of his work in the New York Times.
- 2014: Presentation to and discussions with 12 members of German Parliament on a visit to Silicon Valley.
- Several times each year, IBM has asked Heinrich to give presentations and tours of his laboratory to US elected and government officials.

High-level interactions with business leaders

An important role of Heinrich's lab at IBM Almaden is to deeply impress visiting business leaders with IBM's thought leadership in the future of the IT industry. After over a decade and hundreds of such visits, Heinrich is exceptionally good at interacting with global leaders on any level of technical detail.

- 2014: Visit of 10 members of the IBM Board of Directors to Heinrich's lab, including the CEOs of IBM, American Express, United Parcel Service, Dow Chemical, Boeing, and Caterpillar, as well as the presidents of the Salk and the Rensselaer Polytechnic Institutes. Heinrich presented past work on magnetic data storage and future work on quantum computing.
- 2013: Visit of institutional IBM Investors to IBM Almaden and to Heinrich's lab. Heinrich presented his work on the scaling limits of magnetic data storage.
- IBM brings business visitors to Heinrich's lab on an almost weekly basis. Heinrich has the opportunity to convince them of IBM's deep engagement in the future of the IT industry, with the goal of having them choose IBM over our competitors for our business offerings.

Public Outreach

- Production and publication of the world's smallest movie 'A Boy and his Atom' on YouTube (a viral phenomenon with over 5 million views) in May 2013. Significant press coverage and interviews with Heinrich in all major global media.
- Plenary lecture with IBM VP John Kennedy at Cannes Festival of Innovation (Cannes, France, 2013). We received a Gold Lion award in the category of 'Branded Entertainment' for 'A Boy'.
- General audience talks about nanoscience at Next Fest (New York, 2006) and at Epcot Center (Florida, 2013) including remote atom manipulation, giving a general audience the chance to experience the thrill of building atomic-scale structures.
- Opening lecture at Future of Story Telling Workshop (New York, 2013), an international conference focused on creativity for business leaders.