Magnetism revealed on the atomic scale

30 Years of
Spin-Polarized Scanning Tunneling Microscopy

In 1990 our first paper on (room-temperature) Spin-Polarized Scanning Tunneling Microscopy (SP-STM) appeared in the journal „Physical Review Letters“ combining the atomic-resolution imaging capabilities of STM, as pioneered by Gerd Binnig, Heinrich Rohrer, and Christoph Gerber in the early eighties, with the concept of spin-dependent tunneling due to the tunneling magnetoresistance effect, as first reported by M. Jullière mid of the seventies based on low-temperature experiments.

Since 1990, SP-STM and related techniques, such as spin-polarized scanning tunneling spectroscopy (SP-STS), time-resolved SP-STM, magnetic exchange force microscopy/spectroscopy (MExFM), single-atom magnetometry, spin friction microscopy, spin-polarized scanning field emission microscopy/spectroscopy, and magneto-Seebeck-STM, which were subsequently developed by our group in Hamburg, provided unprecedented insight into atomic-scale spin textures and magnetic phenomena down to the atomic level. Moreover, numerous discoveries were made by our group based on the application of SP-STM to ultrathin magnetic films, magnetic nanostructures, or even single magnetic atoms and molecules on surfaces, including the discoveries of chiral magnetic domain walls, chiral spin spirals and single chiral magnetic skyrmions. The distance and orientational dependence of fundamental magnetic interactions, such as indirect magnetic exchange (RKKY) interactions or Dzyaloshinskii-Moriya interactions could be studied for the first time down to the atomic-scale. Spin-dependent electronic states, such as exchange-split surface states, spin-split Landau states, spin-split Kondo states, spin-split Shiba states, and spin-split molecular states were revealed at the atomic level by our group based on atomic-resolution SP-STS studies. Based on the ultimate combination of SP-STM with STM-based single atom manipulation, as pioneered by Don Eigler and coworkers in the early nineties, we could demonstrate the tailoring of magnetic nanostructures at the atomic level, leading to the first prototype all-spin atomic-scale logic device and, most recently, to the unambiguous observation of Majorana states in artificially constructured atomic spin chains on elemental superconducting substrates.

Our work on SP-STM in the past 30 years has been published in about 180 papers which are listed below for your convenience. If you have any questions on the SP-STM technique and its applications, please do not hesitate to contact us.

Further Information

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Publications on SPSTM from our group in the past 30 years:

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