

Professor Dr. Knut Urban

65 Years



Driven by ambition, inventiveness and personal momentum, Knut Urban may be more active and more visible than ever, despite the biological fact which we are celebrating together with him and to which this special issue is devoted. Born in Stuttgart on June 25th 1941, he grew up in a Swabian environment, which may have shaped him for the rest of his life and has given him this unique combination of professional persistence on the one hand, and his appreciation for arts, literature, and music, but also a good glass of red wine, on the other.

Knut Urban studied physics at the University of Stuttgart and then went to the Max-Planck-Institut für Metallforschung in Stuttgart to perform his doctoral thesis work under the supervision and guidance of Professors Alfred Seeger and Manfred Wilkens. Stimulated by the extraordinary scientific environment at the MPI, his personal career began and was always centred around new and challenging effects in solid state physics and transmission electron microscopy, the latter being his main experimental tool. His early studies on radiation-induced defects and diffusion in metals brought him together with Professor Ernst Ruska (Noble Prize Winner for Physics in 1986). Acting on Ruska's advice, Knut Urban designed and built a high-resolution helium-cooled specimen stage for the high-voltage electron microscope at the MPI in Stuttgart. His pioneering work on the application of electron-irradiation-induced phenomena formed the basis for the study of new physical effects in many metals and alloys. He was the first to notice that the interplay of defect formation with radiation induced or thermally assisted diffusion makes it possible to study a broad range of fundamental effects in solid state physics, such as highly dissipative order–disorder transitions.

Major foundations for his scientific development, which can be seen to influence his work up to the present day, were also laid during two visits as a guest scientist – one at the Metallurgy Section of Saclay Nuclear Research Centre in Paris, France, in 1980/81, where he collaborated with Professors Yves Adda and Georges Martin, and the other at the Physical Metallurgy Division at Bhabha Atomic Research Centre in Bombay, India, in 1982 (supported by the Alexander von Humboldt foundation). At Saclay, he learned to appreciate the power and the significance of theoretical methods in predicting and evaluating new physical effects. At the Bhabha Research Centre he started an on-

going collaboration with Professor Srikumar Banerjee, with whom he worked on ordering phenomena in Ni–Mo and related alloys. Based on the theoretical predictions in work by De Fontaine and others, Knut Urban was able to obtain the first experimental evidence for spinodal ordering in these alloys, and thus of the presence of a second-order structural phase transition.

During his entire scientific career, Knut Urban had a gifted ability to identify the importance of novel scientific areas and to employ his intellectual and experimental skills to make decisive contributions to the development of these fields. One particular example is his work in the field of quasicrystals, which he entered shortly after their discovery in 1984 by Dan Shechtman. By applying his low-temperature irradiation techniques, Urban was able to amorphise a quasicrystalline phase and to demonstrate that the quasicrystalline and not the stable crystalline phase forms upon annealing of these amorphised areas. With these experiments, he was able to show that the quasicrystalline phase is energetically favourable under the given conditions and is not just based on a quenched-in order from the liquid state. Another highlight in his work in this field was the discovery of dislocations in decagonal quasicrystals. Together with Denis Gratias from Paris, Urban also developed the first theory for quantitative dislocation analysis in icosahedral quasicrystals by diffraction contrast experiments in the transmission electron microscope. By growing large single quasicrystals, Urban and his co-workers were able to extend this work to the high-temperature plasticity of quasicrystals, which triggered a large range of theoretical and experimental work by other groups. Consistently pushing for new advances, he became the pioneer of the new field of Complex Metallic Alloys, which combine a quasicrystal-like short range order within giant unit cells possessing the periodic long range order of ordinary crystals. The key expectation is that the combination of these two ordering phenomena on different length scales may lead to unusual combinations of properties, paving the way to important future technological applications.

Another example of Knut Urban's constant striving for exploring new fields is his involvement in high-temperature superconductivity. Based on his broad expertise in solid state and low-temperature physics, he began with the first low-temperature in situ experiments on the new high- T_c

phases right after their discovery in 1986. Within a few years he built up a strong group focusing on Josephson effects in $\text{YBa}_2\text{Cu}_3\text{O}_7$ and related phases. Taking advantage of his experience in high-resolution transmission electron microscopy, Urban and his collaborators developed extraordinarily efficient Josephson junction geometries, which they recently applied to build SQUIDs (superconducting quantum interference devices) with the highest performance to date, which have also been marketed commercially. Another great achievement in this field is the use of the ac-Josephson effect to develop high-performance Hilbert Transformation Spectroscopy, which is now, for example, in operation at the TESLA accelerator test facility at DESY, Hamburg, in an advanced electron beam diagnosis system to detect fast particle transition radiation.

Even though Knut Urban was always more of a solid state physicist than an electron microscopist, his personal achievement with the highest impact may prove to be his constant and active support of the development and the application of aberration correction in transmission electron microscopy. As early as 1989, he teamed up with Harald Rose from the Technical University of Darmstadt and Max Haider, then working at the European Molecular Biology Laboratory at Heidelberg. Together they applied for a project for the realisation of the world's first corrector for spherical aberration for a transmission electron microscope. Funded by the Volkswagen foundation, they subsequently built the first hexapole-based aberration correction system and incorporated it in a Philips 200 kV instrument which was moved to Knut Urban's institute in 2001. In pioneering applications, Knut Urban and his collaborators were able to show that the new possibilities offered by such an instrument would revolutionise microscopy and make it an indispensable tool for any type of scientific application. In a systematic evaluation of the possible imaging modes, they found that overcorrecting the spherical aberration and setting it to a slightly negative value – the so-called NCSI-technique (negative Cs imaging) – produces an image contrast in high-resolution images such that all atomic columns appear bright on a dark background. They also found that in oxides the oxygen columns produce sufficient contrast to be clearly visible in the images. Knut Urban and his collaborators were thus the first to image and to perform a quantitative analysis on the oxygen sublattice in oxidic materials. In view of the vast improvement which can be achieved with these new correctors, all major TEM manufacturers today offer instruments which are equipped with such a corrector for spherical aberration.

For Knut Urban, scientific achievements and new developments were always the main driving factors. Needless to say, his scientific excellence and ambitions also gave rise to an extraordinary professional career. In 1986 he was appointed Professor and head of the new transmission electron microscopy facility at the University of Erlangen-Nürnberg. Only one year later, in 1987, he was appointed director of the newly founded Institute of Microstructure Research at the Department of Solid State Research at Research Centre Jülich and Professor of Experimental Physics at RWTH Aachen University. Based on his success with aberration-corrected transmission electron microscopy, he also took the initiative in creating a new centre providing access to such special, yet very expensive instruments to a much broader community. In January 2004, the Research Centre Jülich and RWTH Aachen University jointly founded the *Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons*, a German national user facility for atomic resolution transmission electron microscopy. As a director of this new centre, Knut Urban has always emphasised the role that universities should play in such a development and thus he has created a politically very well received model for a joint competence platform. With support from the German Research Foundation and the Helmholtz-Society, two new instruments have just been installed at the new centre in its location at the Research Centre Jülich. Equipped with correctors for spherical aberration and monochromators for the electron gun, both instruments offer sub-Ångström resolution in a variety of operation modes, which to date is unrivalled in the world.

Knut Urban has received numerous awards and honours, the highest of which is the Heyn-Denkmünze of the Deutsche Gesellschaft für Materialkunde (DGM), which he received in 1999. He has also served on numerous committees and boards of professional societies and finally, in 2004 became the President of the German Physical Society (DPG), the largest physical society in the world. Since completing his term earlier this year, he continues as Vice-President until 2008. While this has not slowed him down in his scientific inventiveness, it may be a sign of a new stage in his career, in which he tries to serve his community as well as his colleagues and friends with just the same drive with which he has pursued his scientific career.

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