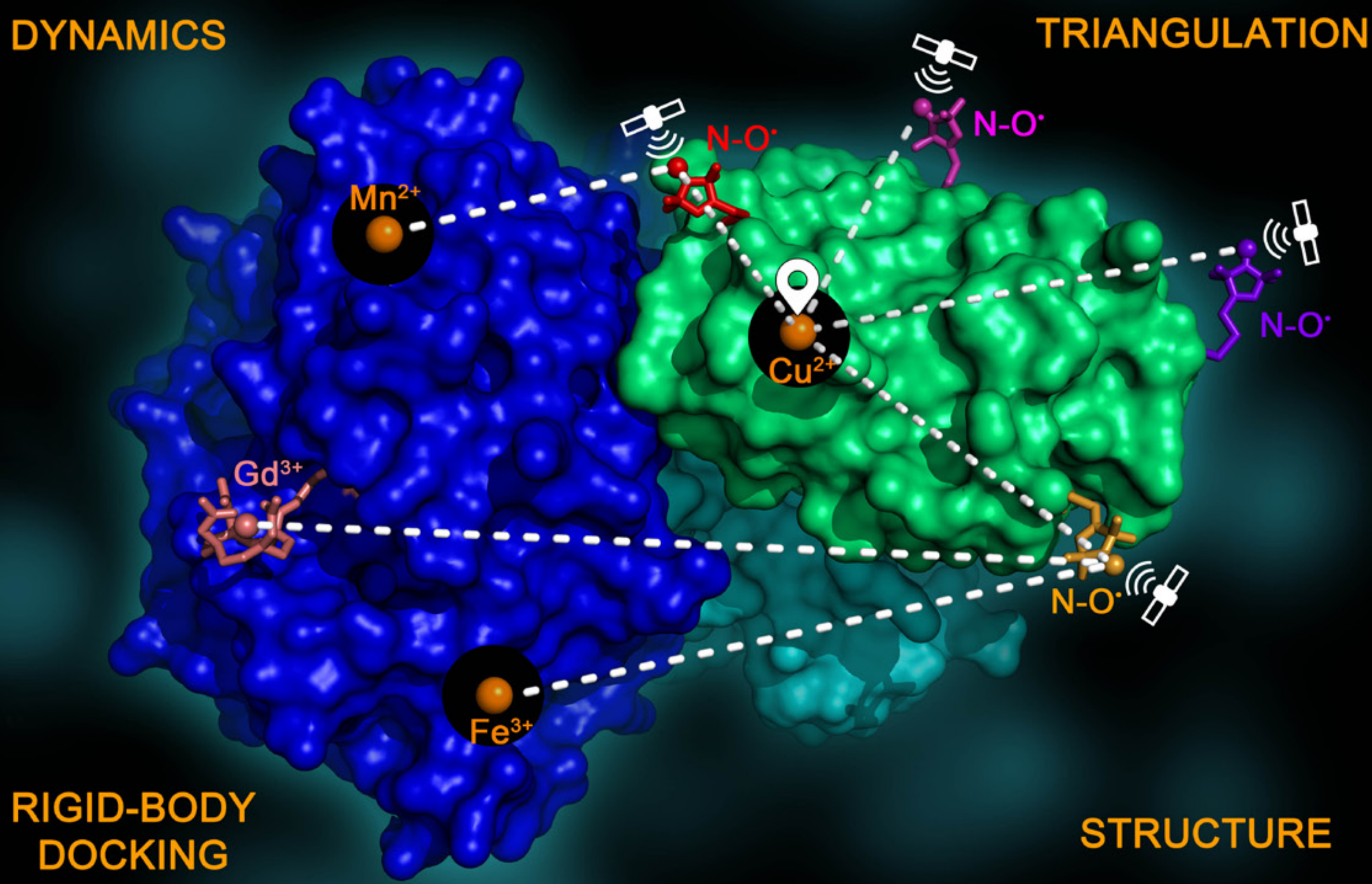
2025
volume 35 number 1-2

epr newsletter



The Publication of the International
EPR (ESR) Society

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PRESIDENT
Marina Bennati
University of Göttingen, Department of Chemistry & Max Planck Institute for Multidisciplinary Sciences (Fassberg Campus) Am Fassberg 11 37077 Göttingen, Germany
phone: +49 551 201-1911
e-mail: office.bennati@mpinat.mpg.de
web: https://www.mpinat.mpg.de/bennati

VICE PRESIDENTS

Americas
Sunil Saxena
University of Pittsburgh, 711 CHVRN
Chevron Science Center, 219 Parkman Avenue
Pittsburgh, PA 15260, USA
e-mail: sksaxena@pitt.edu
web: https://www.saxenalab.pitt.edu

Asia-Pacific
Sun Hee Kim
Western Seoul Center, Korea Basic Science Institute,
University-Industry Cooperation Building,
150 Bukahyun-ro, Seoul, 120-140 Republic of Korea
e-mail: shkim7@kbsi.re.kr
web: https://sites.google.com/site/kbsiepr/professor

Europe
John Morton
London Centre for Nanotechnology
University College London
17-19 Gordon Street, London WC1H 0AH, UK
e-mail: jjl.morton@UCL.ac.uk
web: https://www.ucl.ac.uk/quantum-spins

SECRETARY
Janet Lovett
School of Physics and Astronomy, North Haugh, University of St Andrews, St Andrews, KY16 9SS, UK
e-mail: Jel20@st-andrews.ac.uk
web: https://www.st-andrews.ac.uk/~jel20

TREASURER
Peter Z. Qin
Department of Chemistry,
University of Southern California, TRF 119,
3430-S. Vermont Ave., Los Angeles, CA 90089-3304, USA
phone: (213) 821-2461, fax: (213) 740-2701
e-mail: pzq@usc.edu

SOCIAL MEDIA OFFICER
Christos Pliotas
Division of Molecular & Cellular Function, School of Biological Sciences, The University of Manchester,
The Michael Smith Building, Oxford, UK
christos.pliotas@manchester.ac.uk
https://www.pliotasgroup.org

IMMEDIATE PAST PRESIDENT
Song-I Han
Northwestern University Technological Institute J317,
B176 and Silverman Hall B530 2145 Sheridan Rd
Evanston, IL 60208, USA
e-mail: songi.han@northwestern.edu
web: https://hanlab.northwestern.edu

FOUNDER PRESIDENT
Harold M. Swartz
Dartmouth Medical School,
Department of Radiology & EPR Center,
7785 Vail Room 702, Hanover, NH 03755-3863, USA
phone: 1-603-650-1955, fax: 1-603-650-1717
e-mail: harold.swartz@dartmouth.edu

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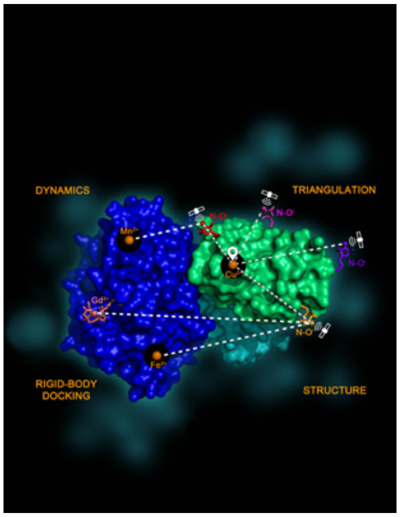
https://ieprs.org/newsletterpage/

The official publication of the International EPR (ESR) Society is supported by the Society, by corporate and other donors, and the Zavoisky Physical-Technical Institute of the Russian Academy of Sciences, Kazan, Russian Federation.

Please feel free to contact us with items (news, notices, technical notes, and comments) or ideas for the *EPR newsletter*.

The *EPR newsletter* is published quarterly by the International EPR (ESR) Society and is available in electronic and printed form to all members of the Society. The deadlines for submission of news for upcoming issues: Spring March, 15; Summer June, 15; Fall September, 15; Winter December, 15.

ISSN 1094-5571



The cover picture illustrates aspects of the research of Olav Schiemann, recipient of the IES medal in Biology/Medicine 2025. It showcases the power of Pulsed Dipolar EPR Spectroscopy (PDS) on example of a protein complex site-directedly spin labelled (SDSL) at various sites with spin labels as satellites. Combining SDSL with a suitable pulse sequence from the PDS toolbox can be used to trilaterate a metal ion binding site (https://doi.org/10.1002/anie.201410396), to solve the coarse-grain structure of the constituents (https://doi.org/10.1093/nar/gkaa703), to dock the complex's constituents (https://doi.org/10.1016/j.str.2019.06.007), and to resolve the dynamics of its formation (https://doi.org/10.1021/jacs.1c01081). Using trityl- or Gd^{3+}-based spin labels makes such studies possible not only in vitro but also in cellulo (https://doi.org/10.1002/anie.202004452).

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Editorial

Dear colleagues,

The Zavoisky Award 2024 to Robert G. Griffin (USA) and Anatoly F. Vanin (Russia) recognized their outstanding contributions to the development of EPR methodology and its applications in biochemistry and living organisms. We also acknowledge the special issue of *Applied Magnetic Resonance* "Celebration of 80 Years of EPR" prepared in Parts I, II, and III by Gareth R. Eaton, Sandra S. Eaton, and Kev M. Salikhov (https://link.springer.com/journal/723/volumes-and-issues/55-9; https://link.springer.com/journal/723/volumes-and-issues/56-1; https://link.springer.com/journal/723/volumes-and-issues/56-5). Taken together these may be considered as the final movement of a glorious symphony in honor of the 80th anniversary of the discovery of EPR.

We are entering a new decade of EPR, and reports of the accomplishments of a younger generation of EPR researchers: Ilenia Serra, Zichen Wang, Kousuke Higashi, Mikhail Kolokolov, Yuya Ishikawa, Zhang Qi (pp. 6–11), and Akihiro Tateno (to be published in the forthcoming issue of the Newsletter) make us optimistic about the future of EPR.

It is so sad to say farewell to several of those who have been our mentors and who have all been outstanding scientists: Klaus Möbius, Noboru Hirota, Alex Pines, and Ralph Weber (pp. 14–31).

For more than thirty years Klaus was part of the *EPR newsletter* universe and it was heartwarming to realize that he was always there for advice, help and support. He highly appreciated the role of the *EPR newsletter* in ensuring the visibility of the IES. Diverse materials from Klaus were the highlights of many issues of our publication.

Ralph was heart and soul of the Tips and Techniques column and co-authored a good number of relevant contributions. It is inspiring that this Bruker BioSpin tradition is continued in the contribution by Timothy J. Keller (pp. 32, 33).

Our grateful memory will keep Klaus Möbius, Noboru Hirota, Alex Pines, and Ralph Weber alive for the years to come.

Laila Mosina

Letter of the IES President

Dear Friends, Colleagues and Students of the International EPR/ESR Society, it is my pleasure to open the Newsletter wishing you a successful, peaceful and healthy 2025!

I'm looking back to 2024 and recognize a wealth of exciting initiatives and interactions in our community accompanied by sad news about loss of great colleagues and friends. Most effort of the new IES Executive Board has been devoted in expanding our scientific network, memberships and financial sponsors, as well as supporting the young generation of scientists through several prizes. I'm particularly proud that in 2024, IES could award twelve poster prizes plus three best-paper awards to students! This was only possible through a concerted effort by many members of IES, who were engaged in international conferences from Asia, US and Europe, talking to students about their scientific work. This process is extremely valuable to give a feedback to our next generation. We are looking forward to continuing this mission in future.

During the past year, Alex Pines, Klaus Möbius, Noboru Hirota and Ralph Weber passed away. I would like to briefly remember their exceptional contributions to our community. Alex Pines was a hero in magnetic resonance, developing fundamental principles of spin physics that have served to understand and design many modern experiments in NMR and EPR. Klaus Möbius made exceptional contributions in EPR spectroscopy, being one of the pioneers of high frequency EPR and on the studies of photosynthetic reaction centers. Noburo Hirota performed many initial EPR spectroscopic studies of structures, electronic states, dynamics, and chemical reactions of paramagnetic radical molecules. Finally, Ralph Weber dedicated himself to serving the entire US EPR community as an intellectual powerhouse, always offering his support and assistance whenever needed. We will miss all them and more extensive obituaries will follow in this Newsletter.

Looking toward the future, one important new initiative by the new IES Executive Board regards the organization of student travel grants to attend EPR-related international conferences, ENC-ISMAR, RSC, EUROMAR, RMC and EF-EPR Summer School and PACIFICHEM. I hope you will be able to take this opportunity in support of your students. Application modalities are explained on our website. I note that the 2025 IES designated meeting is the RSC in London, where the IES annual general meeting (AGM) will take place. I will announce date and time soon.

We have seen high quality nominations for the 2025 Medals in Biology/Medicine and Physics/Material, Fellow of the IES, as well as the Young Investigator Award. The various prize committees had hard choices, but made their final award selection as follows. Congratulations to all winners!

- 2025 IES John Weil Young Investigator Award: Nino Wili his outstanding contributions to theory and instrumentation in the field of EPR spectroscopy.
- 2025 IES Medal in Biology/Medicine: awarded to Olav Schiemann for his seminal contributions advancing the field of EPR in Biology via his pioneering efforts to resolve structural aspects of spin labelled nucleic acids and proteins.
- 2025 IES Medal in Physics/Material Science: awarded to Patrice Bertet for his groundbreaking contributions to the quantum physics of electron spin resonance (ESR), including seminal observations of fundamental phenomena in spin resonance as well as profound technological developments in spin sensitivity.
- 2025 IES Fellow: jointly awarded to Mike Bowman and Hitoshi Ohta for their outstanding contributions to the field of EPR spectroscopy by advancing the methods and applications as well as their invaluable engagement for the community.

The next IES award selection is again an exciting one: the IES Best Paper Award of 2025, with nomination deadline of April 30th, 2025. The first author is honored with this award along with a monetary prize. Please see the nomination rules on our website.

Concerning IES on-line activities, first I would like to thank the team of IVEM of Joseph Mc Peak, Tomas Orlando, Thomas Schmidt and Yujie Zhao for the continuous and invaluable engagement in the on-line seminar series. Please have a look at the exciting list of upcoming talks and news under https://www.eprseminars.org and feel welcome to engage and shape this activity in future. All IVEM speakers get the opportunity to submit synopsis and their photo to the *EPR newsletter* to be highlighted by Laila Mosina. Second, we have started moving our IES social media account from X to BlueSky. More details in this step will be announced by our new Social Media Officer Christos Pliotas.

With the advent of artificial intelligence, the availability of a depository for EPR data, freely accessible to our and other communities, is becoming of outmost importance. IES is grateful to its previous president, Thomas Prisner, who has recognized this critical aspect and is pushing this initiative. A team of IES members is actively discussing how to create such a shared EPR/PELDOR/DEER data base to be located and administrated by the IES. This should also allow many EPR researchers to deposit published data in its raw format to ensure transparency and standardized best practice. Your input is very welcome.

Last but not least, I would like to thank especially Laila Mosina, Janet Lovett and Peter Qin, who constitute an incredible team in serving our community. Their engagement in spreading news widely through the Newsletter, communicating with all of us and administrating IES financial resources is indispensable. IES is dedicated towards supporting a diverse science community, considering geography, ethnicity, gender and otherwise, which will be the generator of creative and innovative ideas. I'm grateful for your help in sustaining this goal. Please become engaged by nominating new names for leadership in the future, awards and new initiatives.

I look forward to meeting many of you in 2025 in person!

Marina Bennati

IES Travel Grant

The International EPR/ESR Society (IES) is pleased to announce a new travel award for PhD students to attend IES sponsored conferences in 2025. Each award will provide funding of up to 750 $ (US) to cover conference related expenses, with up to two awards for each conference. The list of conferences eligible for travel awards in 2025 can be found on the IES website, https://ieprs.org/upcoming-meetings.

The PhD student should write a short case for the merit of their attendance at the conference and how the IES grant will enable this. They should include their abstract for their conference contribution. These should be emailed to the group secretary, along with a short letter of support from their supervisor on headed paper and including a signature.

Travel awards in 2025 will be decided on the basis of a valid case being presented, and in order of the applications being made. Deadline for application is the registration deadline of the respective conference.

Successful candidates should indicate the support of the IES during their conference contribution.

The applicant and their supervisor should be an existing member of the IES. Successful applicants, who are awarded once, cannot apply again.

The stipend will be presented after the conference on receipt of a certificate of attendance at the conference, together with a list of encountered travel/registration costs and a short article on their experiences of the conference for the IES Newsletter.

Broadening Access to User-Driven Innovation in EPR

On October 7th, 2024, Bruker BioSpin announced the acquisition of the Magnetic Resonance business of Bridge12 Technologies, Inc. This acquisition marks a significant step forward for Bruker and the EPR community, combining our expertise to accelerate innovation and broaden access to cutting-edge instrumentation.

Bridge12 has long been known for its deep user-centric approach, creating solutions tailored to help scientists achieve breakthroughs in Magnetic Resonance Spectroscopy. By combining this approach with Bruker's global reach, world-class infrastructure, and dedication to advancing research, we aim to make high-quality EPR instrumentation more accessible – particularly for early-career scientists and research groups with ambitious ideas but constrained budgets.

At Bruker, we believe that impactful scientific progress stems from the ability to innovate and push boundaries. Yet, our previous structure made it difficult to create small series instruments. That's where the new partnership with Bridge12 comes in. Together, we are committed to empowering researchers-providing advanced EPR instrumentation that meets the needs of today's experiments while anticipating the challenges of tomorrow.

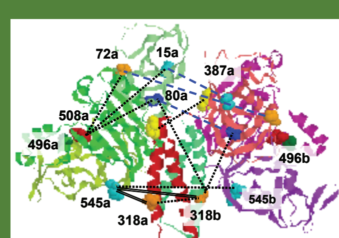
The integration of the EPR business of Bridge12 into Bruker enables us to amplify innovation, deliver custom and reliable solutions, and focus on what matters most: Enabling the scientific community to explore new frontiers and bringing sustainability to innovation. We look forward to supporting researchers around the world, from well-established institutions to emerging labs with bright ideas.

Personally, my goal has always been to create innovative, affordable instrumentation. I had my first interactions with pulsed EPR Spectroscopy in the lab of Prof. Thomas Prisner at the Johann Wolfgang von Goethe University in Frankfurt, Germany. My research and doctoral thesis were primarily focused on developing new pulsed EPR methods for separating overlapping EPR signals and their application to mitochondrial Complex I.

My post-doctoral research led me to the field of DNP-NMR Spectroscopy at MIT's Francis Bitter Magnet Lab in the Group of Prof. Robert Griffin, where I worked on theory and instrumentation for high-field DNP, including development of new polarizing agents as well as applying DNP-NMR Spectroscopy to study low-gamma nuclei such as ^{13}C and ^{2}H. I am incredibly grateful to all the wonderful people I met during my time at MIT allowing me to gain all the knowledge about EPR, NMR, and DNP instrumentation.

On my journey, I saw many principal investigators in a bind: The existing equipment didn't enable them to push scientific boundaries. While they were experts in EPR Spectroscopy, they didn't necessarily know how to build the equipment. This is why I decided to co-founded Bridge12: To build custom Magnetic Resonance equipment and make it commercially available around the world.

This mission resonated with Bruker and was an important reason for the acquisition.



In my new role, I am working on driving EPR innovation for specific research projects. I typically start by exploring what you are looking to achieve and designing your "dream machine." Once we know what the ideal outcome is, I try to pare it back to fit within technological and budget limits; sometimes using your existing equipment and off-the-shelf parts. This helps keep both cost and timelines in check.

If you are envisioning new applications for EPR Spectroscopy or have ideas for custom instrumentation, I invite you to reach out to me at Thorsten.Maly@Bruker.com.

Thorsten Maly, Bruker BioSpin

TeachEPR

Who will teach the next generation of users of EPR? Note that we did not say "EPR spectroscopists". EPR is underutilized for solving problems because it is rarely taught in formal courses in physics, chemistry, or biology. Very few textbooks that would be used in undergraduate courses in the United States mention EPR, so even those who become teachers rarely have the background to teach EPR. Do we need to teach the teachers in addition to the students? These and related concepts are being discussed among researchers when they gather at conferences and via email and Zoom discussions. By this brief essay we hope to further stimulate discussion.

Do we want to:

(a) teach the instrumentation aspects of EPR signal acquisition,

(b) use EPR to demonstrate physical concepts, or

(c) use EPR to illustrate its utility in solving science problems in physics, chemistry, and biology?

A major limitation of teaching future learners about EPR is availability of instrumentation at prices teaching organizations can afford. A low-frequency low-field demonstration machine could be built inexpensively. A more advanced machine that would get students thinking about EPR as one of many methods to solve problems would be more expensive.

The big questions are:

1. What specific topics do we want to teach using EPR?

2. What features and quality should a teaching EPR spectrometer have?

3. At what point in the educational journey should we introduce EPR?

On the instrumentally simpler side, Reef (Philip D.) Morse, the Director of the Steppingstone MAgnetic Resonance Training Center has been teaching EPR to middle and high school students for 15 years. You may have seen these students at various Rocky Mountain Conferences. At the last RMCMR, he sparked a discussion on engaging young students to learn about EPR by first capturing their attention with familiar topics, like free radicals and antioxidants. He has learned that capturing a student's interest with hands-on experience encourages questions about how the technique works to solve these problems. His labs could be easily taught using a relatively simple machine.

On the instrumentally more complex side, educators interested in demonstrating physical concepts with EPR generally prefer high-resolution equipment for studying free radicals, as well as broad magnetic field scans for analyzing metal complexes like manganese, copper, and vanadyl whereas biological studies range from instrumentally simple spin label experiments at $g = 2$ to the instrumentally difficult (DEER, for example). Depending on our educational goals, we may need continuous wave (CW), rapid scan, or pulsed EPR techniques.

Organizing existing educational material is an important first step. At the University of Denver we are creating a depository for teaching materials https://digitalcommons.du.edu/teachepr. This will be maintained in accordance with normal library standards so that it does not depend on grant funding or corporate interest. It is being set up so that anyone can submit files to be posted for others to use. We will have sections for high school and undergraduate introductory materials, laboratory modules, topical reviews that would be "introductory" for researchers not specialists in the area, etc. Librarians and GRE will review items submitted to filter out malware and to judge the appropriate category. One person might consider "advanced" what a colleague considers "introductory".

We need a larger discussion to listen to the educational aspirations of as many members of the EPR community as possible. Please extend this discussion to anyone who might be interested in contributing.

Looking forward to your thoughts,

Gareth R. Eaton,
University of Denver, geaton@du.edu
Reef Morse,
Director Steppingstone
MAgnetic Resonance Training Center,
reef@steppingstoneschool.org

IES Poster Prize at the 12th EFEPR Conference 2024

Ilenia Serra:

I joined the Laboratory of Bioenergetics and Protein Engineering in Marseille at the end of 2023 and it was a pleasant surprise to discover that the next EFEPR conference would be organized by our team in the exact same city! Attending the 12th EFEPR meeting has been not only a chance to meet collaborators and friends from the EPR community, but also an opportunity to engage in stimulating discussions about the projects I am working on as a post-doctoral researcher. I would like to deeply thank the International EPR Society for awarding me with a poster prize, which made my participation to the conference even more exciting.

After completing a PhD focused on the study of heme enzymes by EPR spectroscopy, I started a new journey into the world of iron-sulfur (Fe-S) clusters. These ancient cofactors are essential for life, being involved in numerous biological functions, including electron transfer, catalysis, nucleic acid processing, and sensing to cite a few. EPR spectroscopy played an essential role in the history of Fe-S cluster research, being the method that actually led to their discovery in 1960 [1]! Nowadays, after many advances in our knowledge of Fe-S clusters, EPR is still a technique of choice to investigate these cofactors, which can be paramagnetic depending on their nuclearity, geometry, and oxidation states. In biology, the most common Fe-S geometries consist of [2Fe-2S], cuboidal [3Fe-4S] and [4Fe-4S] clusters, while their electronic and structural properties are largely tuned by the arrangement and nature of the coordinating residues. In the case of [2Fe-2S]-containing proteins, the most common coordination motifs are 4Cys (as in the case of ferredoxins) or 2Cys-2His (as in the case of Rieske proteins). Only in recent times, a new family of [2Fe-2S] proteins was discovered, featuring an unusual 3Cys-1His coordination. These proteins, named NEET proteins from the sequence "Asn-Glu-Glu-Thr", are spread across all domains of life. In mammalian cells, depletion or overexpression of NEET proteins have been associated to metabolic diseases, including diabetes, rare genetic disorders and cancer, making them an attractive target for novel therapeutics [2]. Human mitoNEET (or CISD1) and NAF-1 (or CISD2) are homodimeric proteins which share high structural and sequence similarity and are associated to the outer mitochondrial membrane and to the endoplasmic reticulum, respectively. Despite the high degree of homology, the two proteins exhibit different Fe-S cluster stability, which depends on pH and oxidation state [3].

The work that I have presented in my poster is the result of an ongoing collaboration with Dr. Marie-Pierre Golinelli-Cohen from the CNRS-Université Paris-Saclay. It involves a comparative EPR study of mitoNEET and NAF-1, in order to elucidate the structural determinants responsible for the difference in Fe-S cluster stability between the two proteins. In the attempt to identify perturbations of the Fe-S center upon pH variation, multifrequency continuous-wave EPR and HYSCORE spectroscopy have been initially employed, revealing so far minimal differences between the two systems.

Our current strategy points towards different directions; on the one hand we want to extend the range of pH of our samples in order to detect differences which might become significant only at more extreme pH conditions. In addition, we are currently investigating the pH dependence of the reduction potential for the $[2Fe\text{-}2S]^{2+/1+}$ cluster in the two proteins by performing redox titrations coupled to continuous wave EPR. On the other hand, we plan to perform more advanced HYSCORE experiments with ^{15}N-labelled samples in order to ease peak assignment and in D_2O buffer, to get insights into the exchangeable protons in the vicinity of the Fe-S center.

I would like to conclude by thanking my supervisor Dr. Bénédicte Burlat for giving me the opportunity to work on this exciting project and learn new fun ways of applying EPR spectroscopy to the study of metalloproteins.

1. Beinert H., & Sands R.H. (1960). Studies on succinic and DPNH dehydrogenase preparations by paramagnetic resonance (EPR) spectroscopy.
2. Nechushtai R., Karmi O., Zuo K., Marjault H.B., Darash-Yahana M., Sohn Y.S., King S.D., Zandalinas S.I., Carloni P., & Mittler R. (2020). *Biochimica et Biophysica Acta - Molecular Cell Research*, 1867(11).
3. Salameh M., Riquier S., Guittet O., Huang M.E., Vernis L., Lepoivre M., & Golinelli-Cohen M.P. (2021). *Biomedicines*, 9(4).

Bénédicte Burlat:

Ilenia joined our Team "Biophysics of Metalloproteins and Dynamic Systems" in Marseille as a postdoctoral fellow in December 2023 to study the structure and function of novel atypical iron-sulfur (Fe-S) proteins.

Ilenia is a young European scientific globetrotter. She holds a Master's degree in Industrial Biotechnology from the University of Modena and Reggio Emilia in Italy, during which she completed a three-month Erasmus research internship supervised by Prof. Paul Walton at the University of York in the UK. She then completed her Ph.D. in 2023 between the Universities of Antwerp, Belgium, and Zaragoza in Spain, under the co-supervision of Prof. Sabine Van Doorslaer and Prof. Inés Garcia-Rubio.

During her early research trip across Europe, Ilenia acquired a strong background in advanced EPR spectroscopy at the interface of bioinorganic chemistry, to study the structural basis of the reactivity of certain enzymes of biotechnological interest. This rich first scientific experience has earned her a valuable double hat as a spectroscopist and biochemist.

New country, new challenge, Ilenia came to Marseille to work on a new project aimed at elucidating the physiological function of a family of Fe-S proteins that we had recently discovered in giant viruses. These proteins, whose structure and function are unknown, exhibit exceptional Fe-S binding properties that we believe play a critical role in host-pathogen interactions. Using her broad biophysical and biochemical skills, Ilenia is currently developing very promising studies to assess the functional properties of these viral metalloproteins *in vitro*.

In parallel, Ilenia is using multi-frequency continuous waves and advanced EPR spectroscopy to investigate the key structural features responsible for the differential stability of the [2Fe-2S] $(Cys)_3$His cluster found within the ubiquitous NEET protein family. The NEET proteins have been implicated in several metabolic diseases in mammalian cells. Their role and mechanism of action involving this atypical [2Fe-2S] cluster remain elusive. Congratulations to her for winning one of the best poster prize awards at the EFEPR meeting last September!

IES Poster Prize at the 12th EFEPR Conference 2024

Zichen Wang:

The chemistry and physics of organic semiconductors (OSCs) have been studied extensively for decades. A broad range of OSC applications such as optoelectronic, flexible electronic, and bioelectronic devices are enabled by superior materials performance, unique functional properties and/or attractive manufacturing attributes. Great progress has been made in understanding the unique transport physics regime encountered in these highly disordered materials, which then proved essential in device optimization in many applications. However, charge carrier trapping due to structural or chemical defects is an important factor in most systems, but often, only limited information is available on the microscopic nature of the relevant trap states [1].

Electron spin resonance (ESR) is a powerful experimental method for studying the spin-dependent exciton and charge dynamics in OSCs, providing details about spin states and relaxation processes of (quasi)particles in a molecular environment with weak spin-orbit coupling and hyperfine interactions [2–4]. While ESR provides information about the nature and density of paramagnetic states, the link to the electrical transport properties in bulk materials is still vague.

Here we present, by first time, a continuous-wave electrically detected magnetic resonance (cw-EDMR) experiment on conjugated polymer FETs. The principle of cw-EDMR is similar to that of the field-induced cw-ESR: in the presence of a uniform DC magnetic field and a continuous-wave microwave field at a specific frequency, the spin-1/2 carriers in the accumulation layer of the FET are excited at resonance between their Zeeman-split energy levels. Rather than measuring the absorption of the magnetic field at resonance, as in ESR, changes in the transistor source-drain current are monitored as the DC magnetic field is swept. Any such changes reflect charge transport processes that are sensitive to the spin population.

In our experimental setup, the ambipolar polymer FETs with spin coated Poly[2,5-(2-octyldodecyl)-3,6-diketopyrrolopyrrole-alt-5,5-(2,5-di(thien-2-yl)thieno[3,2-b]thiophene)] (DPPDTT) offer great tunability of carrier types, carrier densities as well as the carriers' drifting velocities [5]. By performing the cw-EDMR scans in a wide range of FET biasing conditions, we distinguished two contributions of EDMR peaks – a narrow EDMR peak occurs only in the ambipolar region, caused by the recombination of electrons and holes which is preferable in singlet rather than triplet configuration; a broad EDMR peak prevails in the unipolar region, which arises from the spin-blockade effects of bipolaron states in the charge trapping sites. The spin-blockade effect suggests that a mobile carrier, with the spin states flipped at spin resonance, can temporarily dwell in the same energy level on the trap site occupied by another carrier, before hopping to the next states along its conduction pathway, while paying an additional energy cost to go to a higher energy state if stay in the same spin state as the trap carrier. Observed in a variety of solution-processible conjugated polymer FETs, such spin-blocking EDMR has a distinct signature of decreased peak amplitudes with the increased drifting current (due to the increased tunneling effect), in contrast to the widely acknowledged recombination of which the peak amplitude is expected to increase with the drifting current (due to the increase in the injection of minority carriers). By measuring the temperature dependence of the EDMR signals, we extract the energy level difference between singlet and triplet bipolaron states and evaluate the physical size of the trap sites. We also performed an *in-situ* measurement on FETs with applied stress over 10 hours and observed the evolution of trapped states during the stress progression. Our findings suggest that cw-EDMR provides a powerful experimental probe to evaluate the influence of trap states on the percolation charge transport in conjugated polymers for a wide range of optoelectronic and flexible electronic applications.

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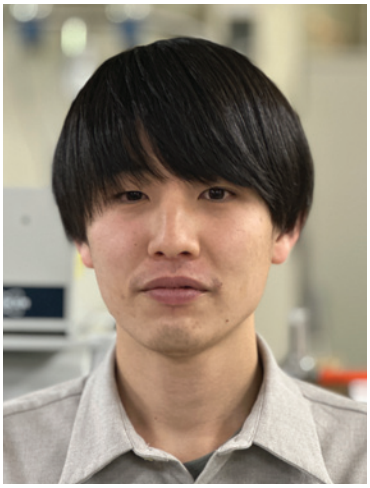
2. Tsurumi J. et al. Coexistence of ultra-long spin relaxation time and coherent charge transport in organic single-crystal semiconductors. *Nat Phys* **13**, 994–998 (2017).
3. Schott S. et al. Polaron spin dynamics in high-mobility polymeric semiconductors. *Nature Physics 2019* **15**, 814–822 (2019).
4. Carey R.L. et al. Spin relaxation of electron and hole polarons in ambipolar conjugated polymers. *Nat Commun* **15**, 288 (2024).
5. Chen Z. et al. High-Performance Ambipolar Diketopyrrolopyrrole-Thieno[3,2-b]thiophene Copolymer Field-Effect Transistors with Balanced Hole and Electron Mobilities. *Advanced Materials* **22**, 647–652 (2011).

IES Poster Prize at the 2024 Spin Chemistry Meeting



Kousuke Higashi:

To begin with, I would like to express my sincere gratitude to the International EPR (ESR) Society for awarding me the IES Poster Prize at the 2024 Spin Chemistry Meeting in Kobe. Kobe is the city where I have lived for the past six years since entering university, and having such a valuable experience at the Spin Chemistry Meeting held in this memorable place is a great pleasure for me. Additionally, I was involved not only in presenting my own poster but also in setting up the venue, managing registration, and assisting with oral presentations. These activities provided me with the opportunity to interact with prominent figures in EPR research, making it an incredibly rewarding experience. The content of the poster presentation for which I received this award is the research I have been working on for three years. I would like to take this opportunity to introduce my research.

To make efficient use of limited energy resources, light energy conversion technology plays a crucial role in modern society. Among them is photon upconversion via triplet-triplet annihilation (TTA-UC), a chemical reaction process that converts two photons into a single higher-energy photon, and it operates even with low-intensity and incoherent light. Therefore, TTA-UC is expected to be a promising method for efficiently utilizing the various wavelengths in sunlight as an energy source, thereby improving light-energy conversion efficiency in organic solar cells and photocatalysis.

My study focuses on elucidating the triplet-exciton dynamics that contribute to high performance TTA-UC materials using time-resolved EPR (TREPR). TTA is a bimolecular reaction in which two triplet-excitons collide to yield a radiative first-excited singlet ($T_1 + T_1 \rightarrow S_0 + S_1$). Long triplet-exciton lifetimes (τ_T) and large TTA reaction rate constants (k_{TTA}) are required for TTA-UC to be efficiently driven. For the most common intermolecular TTA systems in solution, approaches to prolong τ_T are often reported, but the focus has not been on k_{TTA}. Therefore, as a strategy to improve the k_{TTA}, we decided to use tri(9-anthryl)borane (TAB), a trimeric molecule with anthracene core structure, as a TTA material. The high rotational symmetry of the TAB molecular structure allows for multiple energetically equivalent triplet exciton distributions. As a result, the triplet-exciton is expected to move rapidly among the three anthracene moieties in TAB, similar to the pseudo-rotation via the dynamic Jahn-Teller effect in highly symmetric molecules such as fullerenes. If the delocalization of triplet-excitons via intramolecular hopping occurs on the timescale of bimolecular triplet-triplet encounters, the TTA reaction distance may be extended, enhancing k_{TTA}. In fact, the TREPR spectrum line shape of TAB in the triplet state, after energy transfer from platinum porphyrin as a triplet sensitizer was considerably narrower than another triplet molecule with zero-field splitting parameters (D and E values) comparable to TAB. This significant motional narrowing is caused by pseudo-rotation, and we have precisely evaluated the exciton hopping rate (k_{hop}) by EPR line shape analysis based on the coupled stochastic-Liouville equation. In addition, TREPR measurements at different temperatures and solvent viscosities revealed the transition state structure and necessary structural fluctuations of the intramolecular triplet exciton hopping in TAB, respectively. An extremely fast hopping rate ($k_{hop} \approx 0.6\ ps^{-1}$) is observed in toluene, comparable to the collision residence time of the TTA process ($t_{collision}$). Under this condition, the k_{TTA} value of TAB, determined by analyzing time-resolved luminescence measurements, was higher than that of another TTA molecule. Conversely, when the solvent viscosity was increased and the exciton hopping no longer occurred on the effective timescale for the TTA process ($1/k_{hop} >> t_{collision}$), the k_{TTA} value for TAB was smaller than another TTA molecule.

In conclusion, these results confirmed that the structural fluctuations driven by vibronic interactions facilitate the quick intramolecular migration of triplet-exciton among the anthracene moieties in TAB, effectively increasing the TTA reactivity. This novel approach of employing trimeric molecules that induce long-distance intermolecular TTA holds great potential for advancing the development of TTA-UC materials with enhanced light-to-energy conversion efficiency.

Lastly, I would like to thank all those involved in my research, especially Prof. Yasuhiro Kobori and Dr. Tsubasa Okamoto, a member of Kobori Laboratory, for their tremendous support.

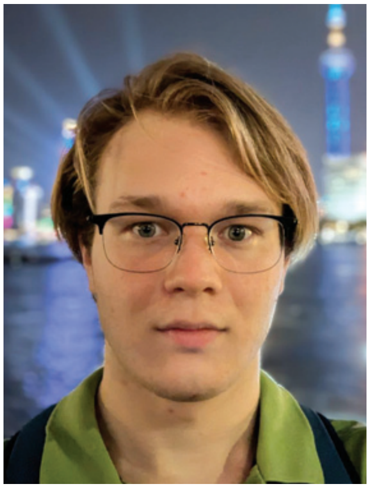
Yasuhiro Kobori:

Kousuke was an excellent student and an independent person when he was an undergraduate. When he joined my group in 2022, we had already started to work on elucidating the spin conversion mechanism involved in photon upconversion with Dr. Tsubasa Okamoto, so I decided to ask him to work on spin conversion and qubit properties by intramolecular exciton pairing in a molecule with three chromophores coupled to a boron in a rotationally symmetric manner. Unexpectedly, through his deep insight and persistent efforts, he discovered that ultrafast intramolecular exciton hopping enhances the efficiency of upconversion emission by intermolecular triplet-exciton collisions using the transient EPR method. I am therefore delighted that he has been awarded the IES Poster Prize by the IES at the Spin Chemistry Meeting 2024 in Kobe, Japan. Not only for his own research and presentation, Kousuke worked so hard to organise the symposium for the Spin Chemistry Meeting 2024 and absorbed many insights from the wonderful presentations of cutting-edge research on quantum science and technology, hyperpolarised spins, novel spintronic materials, quantum information science and magnetic field effects.

It is very sad for me that he has decided to leave my group to join an industrial company from April 2025 without further developing his own spin chemistry at the PhD level. However, I am so proud of Kousuke that he will be able to take up a new challenge based on his fruitful experience in my laboratory and his many interactions with several distinguished scientists in the spin chemistry and related communities.

Finally, I would like to express my deep gratitude to the late Professor Seigo Yamauchi (Tohoku University) for the preliminary discussion of the electronic character in the triplet state of the trimer molecule.

IES Poster Prize at APES 2024



Mikhail Kolokolov:

My current research is primarily centered on the biological applications of EPR. Specifically, our group focuses on studying complex multimolecular biological systems that pose significant challenges for other physico-chemical methods.

As part of this work, I recently had a chance to present a poster at APES 2024 on the EPR investigation of ribosomal-mRNA translation complexes. These complexes have been thoroughly investigated before by our group. Our approach begins with spin-labeling mRNA at both ends and assembling ribosome-mRNA complex. Then, using dipolar EPR techniques, typically DEER, we can determine distance distributions between nitroxide spin labels attached to the mRNA. These distributions reflect contributions from all possible conformations of mRNA within the complex. This allows us to simultaneously detect free mRNA, mRNA bound to the ribosome surface, and mRNA located inside the ribosomal channel.

Interestingly, in a previous study, we discovered that the distance distribution for mRNA within the ribosome showed two distinct peaks, suggesting that mRNA adopts two coexisting conformations. Moreover, the relative proportions of these conformations were found to depend significantly on the cofactors present in different complexes. However, since EPR detects the spin labels rather than the mRNA itself, there was a concern that these effects might be artifacts caused by the spin-labeling process. To address this, we decided to repeat similar experiments using a different spin label. Previously, we exclusively used the NHS-M2 spin label, which can only be attached to the terminal sites of RNA. In our new experiments, we opted to use the R5 label developed by Prof. Peter Qin, which can be attached to any position within the RNA sequence. These labels also have different attachment sites, as NHS-M2 attaches to the nucleic acid base, while R5 binds to the backbone's phosphorus atom.

The plan seemed straightforward: determine how the distance distributions provided by the R5 label would differentiate between pre- and post-termination ribosome-mRNA complexes. And indeed, R5 did exhibit different behavior. To be exact, it did not show neither double peaks nor any differences between complexes at all! This result raised concerns about whether our previously published findings might have been indeed influenced by spin-labeling artifacts.

In order to interpret these obviously contradicting results, I was asked to perform molecular modeling of the studied complexes and simulate how different spin-labeling strategies might impact the observed distance distributions. Fortunately, cryo-EM structures for the studied complexes were already available. However, they represent only the averaged state of the complex, leaving out the information about conformational dynamics.

Modeling distance distributions typically involves two key steps: MD simulations of the studied complexes and modeling the conformations of the spin labels. Due to the complexity of ribosomes, achieving consistent results required testing various force fields and algorithms. For spin labeling, we relied heavily on the ChiLife package, recently developed by Prof. Stefan Stoll's group. This package enabled us to efficiently calculate distance distributions from the MD trajectories with great coding flexibility.

Fortunately, molecular modeling revealed that the results obtained with different spin labels were not contradictory. We showed that the similar distances between backbone phosphorus atoms in different complexes, where R5 attaches, were the primary reason for the lack of differences in the observed distance distributions. Additionally, R5 can bind to the same atom in two different orientations, further broadening the distribution. In contrast, NHS-M2's attachment to the nucleic acid base makes it sensitive to base group rotations between complexes. This sensitivity leads to different distances in pre- and post-termination complexes, resulting in two peaks in the distance distribution. Importantly, our modeling demonstrated that the two distinct cryo-EM structures correspond to the two peaks previously observed by EPR, thereby validating our published findings.

As such, we demonstrated how different spin-labeling strategies may lead to drastically different interpretations of the conformational changes in biological complexes. Beyond contributing new scientific results, this project also offered me an invaluable opportunity to develop new skills. It was the first time I carried out all stages of a research project – from conducting EPR experiments and performing molecular modeling to preparing and publishing an article. I feel fortunate to have gained such comprehensive experience early in my career. Finally, I would like to express my gratitude to my colleagues and supervisors for their guidance and support.

Olesya Krumkacheva:

I have known Mikhail Kolokolov since 2020 when he joined my group as an undergraduate student. From the start, he demonstrated initiative and a strong interest in biophysics, actively seeking out our team in his third year. Given his excellent academic performance and enthusiasm, we gladly welcomed him. Since then, he has become an essential part of our structural research.

Mikhail has demonstrated a strong passion for science and a willingness to take on diverse challenges, from developing technical approaches to modeling biomolecular structures. He has been actively involved in lab life, contributing to meetings and equipment maintenance.

During his master's studies, he upgraded our main EPR spectrometer by integrating an Arbitrary Waveform Generator. He quickly became proficient with advanced equipment, mastered pulsed EPR techniques, and independently wrote the source code for waveform generation. His improvements enhanced the spectrometer's sensitivity, which he demonstrated in experiments on model biological systems.

He also played a key role in our research on ribosome-mRNA complexes, conducting numerous EPR experiments and analyzing data to extract structural insights. During these studies, Mikhail expanded his expertise, recognizing the need for computational modeling to interpret experimental results. He quickly mastered molecular docking, molecular dynamics, and quantum chemistry, applying these techniques to study conformational variability in ribosome-mRNA interactions. His work earned him the IES poster prize at APES 2024.

2024 APES Young Scientist Award

Yuya Ishikawa:

My research activities have been focused on exploring fundamental physical properties of low-dimensional magnetic materials and developing electron spin resonance (ESR) and nuclear magnetic resonance (NMR) instruments.

During my student days, I have promoted the synthesis of samples and the exploration of basic physical properties related to magnetic properties such as magnetic susceptibility and specific heat, aiming at the observation of novel quantum phenomena such as geometrical spin frustrated rate effects in low-dimensional antiferromagnets.

On the other hand, from a microscopic point of view, I have also been engaged in the search for physical properties using ESR and NMR, and at the same time, I have been involved in the development of magnetic resonance equipment. As a recent topic, we have developed a device for spin control of a solid-state quantum computer (QC) device using double magnetic resonance by ESR and NMR. The target model is a qubit with a dilute doped ^{31}P nucleus (I = 1/2) (Si:P) in a Si wafer, and ESR and NMR are used as the initialization and operation method. The ESR and NMR mechanisms were constructed inside a ^{3}He-^{4}He dilution refrigerator because the initialization and operation retention times require a high-field and ultra-low-temperature environment of $B > 3$ T and $T \leq 300$ mK. In order to irradiate different frequency bands (ESR: 130 GHz, NMR: 140 MHz) to the sample simultaneously, we developed a Fabry-Pérot resonator (FPR) composed of a spherical-planar mirror pair using Au thin film, and a planar NMR coil called "meanderline" was developed. The development of a planar NMR coil called the "meanderline" has made it possible to irradiate Si:P with radio waves in a planar geometry efficiently. The ESR observation of dilute ^{31}P nuclei at around 200 mK was successfully performed with the developed resonator and double magnetic resonance system, and about 83% of nuclear polarization was obtained by Dynamic Nuclear Polarization (DNP). These results are the first direct observation of ^{31}P nuclear spins by NMR in the world. These research results have demonstrative significance for the realization of magnetic resonance QC. This research is currently promoting the development of an ultra-compact resonator for controlling electron spins by pulsing ESR.

Since 2018, I have been affiliated with the Research Center for Development of Far-Infrared Region, University of Fukui (FIR-Center), and in addition to the above-mentioned research for the demonstration of quantum computing, I have been engaged in collaborative research on the development and application of magnetic resonance devices using a high-power wave source gyrotron with kW-class output developed by the FIR Center.

In magnetic resonance using gyrotrons, we have developed two main types of electron spin resonance systems. We are developing a pulsed ESR system to obtain dynamic information on the relaxation time of a sample by pulsing millimeter waves from a gyrotron

(FU CW VII B), a gyrotron capable of emitting 154 GHz pulsed millimeter waves cut to tens of ns by an optically driven semiconductor switch using Si wafers, and successfully detected Fourier-Transform ESR signals of BDPA radicals diluted at a concentration of 100 mM in polystyrene. In the development of a multi-frequency magnetic resonance system using a compact gyrotron (FU CW CI), we combined it with a force-detection ESR measurement (Force-Detection ESR) system in collaboration with Kobe University, and successfully detected the ESR standard sample of DPPH and single-crystal one-dimensional antiferromagnetic chain $Cu(C_4H_4N_2)(NO_3)_2$ at room temperature. The ESR signal can be detected at room temperature in fundamental oscillation (108–212 GHz) with an oscillation power of several hundred watts, and multi-frequency ESR at 9 K (295–394 GHz) in second harmonic oscillation with an oscillation power of several watts. The FIR-Center is currently promoting domestic and international collaborative research in the fields of spintronics, engineering, and agriculture using this system. I would like to thank all those who were involved in this research and those who selected us for the Young Scientist Award, and I look forward to hearing from you regarding our collaborative research!

2024 APES Young Scientist Award

Zhang Qi:

I am deeply honored to receive the 2024 APES Young Scientist Award, and I am thrilled to share my research journey in advancing electron paramagnetic resonance (EPR) technology through diamond quantum sensing. My work centers on leveraging nitrogen-vacancy (NV) centers in diamond to push magnetic resonance spectroscopy to the single-molecule scale, with the ultimate goal of enabling real-time observation of single-biomolecule dynamics in living systems.

From a Vision to a Breakthrough

My research began with a fundamental question: Can we detect the magnetic resonance signal of a single molecule without averaging over billions of spins? In 2015, my colleagues and I achieved this goal by utilizing the NV center as an atomic-scale quantum sensor.

The NV center is a spin-1 paramagnetic defect in diamond whose fluorescence emission is spin-state-dependent: the $m_s = 0$ state exhibits strong fluorescence, while the $m_s = \pm 1$ states show significantly weaker emission. By monitoring the fluorescence count rate, the spin state of a single NV center can be optically read out. To detect a "dark" electron spin (e.g., a nitroxide radical) located within a few nanometers of the NV center, we employ the double electron-electron resonance (DEER) technique – a well-established method in conventional electron paramagnetic resonance (EPR). The DEER protocol enables the observation of magnetic coupling between the NV center and the target spin. Shallow NV centers (3-5 nm beneath the diamond surface) retain excellent optically detected magnetic resonance (ODMR) sensitivity. When a protein molecule labeled with a nitroxide radical is positioned near such a shallow NV center on the diamond surface, the NV center acts as a nanoscale magnetometer. The spin-state-dependent fluorescence of the NV allows us to resolve the EPR spectrum of the single nitroxide radical through their magnetic dipole-dipole interaction. This approach leverages the NV's atomic-scale spatial resolution and single-spin sensitivity – capabilities beyond the ensemble-averaging limitations of conventional EPR – to achieve single-molecule EPR detection.

We reported the first ambient-condition single-protein EPR spectra with the above principle [*Science* 347, 1135 (2015)]. *Science* featured it as "an important milestone toward imaging individual proteins in living cells in real time". This work demonstrated the high sensitivity of NV center and its potential to circumvented the limitations of conventional induction coil-based EPR. This work was recognized as one of China's Top Ten Scientific Advances and highlighted by the National Natural Science Foundation of China (NSFC) as a model of interdisciplinary innovation.

Overcoming Barriers in Quantum Sensing

While the single-molecule EPR breakthrough opened new possibilities, practical challenges remained. Biological researches demand techniques with high throughput, minimal photodamage, and compatibility with complex environments. To address these issues, my team and I developed several key innovations:

1. High-Efficiency Readout for Scalability

Traditional optical readout of NV centers suffers from low readout fidelity, limiting measurement speed and risking photodamage to delicate samples. We proposed a near-infrared laser assisted spin-to-charge readout method [*Nat. Commun.* 12, 1529 (2021)], which reduce readout error by an order of magnitude and reducing potential optical damage. This method has also inspired theoretical and experimental studies on other solid-state spin systems, such as divacancies in silicon carbide, underscoring its broad applicability.

2. Noise-Resistant Control for Real-World Applications

Biological environments are inherently noisy. To tackle background fluorescence fluctuations and magnetic noises, we devised advanced quantum control pulse sequences [*PRL* 120, 120501 (2018)] and near-infrared modulation techniques [*Nano Lett.* 22, 1851 (2022)]. These methods enabled diamond sensors to operate in high-autofluorescence models like *C. elegans*, paving the way for *in vivo* studies.

3. Biomedical applications

We believe that transformative science thrives at the intersection of fields. Collaborating with biomedical researchers, we expanded diamond quantum sensing to diverse applications: single-DNA EPR spectroscopy in aqueous solutions and tumor tissue imaging (*Nature Methods* 2018, *PNAS* 2022). These efforts highlighted the translational potential of quantum sensing in diagnosing molecular interactions and disease mechanisms. Our custom-built optically detected magnetic resonance (ODMR) spectrometers, optimized for sensitivity and throughput, have become reliable platforms for conducting these interdisciplinary researches.

As we stand at the frontier of quantum-enabled biology, I am excited to continue bridging the gap between fundamental physics and real-world applications. By refining diamond quantum sensors, we aspire to unlock mysteries of cellular machinery and contribute to precision medicine – one spin at a time.

EPR in China

Jiangfeng Du

Zhejiang University, University of Science and Technology of China

The beginning of EPR in China can be traced back to around 1955. Here the history of EPR in China falls into two broad categories: 1. Hardware (technology development and distribution of spectrometer) and 2. Software (scientific staffs and monographs) sections.

The first part focusses on technology development from 1955 to 2024. The first commercial EPR spectrometer in China was imported from Russia in 1958. Then home-built spectrometers were available from 1962 and 1963 in two different places, and made available to several universities and used until the batch import of the Varian and Bruker spectrometers in 1980s. However, the number of spectrometers increased slowly and there were ~25 in 2008 at the time when the first X-band Bruker ELEXSYS E580 pulse spectrometer was obtained by our group in the University of Science and Technology of China. In light of this situation, our group started to focus on developing technology and instruments to enable more researchers in China and even the world to use high-performance and affordable equipment. Nowadays, the W-band spectrometer has become available commercially from the CIQTEK (Chinainstru & Quantumtech (Hefei) Co., Ltd.), a Chinese domestic company founded in 2016, in addition to the conventional X-band EPR spectrometer commercialized in 2018. All these achievements have promoted the application of EPR in China with the total number of spectrometers of around 600 so far. This has led to conspicuous scientific progress based on EPR methods during the past decade with the rapid development of the liquid helium-free cryogenic technology, and further demand for higher-sensitivity EPR spectrometers over many different fields, especially X- and W-band pulse technology, e.g., to detect the unresolved weak electron-nuclear spin interactions in ENDOR or electron-electron spin interactions in DEER/PELDOR. Meanwhile, mobile desktop spectrometers have been distributed widely for both basic teaching and on-the-spot experiments.

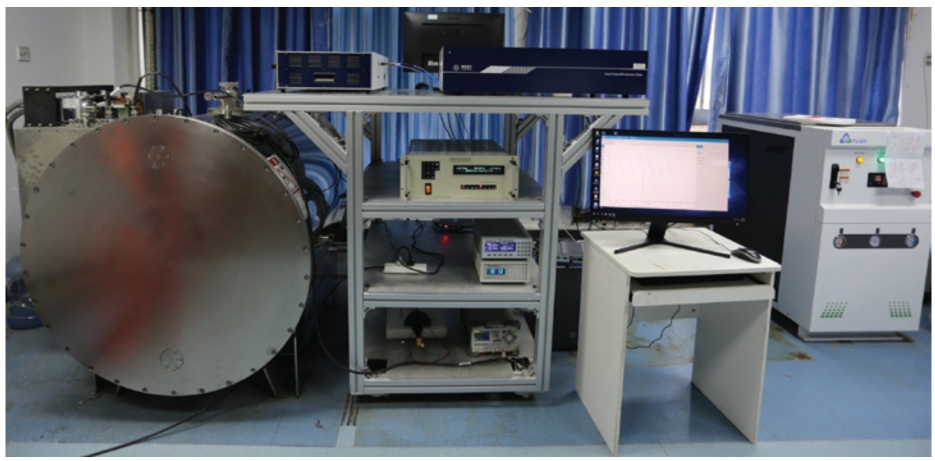
Except for the conventional EPR techniques, quantum sensing based on the nitrogen-vacancy center (NV) in diamond opens a new door for EPR at microscales. Measuring the magnetic resonance spectrum of single molecules and nanoscale materials had been an elusive goal until diamond-based magnetic resonance technology became available for us. It is expected that single-molecule EPR technology will bring a new broad range of applications and vitality to EPR and we are collaborating with scientists from around the world to advance these developments. In order to attract more researchers and to push the field forward, we have summarized the progress and outlook on the new field with a recent review article on the topic of 'Single-molecule scale magnetic resonance spectroscopy using quantum diamond sensors' [Review of Modern Physics 96, 025001 (2024)].

In addition, a high-magnetic-field, high-frequency electronic spin resonance facility was developed at the Wuhan National High Magnetic Field Center, China. The facility can achieve a frequency range of 210–370 GHz, a temperature range of 2–300 K and magnetic fields up to 50 T.

The second, software section includes the academic symposia, publication of EPR monographs, and teaching courses on magnetic resonance.

Before 2010, the National Magnetic Resonance Conference provided only a small focus on EPR spectroscopy and there was no dedicated EPR conference although some one-off EPR meetings have been held. For example, the 2nd, 8th, 12th and 13th Asia-Pacific EPR symposiums had been held in China. In 2011, a provisional EPR symposium was held with ~30 attendees. This paved the way for an on-going annual domestic EPR Symposium in China. In 2023, about 230 attendees took part in this symposium, indicating that the number of full-time EPR researchers has grown rapidly in China.

Up to the present, there have been close to 20 EPR monographs published in Chinese covering experimental treatises and translations. The latest monograph, titled *Electron Paramagnetic Resonance Spectroscopy – Principles and Applications* by Prof. Ji-Hu Su and Prof. Jiang-Feng Du,



The Home-built W-band EPR Spectrometer.

The Chinese versions of *Electron Spin Resonance Spectroscopy of Organic radicals* (left) and of *Electron Paramagnetic Resonance Spectroscopy – Principles and Applications* (right).

was published by Science Press in March 2022. The Chinese version of *Electron Spin Resonance Spectroscopy of Organic Radicals* by Fabian Gerson and Walter Huber (WILEY-VCH, 2003) was translated by Prof. Ji-Hu Su, and will be published by Science Press in April 2025. Moreover, the translation of *Principles of Pulse Electron Paramagnetic Resonance* by Arthur Schweiger and Gunnar Jeschke (Oxford University Press, 2001) is well on the way, the translation also by Prof. Ji-Hu Su. These crucial monographs will further strengthen the foundation of EPR foundation and applications in China.

There is now annual EPR Summer School held at the end of July, and up to 2024, the total attendance was close to 700. Moreover, since the Spring of 2023, there are

2011 China domestic EPR symposium in Hefei, China.

2023 China domestic EPR symposium in Hangzhou, China.

now a number of flexible, short-term EPR Courses, running for 3~4 days per month in various Universities and Institutes around the country. Up to the end of 2024, more than 1000 people-time have participated in these EPR Courses.

In summary, what has been achieved is clearly seen in the vast range of applications of EPR that have occurred in China in recent years, as well as the fact that these days there are more than 600 EPR spectrometers. With the growth in the number of EPR researchers and technological advances, progress has been made in many different scientific fields, represented by publications in national and international journals. In the future, it is expected that EPR will continue to flourish in China.

Klaus Möbius (1936–2024)

On October 18, 2024, Klaus Möbius passed away in his hometown Berlin at the age of 88. For more than six decades he has been a prominent figure in the field of EPR spectroscopy – in Germany and worldwide. He contributed very substantially to the development of multiple magnetic resonance methods like ENDOR and to high-field EPR. The elegant applications of these techniques in his laboratory to solve complex chemical and biological questions, e.g. in photosynthesis, are legendary. During his entire scientific career, he has been affiliated with the Department of Physics of the Free University Berlin (FUB).

Klaus Möbius was born on June 4, 1936 in Berlin during a difficult political time for Germany – between Hitler's rise to power 1933 and the beginning of the Second World War 1939. He was nine years old at the end of the war. The family was living in East Berlin occupied by the Soviet army; in 1949, the German Democratic Republic (GDR) was founded with East Berlin as its capital. In 1952, Klaus was expelled from high school in East Berlin due to his opposition against the political ideas of the regime. He switched to a high school in West Berlin, where he finished his Abitur (high school graduation) three years later. Already in 1953, his family (Klaus, his brother, and parents) escaped from the GDR, a difficult decision since they had to leave behind all their belongings, relatives and friends – but they never regretted this decision. History showed they were right: in 1961, the "Wall" was built cutting off East from West Germany. The GDR regime lasted until 1989/90. Klaus' experiences during the war and the time in the GDR accompanied him all his life and – according to him – had a profound impact on many of his personal and professional decisions. I had the pleasure to spend the evening of the 9th November 1989 with Klaus in Stuttgart, where he was invited by the Chemistry Department to give a lecture. We both considered this day, on which the "Wall" in Berlin was opened, one of the happiest in our lives!

In 1955, Klaus started to study physics, chemistry and mathematics at the FUB in Berlin-Dahlem, only a few years after its foundation in 1949. During his diploma work (finished 1962), performed in the Physics Department under the guidance of Richard Honerjäger, he built an EPR spectrometer from surplus microwave equipment and an available electromagnet. Klaus was fascinated by the possibilities of this rather new method of molecular spectroscopy that was discovered only ~15 years earlier by Evgeny K. Zavoisky in the USSR. He continued to work in this field also for his doctoral degree that he received only three years later (1965) with a thesis on the EPR spectroscopic and polarographic investigation of organic π-radicals in solution. The work was carried out in the AEG research laboratory in Berlin, where he was employed as laboratory manager from 1962 to 1965. After completing his habilitation in Experimental Physics at the FUB (1969), he spent a postdoctoral year with his wife Uta and their two small daughters, Katharina and Janina, in Southern California (UC Riverside) in the laboratory of August H. Maki. There he became more familiar with electron-nuclear double resonance (ENDOR), a rather new double resonance method introduced by George Feher in 1956 in solid state physics. Gus Maki was first, together with Jim Hyde, (*J. Chem. Phys.*, 1964) to apply continuous wave (cw) ENDOR to radicals in liquid solution, in which Klaus was highly interested.

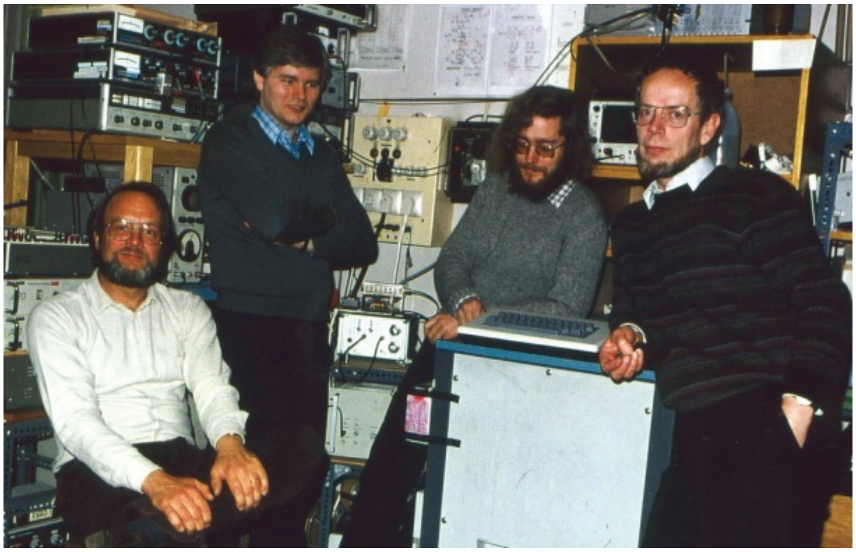
After his return to Berlin, Klaus Möbius soon received a position as professor in the Physics Department of the FUB (1971). The rather difficult task to set up a cw X-band spectrometer for high-power ENDOR was accomplished in his lab by his students Klaus-Peter Dinse and Reinhard Biehl. The instrument allowed experiments to be performed on (bio) organic radicals with an enormous increase in spectral resolution compared to simple EPR. A milestone in the following years was the construction of a cw ENDOR machine with a new resonator and mw/rf channel concept on which the first commercial cw X-band EPR/ENDOR/TRIPLE spectrometer was based developed later by R. Biehl at Bruker (1978). Other novel developments in Klaus' lab were in particular the electron-nuclear-nuclear triple resonance experiments Special TRIPLE (Dinse et al. *J. Chem. Phys.*, 1974) and General TRIPLE (Biehl et al. *ibid*, 1975) that were introduced to enhance the ENDOR signal, for assignment purposes and the determination of signs of the electron-nuclear hyperfine coupling constants (hfcs).

Based on earlier work of Jack Freed (Cornell University) a theoretical understanding of the ENDOR/TRIPLE effect was developed in the group by Martin Plato. This allowed a prediction of the optimal experimental conditions for observation of magnetic nuclei in various types of radicals in different matrices or solvents (Plato et al. *J. Phys. Chem.*, 1981). For the EPR community, this made cw-ENDOR/TRIPLE a versatile method for the investigation of radical species in chemical and biological systems in liquid and frozen solutions/powders, and even in single crystals (Möbius et al. *Phys. Rep*., 1982).

In 1973, I joined the group of Klaus Möbius as a young student (from the group of Harry Kurreck in chemistry). I witnessed all the new instrumental developments and took advantage of them for my diploma and doctoral work (1973–1977), which I did jointly with Harry and Klaus. The vibrant atmosphere in Klaus' group during these years was truly exciting and very stimulating – and I learned a lot about physics and magnetic resonance. I decided to stay and finished my habilitation in chemistry in 1982.

Highlights of Klaus' work during the early years were certainly the applications of ENDOR/TRIPLE to the radical cations and anions (and later radical pairs and triplet states) created by light in the photosynthetic reaction centers (RCs) of bacteria and plants, and on related model systems (Lendzian et al. *J. Am. Chem. Soc.*, 1981; *BBA-Bioenergetics*, 1993). This groundbreaking work elegantly demonstrated the power of these techniques – hand in hand with quantum chemical calculations by Martin Plato – to determine the electronic structure of paramagnetic species in complex biological systems (e.g. membrane proteins) and contributed significantly to the understanding of the function of light-induced charge separation and electron transport in the primary processes of photosynthesis.

A second path of early instrumental development in Klaus' lab, started early in 1974 when Chris Winscom joined the group. He built



Martin Plato, Wolfgang Lubitz, Friedhelm Lendzian, Klaus Möbius at the Physics Department, FUB, ENDOR Laboratory, 1981.

up optical detection of magnetic resonance (ODMR) at zero magnetic field (for a review see Möbius et al. *J. Phys. Chem.*, 1982). Optical detection results in an enormous increase of sensitivity compared to the conventional microwave detection. Following the strategy of the Möbius lab, several multiple resonance techniques were successfully implemented, e.g. optical detection of electron-electron double resonance (ODEEDOR) and of nuclear quadrupole resonance (ODNQR), and also ODMR and ODENDOR at high magnetic field by C. von Borczyskowski and K.P. Dinse (*Chem. Phys.*, 1978), opening new vistas for the investigation of excited triplet state molecules. All these developments paved the way for single-molecule and single-spin detection about ~15 years later, in which former students of Klaus's group were involved (Wrachtrup et al. *Nature*, 1993).

Inspired by the work of Yakov Lebedev (Moscow) in the 1970s, Klaus Möbius recognized the importance of the development of high-field EPR (HF-EPR). In the mid-1980s, he published details of a cw HF-EPR spectrometer build in his lab working at W-band (95 GHz) (Haindl et al. *Z. Naturforsch.* A, 1985). In 1988, the group reported the first cw-ENDOR at W-band (Burghaus et al. *J. Magn. Reson.*, 1988). Pulsed HF-EPR experiments, introduced by J. Schmidt and his group in Leiden in 1989, were soon also implemented by Thomas Prisner during his habilitation in Klaus' group (Prisner et al. *Appl. Magn. Reson.*, 1994). With this versatile instrument, high-field (echo-detected and FT) time-resolved measurements on laser-generated transient radicals and radical pairs could be done over a wide temperature range as well as pulse ENDOR and ESEEM. Later also PELDOR/DEER, RIDME and ELDOR-detected NMR (EDNMR) experiments were performed. Several other groups in Europe and USA got engaged in HF-EPR. In 1996, the first commercial pulse high-field EPR instrument (94 GHz), constructed by Bruker BioSpin, became available. This spectrometer was to a large extent based on the work in the laboratories of Klaus Möbius (FUB) and Jan Schmidt (Leiden University).

Following the trend to higher magnetic fields/frequencies, also in Klaus' laboratory, an instrument working at 360 GHz with a 14 Tesla magnet was constructed (Fuchs et al. *Rev. Sci. Instrum*. 1999, Grishin et al. *ibid*, 2004). All these instrumental and methodological developments together with many interesting applications of HF-EPR performed in Klaus' group – e.g. on spin-labeled bacteriorhodopsin (Steinhoff et al. *BBA-Bioenergetics*, 2000) are described in detail in the monograph that Klaus wrote with Anton Savitsky on High-Field EPR Spectroscopy (*RSC Publishing*, 2009), and in recent reviews (e.g. Möbius et al. *Magnetochemistry*, 2018).

The field received a significant boost through the priority program "High-field EPR in Biology, Chemistry and Physics" of the German Research Foundation (DFG) – not only in Germany, but also worldwide. Klaus Möbius was one of the initiators of this priority program and also its spokesman (1998–2006).

Already in the 1980s, the laboratory of Klaus Möbius at FUB became one of the leading places worldwide for the development and application of (special) magnetic resonance methods and attracted many international visitors, guests, and collaborators. His very good contacts to researchers in biology and biochemistry in Germany and other countries (Hugo Scheer in Munich, Arnold Hoff in Leiden, and others) opened the way to obtain biosamples of excellent quality (e.g. photosynthetic RCs). Klaus was the first professor at FUB to perform biophysical research already in the late 1970s (Hoff & Möbius, *Proc. Natl. Acad. Sci.*, 1978).

Klaus had a remarkable talent to create and maintain a unique working atmosphere in his group at the Physics Department of the FUB. This – and his excellent lectures – attracted many very good diploma and doctoral students – and also postdocs and senior collaborators.

It is remarkable – and understandable – that Klaus, in spite of many opportunities, never left Berlin during his entire career. This was probably due to his dedication and love to the city and his private situation – but most of all owed to the unique working surrounding at the Physics Department of the FUB with sufficient laboratory and office space, several staff and doctoral positions, access to very good students, truly excellent workshops with dedicated personnel, and colleagues, and friends in the nearby Chemistry Department (e.g. Harry Kurreck), who synthesized – often isotope labeled – compounds for new projects, and, last but not least, due to sufficient funding by the university and granting organizations. This enabled a continuity of his research over a period of several decades, which would have hardly been possible anywhere else.

Klaus' excellent scientific projects have been very well funded *continuously* in the framework of three collaborative research units (Sonderforschungsbereiche, SFB 161, 337, and 498) of the German Science foundation (DFG) over an amazing period of 37 years (1972–2009). He also received funds from the DFG priority program High-Field EPR (1998–2006), from the VW-Foundation within the Priority Program *Electron Transfer* (1995–2002), from the Alexander von Humboldt-Foundation, Network Programs of the European Union, and several other agencies.

Klaus Möbius was one of the founders of the European Foundation of EPR Groups (EFEPR) and its first president (1991–1994). He worked for the International EPR Society (IES) for many years as Vice President (1996–1999 and 2012–2013) and President (2014–2015). In 2011, he was appointed as Fellow of the IES. In the broader field of magnetic resonance, Klaus Möbius was actively engaged in the AMPERE Society for many years – he received the prestigious AMPERE Prize in 1998. He also worked for the International Society of Magnetic Resonance (ISMAR), where he was elected as Fellow in 2009. He was member of prize committees (e.g. for the Zavoisky Award, headed by his colleague and friend Kev Salikhov, Kazan), and of many other commissions and review panels in Germany (DFG) and worldwide.

At the FUB he was – over a period of more than 30 years – committed to training the next generation of scientists. He gave excellent lectures at the university, often contributed to magnetic resonance schools and was frequently invited to national and international conferences, which is reflected by his impressive list of lectures. His advice for the next generation of young investigators – taken from an earlier interview – is given as an appendix to this text.

After his official retirement in 2001, Klaus Möbius continued his scientific work, first as part of third-party funded projects at the FUB and then as a permanent guest scientist at the Max Planck Institute for Chemical Energy Conversion in Mülheim/Ruhr (2009–2017), where he collaborated with his former coworker Anton Savitsky and several doctoral students and postdocs using HF-EPR. One of the highlights during these years was a joint project with his colleague and friend Giovanni Venturoli (University of Bologna) on the behavior of proteins embedded in and protected by specific sugar matrices, in particular trehalose. This sugar plays a crucial role in anhydrobiosis ("life without water"), e.g. of plants in arid and hot environments (Möbius et al. *Appl. Magn. Reson.*, 2015). Klaus' continuing scientific activity is best demonstrated by the fact that he published an impressive amount of more than 100 papers after his retirement and wrote two books and one scenic play.

Klaus Möbius received a large number of scientific prizes, awards, and other honors; among them are the Karl-Scheel-Award of the Berlin Physical Society (1966) for his doctoral thesis, the Bruker Prize of the Royal Society of Chemistry, UK (1987), the Max Planck Prize of the Alexander von Humboldt-Foundation (1992), the International Zavoisky Award from the Academy in Tatarstan, Russia (1994), the Philip-Morris Research Award (1996), the Silver Medal (1996) and the Gold Medal (2001) of the International EPR/ESR Society (IES), the AMPERE Prize (1998), as well as the Voevodsky Award (2006) and the N. M. Emanuel Award (2019) – both of the Russian Academy of Science. Klaus has also been a foreign member of the Venice Academy Istituto Veneto di Scienze, Lettere ed Arti since 2002, and of the Academy of Sciences of Tatarstan in Kazan since 2012.

Some of his awards went far beyond his narrow field of work, in particular the Federal Cross of Merit 1st Class (Bundesverdienstkreuz 1. Klasse), which he was awarded in 2006. This was in recognition of his achievements in establishing sustainable international cooperation worldwide, which enabled joint projects, events, and symposia – e.g. with Russia, Israel, Japan, and other countries – as well as mutual visits and research stays, which particularly benefited the next generation of young scientists.

As an outstanding example of Klaus's activities, I remember the journey of a group of scientists from FUB 1989 to the Soviet Union – before the fall of the Berlin "Wall" – that he organized. We visited many Universities and Academy Institutes in Moscow, Akademgorodok, Novosibirsk, Kazan, and Leningrad. Lifelong personal contacts, collaborations, and friendships were established during these weeks that resulted in mutual visits, exchange of students, postdocs and senior scientists and in several joint projects. For many of us – including Klaus – the contact to Russian scientists over the following decades has been important for the development of our specialized magnetic resonance equipment, e. g. high-field EPR. It is terrible that the war in East Europe during the last years have led to a massive deterioration of the relations between Russia and the Western World – including Germany.

Throughout his life, Klaus Möbius worked for peace and international understanding, he actively campaigned against the use of weapons, especially nuclear weapons. It is frightening to see that the possible use of nuclear weapons is being discussed again, for example in the context of the war in Ukraine.

The civilian use of nuclear energy through nuclear power plants has always been taboo for Klaus. Natural disasters such as Fukushima or the targeting of nuclear power plants in the Ukraine war have once again made clear the great danger of using nuclear energy – in addition to the unresolved problem of the final disposal of the radioactive waste. I remember well the discussions that we had with Klaus in Berlin after the Chernobyl disaster in 1986 and when we visited the remains of the coastal towns near Fukushima during our joint visit to Japan – just one year after the destruction of the nuclear reactors by a tsunami in 2011.

Klaus Möbius was also concerned about the massive use of fossil fuels responsible for global warming and was committed to search for alternative, sustainable energy sources. His great interest and his work in natural and artificial photosynthesis were directly related to this dedication. His lifelong fascination with photosynthesis is evidenced by the scenic play "Life on Earth through Photosynthesis" (Bononia Univ. Press, Bologna, 2016), which he wrote together with his friend and colleague Giovanni Giacometti from the University of Padua.

Klaus Möbius loved history and science history, literature, art, and music. He liked to show his guests his extensive collection of old scientific instruments, his books, photos and prints – he had a story ready for each of them. His interests and knowledge, which extended far beyond the natural sciences, entered into his very beautiful last book, which he wrote with Martin Plato and Anton Savitsky: "The Möbius Strip Topology" (Jenny Stanford Publ., 2023), a comprehensive work with excursions into the history of science, architecture, the arts, and many examples related to modern chemistry, nanotechnology, and materials science.

Klaus Möbius was convinced that good scientific collaborations are best built on personal relationships and friendships. He sought contact with other scientific disciplines, from which he received important impulses for his research. His undergraduate and graduate students, and postdocs appreciated his interdisciplinary research approach – it often laid the foundation for their own later work. Personally, I could not have asked for a better academic teacher, mentor, and advisor for my professional career. I am very grateful to Klaus, especially for his help in difficult personal situations and his continuous professional support during the last 50 years. With great pleasure I remember the many discussions we had on scientific, cultural, and also on political and social issues. We were not always of the same opinion – but very often closed our vivid discussion by "agreeing that we disagree" and we still remained friends. I have seen this happening many times with other discussion partners of Klaus – a great way to handle different opinions – and keep a positive relationship.

I remember the many interesting trips with Klaus to scientific meetings and conferences. Coworkers and colleagues often came with us – and sometimes also our wives. Through Klaus' many relationships and friends we all saw and experienced things in Italy, Japan, Russia, and many other countries that would otherwise have remained closed to us. It was wonderful to be able to experience this with Klaus: he was full of detailed knowledge and many stories about history, culture, religion, art, music, literature and he was a great connoisseur of local cuisines.

Thank you, Klaus, for a lifelong wonderful friendship!

With Klaus Möbius we lost an outstanding scientist, an influential advocate for our field of magnetic resonance, a great person and for many of us, a very good friend. We will preserve his memory – and continue his work. We share the mourning with his wife Uta and his daughters Katharina and Janina.

Wolfgang Lubitz
Max Planck Institute for Chemical Energy Conversion, Mülheim/Ruhr, Germany

* * *

Klaus Möbius' message to the young generation of EPR researchers*

"Feel responsible for what you are doing, first of all towards humanity. Too many examples exist in the history of science when the actors didn't care a damn about the consequences of their scientific accomplishments. Don't bow to established thinking of the authorities, be it your professors, the authors whose papers you read in the scientific literature or in the public media, but speak up when you see alternatives. Don't trust those who tell you about the necessity of building up barriers between the "good guys" and the "bad guys" in the world. Perforate those barriers by the possibilities of our scientific community to personally meet people from around the world. Take up the chances for international contacts and cooperation, the field of EPR spectroscopy is flourishing just because of international networking. International cooperation is the best drug against ideology, from whatever side it may come.

If you have an option to choose between different projects to work on, opt for the difficult ones. In most cases in the long run they will turn out to be the most exciting ones. Find a good mentor and chose the best laboratory for your project. Be open and trustful in scientific discussions with your colleagues, even to your competitors. Be honest in your estimation of your own work and the work of others; in most cases we are standing on the shoulders of somebody else. Try to do science according to the highest international standards. This will only be possible if you do it with enduring excitement and full dedication. Allow joy and happiness about a successful experiment to dominate over frustration and disappointment from preceding failures. Such failures are unavoidable in challenging research, and modern EPR certainly belongs to this category. Work hard and don't stop thinking of your project, even when outside the laboratory. Unexpected solutions of a problem often appear under relaxed circumstances. Don't fall into despair when the problems seem to get out of control, but keep in mind that you will be compensated: Your EPR research will ultimately lead to better knowledge and understanding in your field. Moreover, EPR spectroscopy also provides an excellent broadband training and qualification in a variety of scientific disciplines including microwave engineering and complex data analysis. This is highly attractive for subsequent appointments in academic, industrial and medical professions.

Get new inspirations and an infallible feeling for quality standards for your EPR research not only from the literature and your immediate scientific environment. Attend international summer schools, conferences and workshops and listen to the lectures of EPR experts from around the world and controversial discussions. Defend your own results with confidence in the quality of your work, but listen also to constructive criticism from outside. It is my conviction that the future of modern EPR in materials science, chemical kinetics, molecular biology and medical applications is bright – and waits for young researchers to enter the field and to attack new tasks with new ideas and new enthusiasm."

* This text is taken from an interview of Klaus Möbius to the *EPR newsletter* on the occasion of his 75 birthday (*EPR newsletter*, 21/2. pp. 10–11, 2011). We feel that his statements are still very valid today and can be consider as Klaus' legacy for the next generation of researchers in any field of science. We thus decided to reprint it here as part of his obituary.

Wolfgang Lubitz and Laila Mosina,
EPR newsletter of the IES

* * *

I will long remember the first time I met Klaus Möbius. I was a Berkeley Ph.D student with Mel Klein at the time, and Mel stopped by and said, Dave, I would like you to meet my great friend Klaus (such happened often in Mel's group, particularly with all the Alex Pines visitors too). So the three of us went off to the local coffeeshop and had expressos, and that was my first exposure not only to Klaus's scientific interests, but also his passion for art, politics, the environment, and on and on! Klaus and I had another direct resonance once I moved to my faculty position at UC Davis: August (Gus) Maki. Klaus had done a famous postdoc with Gus at UC Riverside before Gus moved to Davis, and they were lifelong friends. In fact, my one co-publication with Klaus is a 2009 Memoriam in the EPR Newsletter about Gus and his amazing EPR career. Fortunately for me, Klaus and I had two major overlapping interests, magnetic resonance (more specifically EPR spectroscopy) and photosynthesis, so I was able to meet with him at a large number of meetings over the years. Those of us in the high field EPR business certainly owe much to Klaus's pioneering work, not only in instrumentation but in applications to important systems such as electron transfer generated radicals in photosynthesis. And his unique insights into broader cultural, artistic, and political issues were always fascinating to hear. One of the many downsides of the global pandemic was to limit such communications, and alas I was not to meet Klaus again after the world froze up in 2020. However, that makes my recollection of spending time with Klaus and Uta in Kazan in 2018 (when I was kindly given the Zavoisky Award) even fonder. Klaus, you will be greatly missed, by me, and our whole community.

R. David Britt,
University of California, Davis, USA

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I first met Klaus at a scientific conference on electron spin resonance at Schloss Elmau in 1972. I remember his great kindness and the interest he showed in our work. I was then a postdoc at the University of Padua, and I was accompanying my supervisor Carlo Corvaja, who had met him a few years earlier: 'I met Klaus in 1964 at a Royal Chemical Society conference. Our encounter evolved spontaneously into a deep friendship. Owing to his extrovert personality, we could converse pleasantly about every subject, including science, the history of physics and art, as well as the history of Europe, which he had experienced in first person in Berlin, back then the focal point of some of the most significant events of the period.'

Over the years, Klaus frequently met several spectroscopists and theorists from the Department of Chemical Sciences at the University of Padua; these encounters sparked fruitful scientific collaborations and marked the beginning of great friendships. I recollect his and Uta's strong friendship with Pierluigi and Francesca Nordio, and the intense exchange of views with Pierluigi in the 1980s on the history of the Second World War, accompanied by lively discussions and interminable historical reconstructions.

In recent times, the long-lasting bond of mutual esteem and friendship between Klaus and Giovanni Giacometti prompted their decision to co-author a book inspired by their shared passion for photosynthesis. The book, published in 2016 and structured in the form of Galilean dialogues, bore the title 'Life on Earth through photosynthesis'.

Donatella Carbonera comments: 'In the 1980s-90s, I admired Klaus Möbius' ability to apply the most advanced EPR and ENDOR spectroscopies to the study of photosynthesis, which resonated with my interests in biology and molecular spectroscopy and ended up sparking an investigation of great cognitive potential. In our collaboration, I cherish the precious memory of his kind encouragements and sincere interest that he showed even in those who were taking their first steps in this field of research.

The 'Life on Earth through photosynthesis' dialogues underscore the dialectic nature of his thinking and represent at once the manifesto of the scientific intellectual as well as his life lesson for whoever met him: science, culture, education and creation of a more equitable society cannot be treated separately and must be a lifelong commitment'.

Marilena Di Valentin recollects: 'I spent the first year of my PhD in Klaus's group in the Physics Department of the Freie Universität. Klaus was perceived as a charismatic leader by all students, owing to his scientific stature as well as his social and political commitment. I recall the vibrant scientific and cultural atmosphere that permeated his laboratory. That period of scientific and human growth is indelibly etched in my mind and accompanies me to this very day'.

My personal collaboration with Klaus was mainly in the context of seminars and European meetings of magnetic spin spectroscopies.

Klaus was instrumental in the creation of a European federation of national electron spin resonance groups (EFEPR), which he chaired for a two-year term, after which he prompted me to replace him for the following term. He was committed to strengthening and facilitating scientific relations in our field between Eastern and Western Europe, setting the stage for building outstanding scientific collaborations as well as personal friendships, such as the one with Kev Salikhov of Kazan University, with whom he established an ideal 'brotherhood'.

Klaus welcomed people into his mental and emotional space with kindness and curiosity, and every encounter with him was a source of human and cultural enrichment. His attention to others was relentless and selfless. A recurring scene that I recall with affection is Klaus' warm welcome extended to some bewildered young students arriving at their first scientific meetings with their posters slung over their shoulders.

In recent years, I had the pleasure of being hosted in Berlin at Klaus and dear Uta's home, and I cherish dearly the memory of those days spent with them.

Marina Brustolon, University of Padua with contributions from Carlo Corvaja, Donatella Carbonera and Marilena Di Valentin, all University of Padua, Italy

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Being the first PhD Student of Klaus, I have the privilege to report about early steps in Klaus's scientific career. When I was a young student, I had the choice between different research groups in the relative new physics department of the Free University in Berlin to obtain the Diploma. I first considered starting in the accelerator group, using a large Van-De-Graaf accelerator inherited from the Max-Planck-Society (former Kaiser-Wilhelm-Gesellschaft) in a large brick tower (still existing today). But then I met Klaus, a very young research assistant in a new research group, developing microwave spectroscopy. Klaus owned a new EPR spectrometer, hosted in the "Baracke", a flat one story building adjacent to the impressive main physics building. For me it seemed to be the perfect possibility to advance technology "hands on", using my expertise in RF technology. The time in the late 50ties and early 60ties was marked by seminal advances in EPR spectroscopy from George Feher, Jim Hyde, Gus Maki, and Jack Freed. Klaus followed this carefully and came in touch with ENDOR in solution during his sabbatical with Gus in Riverside, CA. The power of ENDOR should also be available in Berlin, and he gave me the PhD project in 1968 to develop such an instrument. This task was completed in 1970 using a 1 kW tuned oscillator in close cooperation with Reinhard Biehl, who joined the group later. Klaus arranged for funding and let me go ahead without interference. This was typical for Klaus, trusting his students and coworkers to go their way without micromanaging. This did not mean that supervision of his students was neglected. In contrary, he had regular meetings in his small room in the "Baracke" of less than 8 m^2, in which sometimes sentence for sentence was derived for new publications. Here Martin Plato was an important player, overlooking theoretical aspects and initiating computer applications using the historical, but still operative ZUSE computer in a nearby building.

Habilitation 1969. From left to right: Mr. Hahne, head of the fine mechanics workshop, Klaus Möbius, and Mr. Kurzbach, head of the teaching workshop.

It was also typical for him to generate visibility for his students. His talent finding travel money was outstanding. He tapped into the funds, set-up to enable international contacts for scientists in West-Berlin, being trapped by the wall. So for me it was possible to attend AMPERE meetings in India, Israel, Poland, and Estonia as PhD student and postdoc.

When the high power ENDOR spectrometer was operative over the full temperature range, cooperation not only with colleagues from the nearby chemistry department, led by Harry Kurreck, but also with researchers like Arnold Hoff from Leiden, began. I still remember our excitement, when we observed ENDOR spectra of samples provided by Arnold. The apparently simple way to obtain information about hyperfine interactions of different nuclei and about charge separation was important for Klaus, to center his research on photosynthesis. In the wake of Harry Kurreck, Wolfgang Lubitz appeared, at that time PhD Student of Harry. This was the beginning of his lifelong friendship with Klaus. Seeing the impact of advancing spectrometer capabilities, it was easy for me to convince Klaus developing TRIPLE resonance (1971). The resulting progress in the analysis of hyperfine interactions boosted further research. What did I learn from Klaus?

– Be open for new developments
– Expect the unexpected

– Reach for the top
– Don't hesitate to do hard work
– Be part of the group and let everybody be visible
– Accept the existence of past and present giants

Klaus-Peter Dinse,
Freie Universität Berlin, Germany

* * *

When I heard about the passing of Klaus Möbius, my first instinct was that it simply could not be true. While I constantly see myself and others age, Klaus always seemed to be unaffected by time, with his characteristic looks, an extremely sharp mind and a lot of wit. Even when he was no longer a regular visitor at conferences and encounters become more scarce, it was clear from his publication record that he remained thinking about EPR and science in general. His last scientific article in the web of science dates from 2024.

Klaus entered the field of EPR long before I did, and, like many other EPR spectroscopists, I could profit from the fact that he had paved the scientific path in many areas. I first encountered his name in literature during my PhD in the context of continuous-wave ENDOR, and since Möbius is of course an easy name to remember for any person trained in natural sciences, it was a name that also stuck with me. I don't remember when I talked to Klaus for the first time, but I guess it must have been some time in the mid-90s at one of the conferences. I had by then already discovered that I could use his name as a starting point to search for literature about ENDOR, radicals, photo-induced EPR and ODMR, high-field EPR, EPR on proteins – in short, I could turn to Klaus' work if I wanted to learn about the broad field of EPR and its applications. After meeting Klaus, I soon found out that he was not only very knowledgeable on EPR, but also very much interested in art, politics and history. During conferences, it was a pleasure to hear him talk about these topics till very late at night. He usually accompanied his stories with a glass of wine and a cigarette (or multiples of these), but these late nights did not stop him from asking in-depth questions at the scientific sessions the next morning. As every person, Klaus had his good and bad sides, but he was the kind of person that did not go unnoticed. He was a unique scientist and above all a free spirit. The latter was a direct consequence of having been confronted at a very young age with the horrors of war and dictatorial doctrines in his home country, a history that we should also not forget in current times.

It is sad to realize that Klaus is no longer part of our EPR family. Fortunately, his scientific legacy is carried on by many of his former collaborators, friends and students. Klaus' own words will keep on resonating forever in his books and articles, like a Möbius strip. And after all, it is better to become 88, than not to become 88, as he himself pointed out so many times (changing the number at every birthday). We will miss him.

Sabine Van Doorslaer,
University of Antwerp, Belgium

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Our personal interactions with Klaus Möbius were at magnetic resonance conferences, but we, like many others, were students of Klaus via his many published papers. Those who knew Klaus well will not be surprised that after our first meeting with him, at the next conference Klaus greeted us as old friends. His contributions to the understanding of the photosystem are legendary. We especially studied his contributions to instrumentation and methodology. Beyond the specifics of his research, Klaus was a major contributor to the development of the international EPR community.

Gareth and Sandra Eaton,
University of Denver, CO, USA

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I believe Klaus and I first met at a (Gordon) Conference in the early 1970's. I had a few years earlier predicted the virtues and requirements for doing triple resonance as an improvement over ENDOR for studying free radicals in solution. Its requirement was for very strong NMR irradiation simultaneously at the two nuclear frequencies of the free radical. Klaus had recently succeeded in this challenging experiment confirming my predictions. I got to visit Klaus at his lab at the Freie Universität in Berlin in 1978 when he could demonstrate this experiment for me. TRIPLE (as it was called) had served Klaus well in many studies.

Subsequently we met at many conferences. In 1990 we spent almost five months together during our respective Sabbaticals at the Advanced Study Institute of the Hebrew University in Jerusalem. There we had many social contacts, living in the same apartment building, and got to know Uta and Klaus much better. Also, Renee and I attended symposia honoring Klaus for his 65th, 70th, and 80th birthday celebrations in Germany and he was the honored speaker at conferences celebrating my 65th and 75th birthdays at Cornell, as well as a featured lecturer at the Cornell Chemistry Department when Uta and he could visit for several days. In the process Klaus and I became good friends. In 2001 Renee and I spent a long week in Berlin when Uta and Klaus hosted us. A special memory is that during that visit the horrible events of 9/11 occurred in the US, and Uta and Klaus showed us great warmth and sympathy at their home in Berlin.

In our several visits to Berlin, Klaus and Uta were always wonderful hosts. I remember our trip to Potsdam together during a terrible downpour. Another time when Klaus was taking us around to see Berlin sites, I remember him showing us the many plaques in the sidewalks commemorating where Jewish families lived prior to their extinction during the Nazi regime.

In order to keep up between visits and meetings, Klaus would send me emails with many kind thoughts. I would reciprocate, of course.

Both Renee and I miss our friend Klaus Moebius. He was always so kind and thoughtful in spanning our two cultures. While I emphasize our personal relations, I do wish to point out his great contributions to science, especially to electron paramagnetic resonance, which was a common cultural language we shared.

Jack H. Freed,
Cornell University, Ithaca, NY, USA

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Klaus has made substantial contributions to the development of EPR methodology and has significantly influenced numerous fields, including chemistry and biophysics. Personally, Klaus has been a profoundly influential figure for me — not only through his unwavering commitment to scientific rigor, his meticulous evaluation of data, and his insistence on accurate representation of results, but also through his broader example in life.

Klaus (and undoubtedly Uta) have inspired me to enrich my general education, remain politically engaged, and approach everyone with an open mind, free of prejudice. I believe Klaus's attitude and values will continue to inspire and guide many of us for years to come.

Georg Gescheidt-Demner,
Technische Universität Graz, Austria

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In memory of Klaus Möbius

I still vividly remember the first time I met Klaus; it was during the AMPERE conference in Poznań, Poland, in 1988. It was my first conference as a young PI who had just started her lab. I was struck by how approachable and kind Klaus was – a prominent scientist who took the time to talk to me, asking about my scientific background and future plans. That moment marked the beginning of a long, wonderful, and meaningful friendship.

Klaus was not only a friend but also a mentor. He offered me unwavering support and encouragement, opening doors I could have only dreamed of. One notable example was his invitation for me to join the high-field EPR *Schwerpunkt*, a collaborative initiative he led with Klaus-Peter Dinse in Germany.

Klaus was one of the founding fathers of EPR, a key figure in the development of high-field EPR and the considerable advances it brought to the field and science as a whole. He was deeply passionate about nurturing the next generation of scientists. He actively supported young researchers who dared to venture into this challenging area, generously sharing his vast knowledge. His love and enthusiasm for science were contagious, inspiring all who had the privilege to work with him.

Klaus had a clear vision for the future of our community and how to strengthen it. I remember vividly how he approached me many years ago, asking if I would consider succeeding him as president of the Federation of the European EPR groups he had founded. At the time, I couldn't imagine taking on such a responsibility. But Klaus, with his gentle yet persuasive encouragement, made it impossible for me to refuse. His faith in me gave me the confidence to step into a role I had initially hesitated to accept.

Beyond his dedication to science, Klaus was a remarkable humanitarian. His genuine care for people was extraordinary, and he valued scientific connections and friendships that transcended political barriers. He was honored with a prestigious medal from the German President for his immense contributions to fostering international scientific relations.

The picture is from the BioEPR meeting in Mülheim an der Ruhr with Daniella Goldfarb in 2011.

Meeting Klaus and Uta around the globe or in their welcoming home in Berlin was always a joy. The warmth and kindness Klaus radiated were unparalleled. In the last few years, as travel became more challenging for me due to COVID and the war in Israel, we stayed in touch primarily by phone. Whenever I called, Klaus would answer immediately, his gentle and caring voice greeting me with "Hello, Daniella". It was so reassuring, and I could feel his smile through the line. I will miss him dearly.

Daniella Goldfarb,
Weizmann Institute of Science, Rehovot, Israel

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With Klaus Möbius my dearest friend in EPR passed away. Science brought us together and for more than 35 years our friendship grew in countless contacts during meetings and mutual visits.

I got to know Klaus when I joined Leiden University in the late eighties of last century. At that time, the Berlin group had a strong program that focused on the development of high-field high-frequency EPR. We pioneered the construction of a pulsed EPR/ENDOR spectrometer operating at 95 GHz under the supervision of Jan Schmidt. This entailed a scientific competition, which, thanks to the cooperative nature of the players involved, stimulated both groups through the exchange of ideas and preliminary results. Such interaction continued when the next steps were set, towards EPR at 360 GHz in Berlin and at 275 GHz in Leiden.

For both the Berlin and Leiden groups, the drive to develop EPR at higher fields and frequencies was essentially based upon the impact such a development would have for the application of magnetic resonance in chemistry, material science and biology. Two of my long-term projects illustrate so, the study of the electronic structure of the type 1 copper centre of blue-copper proteins and of the electronically excited states of fullerenes. For both projects I enjoyed many fruitful discussions with Klaus as did my PhD students. I often noticed how much they appreciated the interaction with Klaus in sharing their scientific results.

The efforts of Klaus were key to the flourishing of the international EPR community. He was actively involved in (setting up) a number of EPR networks in the European Union and I was happy to cooperate with him in some of these. A more recent project concerned a Dutch-German cross-border initiative in biosciences. I was particularly pleased with this cooperation, not the least because it resulted in the only publication for which I share the authorship (among others) with Klaus. It concerned the use of nitroxide spin labels to probe the micro-environment at different sites within membrane proteins, a subject of long-term interest of Klaus. The variation from site to site of the low-field part of the 275 GHz cw EPR spectrum turned out to reflect the difference in the proticity of the micro-environment, and the polarity contributes marginally.

In the spare time at scientific meetings, we sometimes visited a museum. Interested in and knowledgeable about art, Klaus visited musea all over the world. On one of my early visits to Berlin I noticed that the walls of the corridors in his laboratory were decorated by posters referring to exhibitions he had visited. I copied this idea for the walls of the attic at home. As an unforeseen joy, this poster wall continuous to remind me of Klaus.

Edgar Groenen,
Leiden University, The Netherlands

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I will not write in praise of Klaus' superb science: others will do that better than I could. Instead, a few remarks to celebrate the man I knew and admired so deeply. In doing so I will focus on three 'words'.

The first is, "kind". In thinking of Klaus, that is always my first thought. He was kind and gracious to all in a way that both drew you to him and put you at ease in his presence, and indeed in your own 'skin'.

The second word is "moral". He had a deep and unwavering moral sense that informed his view of the world, and educated those with the good fortune to share time with him in conversation. He did not preach, but rather served as the exemplar of the moral life.

The third is "family". Once, I was in Muelheim to give a lecture, and before beginning I stopped and took a long look at the faces of an audience filled with so many friends. And as I looked, I realized they were more than friends. In the moment I was moved to formulate the following idea. A person, if extremely lucky, has three families. The first, of course, is the family into which one is born. The second, if lucky, is a family created with a partner and (in my case) daughters and grandkids. The third I think is a precious rarity. The scientific community to which we all belong forms my third family. It is spread throughout the world, but wherever there is a member of that family, I am home. And Klaus was a shining, much missed, member of my family.

Brian Hoffman,
Northwestern University, Evanston, Il, USA

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Klaus Möbius, teacher, mentor and friend

For four decades Klaus Möbius has been a constant presence in my life. In the beginning as a supervisor, then as a mentor and friend. He excelled in, and transitioned smoothly between all these roles. Besides his groundbreaking contributions to magnetic resonance, which made him an eminent scientist, his personality, a combination of integrity, respectfulness, fairness and friendliness stands out.

In many aspects, such as interdisciplinarity and inclusiveness, Klaus approach was *avant la lettre*: Interdisciplinarity – the collaboration with chemists and later with biologists was an active and necessary part of his research activities. Back in the mid-1980's he even hosted an organic chemist in his group, Bernd von Maltzan, to perform the synthesis of porphyrins. Next, inclusiveness: Unlike most physics-groups at the time, in the1980's and 90's, the group had a large female contingent, and at some point, even the majority was female. Klaus fostered this by creating an environment in which everyone felt accepted and valued. As a result, the atmosphere in his group was almost family-like, and social events, like the annual Christmas party and the group excursions were fixed items. Discussions in group meetings could be fierce, and a bit scary to the newcomer, but the underlying atmosphere was one of mutual respect and driven by the aim to solve the problem at hand. Klaus saw science as a universal endeavor, performed by people with a common goal, so the borders between political systems should not impede the scientific progress. Consequently, early on, he initiated collaborations across borders, for example with scientists of the former Soviet Union in the 1980's. The personal ties forged in these collaborations laid the groundwork for future generations, perhaps his personal legacy for 'peace on earth'.

On the level of science organization, the idea that there is enough room for all initiatives to thrive and to work together as a magnetic resonance community was strongly driven by Klaus and the colleagues he assembled. Several successful initiatives for DFG Sonderforschungsbereiche witness his ability to bring research groups together and achieve funding that would lead to developments that united the communities and provided funding for diverse areas.

Klaus' interests in and knowledge about literature, arts and architecture variously entered the science he did, most recently manifested in the monograph the "The Möbius Band Topology". In this respect, Klaus was perhaps the closest one can come to being an "Universalgelehrter" in the modern world. In Klaus' presentations at conferences, art was never far. His audience may remember having seen Henri Rousseau's painting 'The Dream' show up in Klaus' beautifully illustrated magnetic resonance talks to make a point. Not only after powerpoint made this easy, but also, in the early days, when such a painting would have to be printed on an overhead transparency.

Klaus will be dearly missed by all the community, but the seeds he planted and the example he gave should and will live on, even in these difficult times.

Martina Huber,
Leiden University, The Netherlands

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I first met Klaus at the Spin Chemistry Meeting in Konstanz in 1992 when I was a PhD student. The conference was buzzing with EPR studies concerning photosynthetic reaction centers due to the publication of the crystal structure from *R. virdis*. If my memory serves me right, Klaus presented fascinating continuous-wave ENDOR studies on bacterial reaction centers from his group together with molecular orbital calculations; the latter led by his senior scientific assistant, Dr Martin Plato.

With the end of my PhD in sight, I started considering where to do a postdoc. I wrote a letter to Klaus and received a reply (by post) that there would indeed be a possibility for a stipend to join his group at the Department of Experimental Physics at the Free University Berlin, initially for one year. His secretary, Helga Reeck, organized an apartment and I moved to Berlin in October 1993.

Not only was Berlin – soon after reunification of Germany – an amazing place to live, but the atmosphere in Klaus's group was special. As well as the many German students, postdocs and Habilitands with whom I became friends, there was a constant stream of academic visitors from around the world, especially from the former USSR. Listening to their seminars and chatting informally was wonderfully enriching for a young scientist at the beginning of his career and gave me insights that I would never have gained elsewhere.

The group typically went to the university refectory for lunch at 11:30, which was way too early for me, but an important social occasion. I was always amazed how quickly a meal could be consumed, despite constant conversation. Possibly food was merely an appetizer for the main event, namely coffee, which alas I don't drink, and, for Klaus, a cigarette. Of course, one year went by too quickly, and I was delighted that Klaus extended my contract several times and I ended up staying in his group until his "official" retirement in 2001.

I would like to illustrate how my research developed over that period with Klaus's support. The existence of a student workshop in the Physics Department meant that I was able to learn how to use a mill and lathe and hence build my own TM_{110} ENDOR resonators. We employed these to study the electronic structure of photoexcited triplet states of chromophores, especially porphyrins related to chlorophylls, using time-resolved EPR and ENDOR. Some of the molecules were synthesized in the group of Klaus's friend and collaborator, Harry Kurreck at the Chemistry Department at the FU Berlin. Together with Marilena Di Valentin from the group of another of Klaus's friends Giovanni Giacometti in Padova, we performed the first time-resolved ENDOR study on the triplet state of Photosystem II. During that time, I published sixteen papers with Klaus, and later he was generous enough to allow me to publish without him being a coauthor.

Klaus also supported travel to national and international conferences. A highlight was the opportunity to visit Tohoku University in Sendai, Japan in 2000. This visit laid the foundation for many visits to Japan and friendships with Japanese scientists which continue to this day.

To conclude, Klaus had an indelible influence on my life. Moreover, he gave me the freedom to choose my own approach and supported me on my academic journey. This was key to my development as an EPR spectroscopist working at the intersection of biology, chemistry and physics, and subsequently my being offered a faculty position at UCL. Thank you, Klaus.

Chris Kay,
University College London, London, United Kingdom
and Saarland University, Germany

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I first read about Klaus Möbius when I was a postdoc at the University of Leiden, studying photosynthetic reaction centers using solid-state NMR. Of course, we in Leiden quickly became familiar with the work of Klaus Möbius. I was always impressed by the meticulousness of his work. Only later did I realize that Klaus had not only published wonderful EPR work on photosynthesis, but that he was also one of the great pioneers of this method.

I first met Klaus at the Spin Chemistry Meeting in Oxford. He was also familiar with my work on photosystem II using Photo-CIDNP MAS NMR. We hit it off immediately, and he, who seemed so much older to me, treated me very nicely: I felt very honored that he introduced me to some of his EPR colleagues. Later, of course, we met more often and our friendly relationship developed. Today I do not feel the same distance to younger people, with the same age difference, and I suspect that Klaus felt the same way about me.

I quickly realized that Klaus was much more than a one-sided specialist, but that he had a deep knowledge of other countries and cultures, as well as our own. He seemed to me to be a person who, even in his old age, still had a lot of youth in him. He was able to find new aspects in the world that fascinated him and inspired him to research. The result was a knowledge of the world that was not only extraordinarily broad, but also of unusual reflective depth.

Klaus once mentioned that his wife was from East Prussia. He told me about their amazing trips together to East Prussia, which became possible right after the fall of the Berlin Wall. I replied that I could serve a special culinary specialty based on an old family recipe, since my grandmother was also from East Prussia: Königsberger Klopse. So my wife and I invited the Möbius couple to our home in Leipzig, and we enjoyed the humorous way the couple interacted.

Now he has passed away. I will always remember him: his friendly and spirited face, the warm eyes, the warmth in his voice, and the many good words and demanding works. I will be grateful to have met Klaus Möbius personally.

Jörg Matysik,
Universiät Leipzig, Germany

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In Memory of Klaus Möbius by his lifelong colleague Martin Plato

The scientific careers of Klaus Möbius and myself were linked by a long-lasting friendship. It began in 1955 – 10 years after the end of World War 2 – and lasted almost 70 years.

We first met in front of the Physics Institute of the newly founded Free University (FU) in Berlin-Dahlem, Boltzmann-Str. 20. There we both participated in our first joint mathematic course in a rather crowded cellar.

This was the beginning of our exciting even though partly rather tedious academic education ending with our physics diplomas and finally with the promotions by both of us to the title "Dr. rer. nat." in 1965.

On the way to these final academic titles it showed up very clearly where the special scientific talents were located on the two of us. Klaus preferred to tackle problems of chemistry rather than mathematics whereas it was exactly the opposite case with me. However, since we always worked close together, this helped to solve the various mathematical or chemical problems encountered during our studies more easily!

The next big step into a professional job brought us both – naturally together again - into the AEG Research Institute in Berlin-Reinickendorf. There Klaus held a position as the chief of an application laboratory for modern measuring equipment (including ESR), whereas I was responsible for the first computer applications (e.g. simulations of experimental spectra) in the field of molecular spectroscopy. The available computer was the first large AEG-Telefunken computer stationed in Frankfurt/Main. Both our jobs were highly interesting scientifically, and in addition, they were our first payed jobs in industry.

However, Klaus very soon gave up his AEG job because he was given the chance of acquiring a professor's position in the Physics Department of the FU Berlin. This was certainly the best decision for him (and for society) because he was ideally qualified as a university teacher and also as leader of a successful scientific team. The following years showed this very clearly. However, Klaus' decision left me somewhat alone in the AEG lab, but it fortunately turned out a few years later that he finally fetched me into his group (1971).

The cooperation between us continued to be very efficient for the three following decades. Klaus and his group successfully set up different magnetic resonance techniques and applied them to interesting chemically and biological problems – for example light-induced charge separation in photosynthesis and related model systems - and I helped with the theoretical interpretation of the data and their significance for the function of the system studied.

Klaus established very active cooperations with various foreign scientific groups (e.g. from Israel, USA, Russia, Japan, Holland, Poland, and Italy). We all participated in numerous conferences including the presentation of talks and/or posters. The experimental and theoretical results of the group also produced a large number of publications. All group members including higher grade students profited from these activities for their later careers.

This very efficient period lasted until about 2001 when both our appointments at the FU ended by their official pensioning limits. But it continued on a private basis for many more years.

As a kind of coronation of our joint team work within the Möbius group, there recently appeared a book with the title "The Möbius Strip Topology" (Jenny Stanford Publ. Singapore) by the authors Klaus Möbius, Martin Plato and Anton Savitsky. This book describes the important role of the Möbius Strip (a favorite object of Klaus) in Chemistry, Physics, Material Science, Architecture and the various Arts (https://www.jennystanford.com/9789814968201/the-mobius-band-topology).

The recent unexpected death of Klaus was a great shock for me as well as for the vast magnetic resonance community. For me it meant the sad end of a very productive cooperation lasting over 70 years and the loss of an irreplaceable friend.

Martin Plato,
Freie Universität Berlin, Germany

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I joined the Möbius group from 1990-1996, doing my Habilitation in the Physics Department of the FU Berlin. It was a great time and I profited much from Klaus's very well established scientific contacts and from the great atmosphere in his group, the department and the very active magnetic resonance community in Berlin at that time. Klaus had very good scientific connections to the Russian magnetic resonance community. I remember very much a meeting in Berlin with scientists from Kazan and Novosibirsk soon after I started there. His very good connections to Yakob Lebedev were also very helpful for me in constructing the pulsed high-field W-band EPR setup. He and Oleg Grinberg were visiting and brought me W-band Pin-diode switches with very good performance built by Krimov. I also remember that the first time we got echo signals out of this spectrometer Kev Salikhov and Alexander Doubinskii were there as visitors. Kev immediately convinced me to send the first article, describing the spectrometer performance, to *Applied Magnetic Resonance*. And Alexander unstopped a bottle of Crimea champagne directly in front of the spectrometer (whereof I was not so amused). Klaus had similar strong connections to the Italian photosynthesis/magnetic resonance community and to many other groups in the UK and in the Netherlands. Together with the other EPR groups at that time in Berlin (Lubitz, Stehlik, Kurreck, Stößer) this resulted in many visiting scientists from all over the world and also in many fruitful scientific contacts and collaborations. It was a very stimulating scientific atmosphere, with great discussions and support by Klaus and these other peers (together with some of the other young scientists at the same career level at that time in Berlin, as Robert Bittl, Art van der Est, Jenny Schlüpmann and Martina Huber). Klaus was with his many scientific contacts an important propagator of my scientific achievements and great supporter of my further career. Also with respect to teaching: I remember very well that he, as mentor of my habilitation at the FU, participated in almost all of my lectures of my first for the habilitation required official undergraduate teaching course (Experimental Physics 1). This was a demanding first semester teaching course with more than 100 students, including experimental demonstrations and exercises. Klaus's feedbacks after the courses were always very good: friendly and supportive, but also engaging and precise! Typical for Klaus in all of his scientific discussions, which made him so many friends all over the world.

Thomas Prisner,
University of Frankfurt/Main, Germany

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Klaus and I had a dream to spend some time on the beautiful river Kama near Kazan. To sit on the shore, watch and listen to the river and the woods all around. Fishing with a fishing rod or spinning rod. Unfortunately, it was not destined to happen. Pity...

I had three brothers and a sworn brother, Klaus. They were all older than me. I miss them very much. My family and I have visited the house of Klaus and Uta many times. And they have visited us in Kazan. I hope that our families and children continue to be friends.

Berlin and the Free University have played a big role in my life and scientific work. I think that four cities can be singled out in my life: Leningrad (St. Petersburg), Akademgorodok (Novosibirsk), Kazan, and Berlin. I worked a lot at the Free University and found many friends. Dietmar Stehlik and Klaus Möbius got me interested in studying the primary process of charge separation in the reaction center of photosynthetic systems. I continue to study this now. Together with Alexey Semenov from Moscow University, a friend of Dietmar and Klaus, we have been studying the molecular mechanism of the reaction center's resistance to drought and unfavorable temperature in recent years.

Klaus has always been socially active. Therefore, it was interesting and instructive to discuss with him the problems that real life poses to us.

For many years we worked together on the Zavoisky Award Selection Committee. It is not an easy task to select an awardee out of the large number of dignified nominees (sometimes more than forty worldwide) each of which deserves an award. It has always been very useful for me to have Klaus' advice, or to be able to consult with him on different occasions.

In 1993, Dietmar Stehlik and Klaus Möbius recommended me and I was elected as a Fellow of the Wissenschaftskolleg zu Berlin (Institute for Advanced Study). My family and I spent an absolutely unforgettable nine months in Berlin. There were ideal conditions for research there, and I spent this time very productively.

It was assumed that during their stay, each Fellow had to prepare a public lecture. These public lectures had to be of high quality, scientifically meaningful, but at the same time understandable to a wide audience. I shared with Klaus my ideas about what I could give a lecture about. I decided to talk about my work. And I could not think of an attractive title for my lecture. I wanted to tell how sometimes very weak interactions can have big consequences. But in physics, weak interactions can be anything but small. That's why I wanted to avoid the combination of words "weak interaction". While Klaus and I were crossing a large, beautiful forest on our way from the Wissenschaftskolleg to the Free University, Klaus came up with the title "Minor interactions with major consequences in chemical reaction". I was thrilled with Klaus' suggestion. I have been delighted by it for 30 years now. On many occasions when I have to unexpectedly give a popular science lecture, I choose this lecture. And every time I think of Klaus with gratitude, the same as in many other cases.

Klaus Möbius, Wolfgang Lubitz and Kev Salikhov in St. Petersburg, 2015.

Kev Salikhov,
Zavoisky Physical-Technical Institute,
RAS, Kazan, Russia

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I first met Klaus Möbius during the Congress AMPERE dedicated to the 50-th anniversary of the EPR discovery held in Kazan (Russia) in August 1994. At that time, I was a PhD student at the University of Zürich dealing with time-resolved EPR on organic radicals in liquid solution. In the following years, I met Klaus at several EPR conferences. In particular, I remember our conversations at the Spin Chemistry meeting in Jerusalem (Israel) in October 1997. I was already finalizing my PhD thesis and was looking for the best possibility to continue my scientific carrier. Klaus offered me a position in his laboratory at the Free University of Berlin and I was happy to accept the offer to work in one of the best EPR facilities in the world. I moved to Berlin in January 1998. Following Klaus suggestion, I started to work with high-field EPR spectroscopy concentrating on the W-band EPR spectrometer which was in continuous development in Klaus laboratory since the mid-80's. In the following years, I was involved in many projects initiated by Klaus, such as EPR on nitroxide spin labelled proteins, photosynthetic systems and their models, etc. Most of the results we summarized in our monograph "High-Field EPR Spectroscopy on Proteins and their Model Systems" published by the Royal Society of Chemistry (UK) in 2009. I also want to acknowledge Klaus strong support of my interests in the development of EPR instrumentation. As last of Klaus' coworkers, I had to leave Berlin in 2009 and accepted a group leader position at the Max Planck Institute for Bioinorganic Chemistry (MPI BAC) at Mülheim/Ruhr in the department of Wolfgang Lubitz. However, this was not the end of my collaboration with Klaus as he became a permanent scientific guest at the same institute in the same year. We continued our work also after my move to the Technical

Anton Savitsky, Alexander Dubinski and Klaus Möbius in front of the home-built W-band EPR spectrometer after the move to MPI BAC, Mülheim an der Ruhr 2009.

University of Dortmund in 2018. Our fruitful cooperation resulted in more than 60 joint publications and two monographs. The last monograph titled "The Möbius Strip Topology" was published in 2022. It was the last big project of Klaus Möbius and I am happy that I could contribute to it.

During the last 25 years my work with Klaus Möbius developed into a strong friendship – not only between us but also our families. It is very sad to realize that we lost not only an excellent scientist with a deep knowledge and visions in physics, chemistry and biology, we also lost a remarkable mentor and very good friend of many of us. I am personally very thankful for the time I was allowed to spend with Klaus. I will always remember his advises and suggestions for my scientific work and also for my private life.

Anton Savitsky,
Technical University Dortmund, Germany

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When I, as the speaker of the "AK EPR" of the grouping "Magnetic Resonance" in the German Chemical Society, was informed by Wolfgang Lubitz about Klaus' death, I was shocked because, for me and my whole EPR generation, Klaus has always been there. Scientifically, we, as a community, will remember him for his seminal contributions to Electron-Nuclear Double Resonance, high-field EPR, and photosynthesis research. Beyond this, he will be remembered for his ability to connect with people worldwide and to profoundly discuss many different topics also beyond science.

I first met Klaus at a conference shortly after starting my habilitation in Thomas Prisner's group. I don't know which conference it was, but I do vividly remember that we discussed my experiments sitting in a window niche, which, although I was new in the community, gave me the feeling that I was welcome. I learned about another side of Klaus at the EFEPR conference in Budapest, where he told me with sparkling eyes about the Art Nouveau Gellert bath and enthusiastically tried to convince me to also go there, which, in the end, I did. And holy moly, yes, that is a beautiful bath. The last time I met Klaus at a conference was at an Awaji conference in Japan shortly after the Fukushima disaster. There, he gave an enthusiastic after-dinner speech against nuclear energy and for green energy. I will miss Klaus because of his friendliness, enthusiasm, and wide range of interests. At the conferences to come, I, and I am sure many others, will remember and talk about him. And as it is said, as long as one thinks/talks about someone, he is still with us.

Olav Schiemann,
University of Bonn, Germany

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I joined Klaus Möbius' group at the Free University Berlin at the end of the nineties as his last doctoral student. Although Klaus' own career was already advanced at that time, I was from the very first day struck by the pioneering spirit and the curiosity that could be felt everywhere in his working group. Setting up a new EPR experiment or even spectrometer at that time was not a problem if Klaus was convinced of its potential and usefulness for his research. He provided great freedom to the researchers in his laboratory and still managed to keep a forward-looking direction of its own, a great art that I only understood much later.

Science with Klaus was to a large extent conversation, in which he would offer new thoughts on scientific problems and ideas for experiments. It was easy to see what interested him and what didn't, but he rarely discouraged collaborators from trying things and pursuing their own thoughts. Much of Klaus's scientific guidance was simply bringing together scientists, often from different countries and backgrounds, and providing the impetus for joint projects. This leadership was highly effective and created connections that often continue to this day. It was the most inspiring environment that my wife Evgeniya Kirilina and I could have chosen to begin our scientific journey and our life together.

What fascinated me most about Klaus, besides his scientific ideas, was his broad education and his desire to be socially effective and useful. Having grown up and socialized in divided Berlin, he was certain that he could not stand aside from social developments as a person and as a scientist. He never forgot how it came to the special situation in divided Berlin. Nazi Germany's military aggression against its neighbours, especially the war of extermination against the Soviet Union and the Eastern European countries and the annihilation of European Jews, were defining events for him that had to be remembered and from which he drew consequences for his actions.

In addition to advocating for disarmament and peace, Klaus courageously established scientific connections with researchers at institutions in the former Soviet Union, Eastern Europe and Israel. These collaborations, formed in joint symposia, research projects and laboratory visits, led to many lasting friendships that also included many of Klaus's colleagues in the German and European EPR community. These friendships and the relationships of trust they formed are in many cases the basis for an ongoing exchange in today's more difficult political circumstances.

Klaus' death leaves a deep void in our scientific community. He will be greatly missed as a great and generous person and not least because of his role as a mediator.

Alexander Schnegg, Max Planck Institute
for Chemical Energy Conversion,
Mülheim/Ruhr, Germany

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Klaus and I met at the Gordon Conference on Biophysics of Photosynthesis in 1997 in New Hampshire. I immediately felt sympathy and trust for Klaus, and we quickly became friends. Amazingly, he almost instantly understood not only what I wanted to say, but also grasped the deep meaning of what was said. I realized that we were kindred spirits.

A year later, he invited me to come to Berlin with my wife, and we stayed in the hospitable house of Klaus and Uta. From that moment until the end, we often saw each other in Berlin, Moscow, Bologna, Mülheim and Kazan. We became close friends, and often spoke quite frankly.

Klaus was a friendly person with deep knowledge in various fields, the breadth of his interests was amazing. Klaus was extremely modest and democratic; he never made his interlocutor feel his own superiority. I was struck by the fact that during one of my first visits to Berlin, he considered it necessary to show my wife and me many places connected with the genocide of the Jews under the Nazi regime, in particular the platform from which trains departed for the extermination camps in 1943.

In 2003, we received a joint INTAS grant, within the framework of which, during a visit to Bologna, I introduced Klaus to my old friend and colleague Giovanni Venturoli. This acquaintance also developed into a long and successful collaboration and friendship between Klaus and Giovanni. As a consequence of the joint work of the laboratories of Venturoli, Möbius, his student and disciple Anton Savitsky and Wolfgang Lubitz, important results were obtained on the effect of the disaccharide trehalose (a bioprotector) on the kinetics of electron transfer in photosynthetic bacterial reaction centers (bRC). Somewhat later, similar work was done on the much more complicated protein complex photosystem I (PS I) from cyanobacteria with the participation of our laboratory. It was shown that drying in a glassy trehalose matrix at room temperature leads to a slowdown in the kinetics of electron transfer in both bRC and PS I due to the limitation of the conformational mobility of the protein and the long-term preservation of its functional activity in the state of reversible anhydrobiosis.

Klaus was a great connoisseur of music, painting and literature – and he was fond of the history of science. He was interested in the discoveries of the famous mathematician August Möbius, especially the Möbius strip. He knew a lot about the life of Möbius' teacher, the great Carl Gauss. Once Klaus surprised me by telling that Gauss had specifically learned Russian in order to read the articles of Nikolai Lobachevsky, which were published only in Russian. Interest in the Möbius strip led Klaus, together with his long-time colleague Martin Plato and Anton Savitsky, to write and publish at the end of his life a book about Möbius strip-topology structures in mathematics, astronomy, physics, chemistry, biology, music and architecture.

Klaus was a witness of many of the important historical events in Germany – the entry of Soviet troops into Berlin in 1945, the blockade of West Berlin by the Soviet army in 1948/49, the construction of the Berlin Wall and the closing of the border between East and West Berlin in 1961, the youth revolution of 1968 and the destruction of the Berlin Wall in 1989. His stories about these historical events, as well as stories about German science at the Kaiser Wilhelm Institutes in Dahlem were extremely interesting.

Although Klaus lived a long and eventful life, he retained until the end a full interest in what was happening around him. His stories and the discussions with him are sorely missed. He was a very unique person. Blessed and long memory to him!

Alexey Semenov,
Moscow State University, Russia

* * *

Remembering Klaus Möbius

Having known Klaus Möbius through his publications, our paths first crossed in the mid-1990s during the preparation for a DFG priority program, "High-Field EPR in Biology, Chemistry, and Physics". From our very first meeting, I was struck by Klaus' boundless enthusiasm for science and his open, friendly nature. His ideas on applying high-field ESR methods to biophysical questions involving site-directed spin labeled proteins were so inspiring that they not only led to a long and fruitful collaboration within the priority program and subsequent projects but also encouraged me to establish a high-field ESR spectrometer at my own institute.

Our meetings at his institute were marked by invigorating discussions. I came to deeply appreciate him as a colleague and friend whose interests extended far beyond the natural sciences. I also fondly recall my visits to his home and garden, where our conversations were equally insightful but unfolded in a relaxed and familial atmosphere. During my first visit, I was particularly impressed by his extensive collection of historical scientific instruments, each with a story he recounted with enthusiasm and delight.

It was impossible not to be captivated by Klaus' enthusiasm for science. His infectious passion not only energized the work environment around him but also demonstrated how science can be a collective joy. For me, Klaus became a role model, showing how successful science can emerge from friendship and collaboration. His approach continues to influence me to this day.

What stood out most about Klaus was his ability to bridge the personal and professional with such ease. He had a rare talent for creating a sense of community among colleagues, making everyone feel valued and included. He showed us that science is not only about advancing knowledge but also about the shared experiences and relationships that make the journey meaningful. His legacy is not only found in his pioneering contributions to high-field ESR but also in the numerous lives he touched with his warmth and inspiring vision.

Heinz-Jürgen Steinhoff,
University of Osnabrück, Germany

* * *

Klaus, True Mentor in Science and Life

It was almost 50 years ago when I was just a postdoc at UBC and met young Klaus for the first time at the 6th ISMAR Conference at Banff, 1977. At that time Klaus was an already established and well-known scientist in the field of advanced magnetic resonance. Klaus used to very carefully listen to my little scientific achievement in the field of genuinely organic high-spin chemistry, which had not yet been appreciated as today. Klaus encouraged me in his specific way, foreseeing and saying that the field would be broadened and has great perspective. Klaus kindly bought mugs of beer for me and a German postdoc, with whom I made friends during the conference, encouraging both of us to have successful achievements in the long term. Since then, fortunately I used to travel around and met Klaus in many conferences. Klaus kindly arranged and allowed me (as beginning assistant professor) to visit his laboratory in Berlin and give a lecture even while he was away, and I met his colleagues such as young Martin Plato and brilliant graduates, learning how advanced research laboratories were shaping up. Some of them have become professors in Germany. It was always enjoyable for me to meet Klaus anywhere and discuss science and also frankly talk about our own life, including political or even personal issues.

Klaus was a rare foreseer in term of emerging science and technology in academic societies. In his personal correspondence to me in the early 1990s, I found that Klaus was able to project technological advances in high-field/high-frequency electron magnetic resonance in Japan. Some description relevant to this wide perspective of him is found in the Preface of *High-Field EPR Spectroscopy on Proteins and their Model Systems* by Klaus Möbius and Anton Savitsky (RSC Publishing, 2009). We remember that the Sendai-Berlin Bilateral (later Sendai-Berlin-Novosibirsk Trilateral) EPR Conferences had been regularly organized only through the efforts of Klaus – in strong collaboration with the late Prof. Seigo Yamauchi and colleagues in Novosibirsk.

Klaus was appointed as one of the external reviewers for assessing the scientific achievements of our Chemistry & Materials Science Departments and he kindly visited Osaka despite of his very hectic schedule. Klaus patiently interviewed quite a number of our faculty members and completed his review reports quickly afterward. These were truly impressive, among the most elaborately written reports I ever had. One cannot imagine how such reports were appreciated, encouraging the faculty members to go further. I believe Klaus had known that review reports need formalities but those of true usefulness also need fair scientific content and details – and this requires a demanding job. Klaus was such a person, always. Also, I remember that Klaus' style of scientific presentations, precise, persuasive and enjoyable, was very special – it won't be seen anymore.

Klaus was a true mentor for me for almost fifty years since I first met him at Banff, and the one that I have ever had in my life.

Takeji Takui, Osaka City University/
Osaka Metropolitan University, Japan

* * *

I feel honoured to be among those who will pay tribute to the memory of Klaus Möbius. Collaborating and interacting with him has been a privilege and always a joy, because Klaus has been, besides an eminent scientist, a great human being. For me, he has been an invaluable guide in science and a generous friend in life.

Over the last twenty years, in the frame of our scientific collaboration, he catalysed a number of scientific meetings, many reciprocal visits to the respective laboratories in Berlin and Bologna, as well as common vacations, which allowed for enjoyable discussions on issues of both science and the humanities. Among the countless expressions of his exquisite kindness, I cannot forget his welcome when I visited his laboratory in Berlin for the first time, to start an EPR project suggested by him during our first, lucky meeting at Bologna University. Klaus kindly picked up me and my wife at the airport and had the wonderful idea of carrying us by car through a few districts of the city related to his youth time, meanwhile illustrating the urbanistic and architectural features of the places we were passing through and telling episodes of his life. Listening to him, we felt immediately like at home, everything looked so familiar to us and, at the same time, fascinating. Such was the extraordinary empathy and kindness, combined with deep culture and spontaneous affability, of Klaus.

During our long scientific collaboration, I have been struck not only by the originality of his vision and by the lucidity of his analyses, but also by his unique ability to communicate a profound enthusiasm for the project we were carrying on, disseminating it also among the other coworkers. Even when tiredness and discouragement seemed to prevail, talking with Klaus induced miraculously a fresh interest and a positive point of view. This occurred indeed whether we were dealing with physics or discussing about current events of life.

As part of our collaboration Klaus spent rather long periods in Bologna as a senior fellow of the Institute of Advanced Studies. Of the many memories belonging to the time of these visits, one comes often to my mind and moves me. One evening, I was bringing him back to the University residence by car, navigating the city traffic. We were a bit tired and silent after a long day of work and discussions in the laboratory. Suddenly, following presumably the silent course of his thoughts, Klaus told to himself: "Science is so wonderful!". This seemingly insignificant episode tells how deep was his passion for science: the passion of a poet.

Giovanni Venturoli,
University of Bologna, Italy

* * *

Early Memories of working with Klaus Möbius and his group

I first met Klaus in 1969-70 during his sabbatical time in Prof. Gus Maki's laboratory at UC Riverside. He was wrestling with Gus' temperamental ENDOR machine in one corner of the lab, whilst I was cobbling together an early zero-field ODMR spectrometer with "tired" surplus equipment in the other. Back at the FU Berlin, the efforts of Klaus and other colleagues of the Fachbereich Physik, were successful in establishing the SFB 161 "Hyperfeinwechselwirkungen". This new DFG funding allowed me to take up Klaus' attractive offer to join his group in 1974. I shall be forever grateful to Klaus and his wife, Uta, who kindly offered me their hospitality on first arriving in Berlin to ease my way into the new environment. It set the stage for a close working relationship with Klaus for years to come.

Klaus' group was housed in a large single storey structure (lovingly referred to as "die Baracke") in the grounds of the old Kaiser-Wilhelm Institute. Its core-members comprised Reinhard Biehl, Peter Dinse and Klaus' long-term friend and colleague Martin Plato. Functioning EPR and ENDOR spectrometers were already established, and Klaus' vision was to supplement this capability with a well-equipped zero-magnetic field ODMR machine. A functioning version was duly constructed, and working together with a doctoral student, Werner Fröhling, and Peter Dinse, a succession of novel high-resolution ODMR and ODNQR studies was accomplished. Experiments at liquid helium temperatures were long-running, so a frequent late-evening visitor for coffee was Reinhard Furrer, also conducting ODMR experiments, but in high field, elsewhere in FB Physik. (Furrer went on to become a German astronaut on the second Spacelab mission, and later died in a tragic flying accident.) Throughout this early period, Klaus enjoyed a friendly collaboration with Prof. Harry Kurreck in FB Chemie, with a jointly-supervised doctoral student, Wolfgang Lubitz. After the group moved to the new FB Physik building, I shared an office with WL for a number of happy years. We became firm friends, working together on oxygen-carrying cobalt complexes, and discussing the opportunities for EPR/ENDOR studies of metal complexes in areas of biochemistry. At that time there was a noticeable shift in science towards solving specific chemical and biochemical problems by applying many different physical techniques. Klaus' proposal was to use the group's magnetic resonance "menagerie" to study the fundamental processes of photosynthesis. To this end Klaus forged collaborative links with many internationally-recognised scientists in the field of photosynthesis, and the group benefitted from the continual exposure to the frequent prominent visitors.

For me, the experience of working with Klaus and his group and the many international visitors was an interesting, challenging and enjoyable period of my life which I look back on with great fondness. However, nothing in life stays the same, and with the end of the SFB I eventually returned to the UK in 1988 to join Kodak European Research – interestingly, not as a magnetic resonance spectroscopist, but as a photochemist!

Chris Winscom, Brunel University, London, United Kingdom

* * *

I began my journey as a diploma student in Klaus' group in 1989. From the very start, I was drawn to the group's dynamic and collaborative atmosphere – open doors to offices and labs, daily tea meetings, and in-depth scientific discussions that carried on throughout the day. Klaus placed great trust in everyone, including beginners, which allowed me to immerse myself in the project immediately.

At the time, the group was deeply engaged in studying energy and charge transfer in photosynthetic model systems. I worked alongside a PhD student on triplet-state EPR of porphyrin dimers. However, with more students than available spectrometers, we faced the challenge of building an X-band EPR spectrometer with optical access ourselves. The group maintained a repository of unused parts, which we combed through to gather the necessary equipment. As a beginner, this was an incredibly valuable and formative experience. Klaus would often stop by when he had time, helping us navigate the storage and offering insights into the history of various instruments – many of which had played significant roles in past experiments. The group also included experienced members, particularly those working on the W-band machine, who generously shared their knowledge and taught us how to use the equipment effectively. Throughout my diploma work, I never needed to order a single part; instead, I was constantly repairing and repurposing equipment from the group's storage.

Our scientific objective was to identify energy transfer from triplet-state EPR spectra. However, our data clearly showed that no such transfer was occurring. Rather than being discouraged, Klaus showed keen interest in our findings and encouraged us to seek an explanation. Working closely with Martin Plato, we conducted simulations that ultimately clarified our observations, turning an unexpected result into a valuable scientific contribution.

During my year in the group, we hosted numerous visitors from around the world. Klaus took great joy in welcoming them, and their presence infused the lab with fresh ideas and diverse working styles. These interactions were especially inspiring for beginners like me. At the time, Klaus was organizing a conference that attracted a significant number of attendees, particularly from Israel. Having read many papers from some of these scientists I was thrilled to engage in lively discussions with them in the lab. In the years that followed, I had the privilege of visiting several of them, and though I eventually changed research topics, these early connections laid the foundation for my long-standing collaborations with Israeli scientists.

Klaus was not only a brilliant and passionate scientist but also an exceptional mentor and leader who profoundly influenced those who worked with him. Being part of his group and experiencing such a rich scientific community was one of the best decisions of my career. His guidance and enthusiasm left an indelible mark on my journey, shaping my approach to research and collaboration in ways that continue to inspire me today.

Jörg Wrachtrup, University of Stuttgart, Germany

Noboru Hirota (1936–2024)

Hirota-sensei passed away on 28 October 2024. He was a truly great scientist and a gentle supervisor of students. I pray that he rests in peace.

I was his first undergraduate student at Kyoto University when he came back to Japan from the State University of New York in 1976. We constructed instrumentation for studying triplet-state electron paramagnetic resonance (EPR), in which a cold crystal sample in a microwave cavity was irradiated by Xenon (Xe) lamp light, and optically detected magnetic resonance (ODMR), in which the zero-field splitting of the triplet levels was measured by observing intensity changes in phosphorescence caused by microwave transitions. The Hirota Laboratory at Kyoto University was soon established, and many students joined us within a few years.

Hirota-sensei had previously worked in Hutchison's group at the University of Chicago as a research fellow and had become internationally recognized for his EPR hyperfine structure studies of the naphthalene triplet state (*J. Chem. Phys.*, Vol. 40, 3717 (1964)). He was one of the great pioneers of studying electronic excited states by EPR and produced groundbreaking EPR research at Kyoto University on various organic molecules, including carbonyls, substituted benzenes, and nitrogen-heteroaromatics.

In the 1990s, lasers became popular. He introduced pulsed lasers to initiate time-resolved EPR studies. This technique was powerful. He discovered unexpected and novel photochemical processes involving the triplet state of reactive molecules. Today, time-resolved EPR is widely used to analyze fast chemical processes and design new materials.

After his retirement in 2000, Hirota-sensei continued to study the history of modern chemistry and worked on triplet-state dynamics of isolated molecules in a supersonic jet. He published a valuable and fascinating book, *A History of Modern Chemistry* (Kyoto University Press / Trans Pacific Press), available in Japanese, Chinese, and English. Through his writing, he aimed to inspire and support young scientists who would lead the next generation.

He has closed out a life of 88 years, but his legacy and lessons live on with us. It is my hope to hand his lessons down to future generations.

Masaaki Baba, Kyoto University

Alexander Pines (1945–2024)

It is hard to write a tribute for Alex Pines because he meant so many things to so many people. What his former students and postdocs, collectively called "Pinenuts", will agree on is that the biggest impact of Alex Pines was to teach us the power of mentorship. This is what I will dedicate my tribute to after a short description of his resume.

Alex Pines, the Glenn T. Seaborg Professor of Chemistry Emeritus at the University of California, Berkeley, left this world on Nov 1, 2024. He was born in 1945 in Tel Aviv, Israel and spent his childhood in Zimbabwe before moving back to Israel at the age of 16. Fortunately for magnetic resonance, he had Ze'ev Luz as his science teacher in high school, who would later become a world-renowned magnetic resonance spectroscopist at the Weizmann Institute. He pursued a Ph.D. in Chemistry at M.I.T. under the mentorship of John Waugh, studying fundamental principles of NMR, including time reversals in the dynamics of multiple interacting spins and cross-polarization, accomplished using a home-built double resonance NMR spectrometer. His work helped lay the foundations of solid-state NMR as we know it today. After his Ph.D. study that made him famous already, Alex Pines started his independent academic career at the University of California Berkeley in 1972 as an assistant professor in chemistry. Legend has it that his first laboratory space in Berkeley were the hallways of D-level Hildebrand when he was told that his space was not ready yet, since "no" was a foreign concept to Alex. For the next fifty years Pines and his coworkers amazed the community with studies that were at the cutting edge of magnetic resonance, while other explorations seemingly "fell off the edge" into the magical and impossible that years later manifested themselves. In fact, "impossible" was a favorite adjective for experiments that Alex Pines found worthy of pursuing. The scope of his scientific pursuits is too vast to summarize in this short tribute but let me just say that he loved all spins, especially the ones that dance in multiple quantum coherences, electron and nuclear spins alike, and he predicted decades before others that their coupling to light will be an exciting avenue to pursue.

Of all the achievements of Alex, the most impactful one for the magnetic resonance community was the next generation scientists and leaders that he inspired. There are more than 330 Pinenut graduate students and postdocs, of whom more than half are pursuing an academic career and others thriving in other exceptionally successful ways. Alex was a brilliant scientist and a visionary, but first and foremost he taught us that *Science is Human*, *Science is Family*, and *Science is an Open Mind*. Everyone he worked with was "family", and he so convincing called us "brilliant", an adjective that we were not used to being described with, that he made us begin to believe in his fantastical version of us.

Of course, in his scientific pursuits, the crazier the ideas the better. We often left meetings with Alex, just having enthusiastically agreed to something, instantly regretting "what did I just commit to?" Remote detection, MRI brain helmet, Ex-situ NMR, hyperpolarized xenon biosensors – those were the "hot topics" in the Pineslab in the years I was there.

Pinenuts fondly remember how they made "magic" work: with crooked home-built probes that just have to hold up one more experiment, using hastily cabled-up spectrometers that are better checked to make sure the amplifier was not taken out the day before by a fellow pinenut for their urgent "mission-to-mars", and to trust one's nose, ears and eyes if strange smells or signals appear, because "proper protocols are for pedestrians, not for Pinenuts!" (which of course was a delusion).

Alex was a pioneer of diversity and inclusion well before it was trending, and a feminist ahead of his time. How so? He had a unique capacity to empower everyone around him. He really SAW you for who you are. He valued those who were ambitious, those who were conscientious, the deep thinkers, he recognized who is the "soul of the group" and the good listeners, or the brilliant debaters. Everyone had a role, and he always saw the best in his students. He elevated women scientists early on without us realizing it at a time. Only later we learned that his actions were very intentional to give his girlnuts "wings".

Here is a story I want to share. After my first year as a Postdoc, I told Alex that I am not sure about academia, and I shared my reasons with him. He listened intently, and then said: "You did not convince me. Remember, confidence is practiced!" He then told me an anecdote, that John Waugh said "Alex, I have a secret to confess. I always worry when will everyone figure out that I am a fraud?" Alex told me that John Waugh was the most brilliant men he knew, and yet he had imposter syndrome, adding with a smile: "Well, I don't have that problem!" I was not convinced that I should be in any shape or form compared to John Waugh, but he gave me the wings I needed to keep pushing forward.

Alex cheered all of us on, in and outside of academia. The number of people he kept in contact with is astonishing. It was also clear that he never once thought that a scientific achievement or accolade was more important than family, friends, life and living. Alex treasured life.

There is a lot of emphasis on professional development today, but there is something that cannot be prescribed. The power of a mentor who believes in you, and who deeply cares with a big heart. This will inevitably blur the boundary between personal and professional space, but how can it not be in a profession that is about raising the next generation leaders. So many of us would remember to text him photos, memes, jokes and words of love on special events, like family does.

Alex reminded us, through his action, that Science is still a uniquely human experience that relies on humanity. How so? Only a human is capable of understanding that we do not know what we don't know. Alex loved to quote John Cleese: "If you are really really stupid how can you even recognize that you are stupid"? Only a human is capable of being humble in light of the vastness of the universe and the wonder of biology. So, Alex taught us to be generous and open minded, to give others space and to help elevate everyone around us, since there is space for all of us and all of our ideas.

Songi Han,
Northwestern University

Ralph T. Weber (1958–2024)

It is with profound sadness that we announce the passing of our esteemed colleague and friend, Ralph T. Weber. Ralph passed away unexpectedly on November 17th, 2024, at the age of 66 in his home in Watertown, Massachusetts. He is survived by his wife Anne Lawthers, his brother Michael, and his parents Bärbel and Kenneth. Our heartfelt condolences go out to his family during this difficult time.

Ralph began his scientific journey at Brown University, where he earned a B.A. in Chemistry and German Literature and Language in 1980. He continued his education at the University of Chicago, obtaining a Ph.D. in Chemistry in 1984, focusing on EPR and ENDOR studies of proteins and lanthanide complexes under the guidance of Prof. Clyde Hutchison. Ralph then pursued two postdoctoral positions: at Leiden University in the Netherlands, where he studied excited states of molecules using ODMR and designed a high-frequency pulse EPR spectrometer, and at MIT, where he worked with Prof. Robert Griffin on motional dynamics in lipids via solid-state NMR and contributed to the design of a DNP spectrometer.

Ralph joined Bruker in 1989 and dedicated 35 years to helping our customers with unwavering commitment and expertise. His exceptional ability to connect with and support clients had a significant impact on the EPR community worldwide. Ralph's passion for his work was evident in every interaction, leaving an indelible mark on our organization. Beyond his customer service excellence, Ralph was a mentor and teacher to many younger colleagues. He generously shared his extensive knowledge of electron paramagnetic resonance spectroscopy, fostering a culture of learning and growth within our team. His dedication to teaching and mentoring has shaped many careers, and his legacy will continue to inspire us all. We will deeply miss Ralph's kindness, wisdom, and the positive energy he brought to our workplace.

The memories shared here by those who knew Ralph paint a vivid picture of his well-lived life. Due to space constraints, we couldn't include all the cherished memories that highlight the countless ways Ralph touched our lives.

Art Heiss, who hired Ralph at Bruker and was his manager for decades, wrote: "Ralph's depth of knowledge and unwavering attention to detail quickly became hallmarks of his professional life. His exceptional writing skills resulted in clear, practical manuals that set a high standard for usability, and his commitment to assisting others often went above and beyond, ensuring users felt confident and supported. A gifted communicator, Ralph delivered lectures on applications and instrumentation that were as insightful as they were impactful. He was deeply respected by colleagues and customers alike, becoming a trusted source of knowledge and inspiration within the Bruker EPR community. His legacy will be cherished by all who knew him, as both a brilliant scientist and a generous mentor. His contributions to research and education will continue to resonate in the lives he touched."

Gareth and Sandy Eaton from Denver University worked extensively together with Ralph on several projects. "It would be difficult to find anyone who uses EPR whose research or other applications of EPR have not been directly impacted by the ideas of Ralph Weber. His Ph.D. study of lanthanides is now recognized as more important than at the time of his graduate study. His up-conversion, down-conversion innovation in high-frequency (95 GHz) EPR instrumentation during his postdoctoral studies in Leiden are the foundation for almost all non-X-band instruments. In his role as application scientist at Bruker, Ralph taught many people how to use EPR spectrometers and worked out methods individually for many research groups. From the many years of vigorous interactions with Ralph, we select one anecdote that displays his style of interaction with strange requests from EPR users. One day during our development of Rapid Scan EPR, Gareth called Ralph and asked him if he could rotate his X-band ENDOR resonator 90 degrees in the magnet – is there room for it? He said, "well maybe, but why would you?" Gareth waited while Ralph tried. Then Gareth said he wanted to use the magnetic vector of the RF radiation as the rapidly scanning magnetic field. As quickly as we could schedule time to work together, we implemented the idea (and we bought a Bruker ENDOR system). Although we are supposed to use units of tesla, Ralph enjoyed that we could report field scans in Giga Gauss per second."

Sunil Saxena, a professor of chemistry at the University of Pittsburgh, met Ralph more than 20 years ago. The two became close friends when they started a partnership that has impacted

July 2019, Rocky Mountain Conference. From left to right: Kalina Ranguelova, Gareth Eaton, Marylin Heiss, Art Heiss, Sandra Eaton, and Ralph Weber.

April 2003, Denver University, The Eatons' laboratory.

July 2022, University of Pittsburgh, Sunil Saxena's group. From left to right (back row): Xiaowei Bogetti, Ralph Weber, Andrew Deng, Niko Moriglioni, Kevin Singewald, Suni Saxena; (front row): Alysia Mandato, Hannah Hunter, Zikri Hasanbasri.

not only Sunil's career but that of graduate students in his group. "In my computer there is a subfolder for each member of the group. The last entry is "RalphWeber_honorary member". Ralph and I go back more than two decades. Simply put, Ralph was the gentlest and most well-meaning person I have ever met and all he wanted was to help people as much as he could. I cannot overstate how much I appreciate the help he provided me and my group. When service was part of EPR he would endlessly and selflessly help us debug our spectrometer issues, patiently arranging loaners at critical times for me (right before tenure and beyond). There is no part of my independent academic journey that Ralph has not been a part of. In between all these years, Ralph was an ever-present figure in my group. "Ask Ralph" was a phrase every member of my group has heard. And he was there patiently explaining, patiently helping debug, and until service was part of EPR, arranging loaners or workarounds so research could continue. Ralph was Bruker-EPR, and

January 2020, Budapest, Hungary, Bruker BioSpin Global Sales and Services meeting. From left to right (back row): Stojan Mitrovic, Silke Kummer, Peter Hoefer, Ralph Weber, Hideyuki Hara; (middle row): Anne Lawthers and Manuela Liberi; (front row): Jessi Yang, Kalina Ranguelova, Antoine Wolff.

Bruker-EPR was Ralph. Sales was never his job description, but inherently he understood the sales did not end upon "proof-of-specs." He took the long-term view, cared deeply about learning continuously, enabling science and the next generation of scientists, and he kept research groups going. In doing so, many of us kept going back to Bruker EPR."

While everyone described Ralph as a brilliant scientist, he was also a world traveler. According to Peter Hoefer, a former Director of the EPR Business Unit at Bruker BioSpin "Ralph joined Bruker one year after me and we were colleagues for more than 30 years. It was always a pleasure to have a skilled and passionate person like Ralph aside. He was also a gifted teacher, and he loved to travel, as a result he was giving EPR training courses all over the world and was worldwide acknowledged as a scientist. Each year I have looked forward to meeting Ralph at the Rocky Mountain Conference to exchange our ideas about EPR. He will be dearly missed by his family, friends, Bruker, and the worldwide EPR community."

"Ralph Weber was a wonderful friend, scholar and scientist" Glenn Millhauser, a professor from University of California, Santa Cruz, added. "His passing is a true loss to the EPR community. I've known Ralph since my early days as an assistant professor. He was always willing to share his vast knowledge and do so in such a friendly way. Whether a conference or visit to my lab, it was always great to see him. Incredibly fun and interesting to talk science and, even better, talk about the history of EPR – its developments and the interesting people behind those developments."

According to Stefan Stoll, a professor from University of Washington, "Ralph's expertise in all things EPR was unparalleled. There was no topic he didn't know about, nor any type of sample he hadn't measured at some point. The spectrometer manuals he authored are invaluable treasures – my students study them religiously. Some of the most fascinating things about continuous-wave EPR I learned from Ralph, such as the fact that the circulator leaks slightly from port 1 to port 3 and that the matching process includes compensating for this leakage. When a user described some unexpected behavior in a spectrometer, Ralph would begin his response with "This could have a variety of reasons" before launching into a comprehensive list of potential causes."

Ralph's current manager at Bruker BioSpin, Frederic Jaspard, was working with Ralph for only 4 years, but he "immediately recognized an exceptional technical expertise, truly remarkable and greatly appreciated by all of us and by our customers."

Ralph was not just a coworker but also a cherished friend to all of us. Always willing to lend a helping hand, Ralph was known for his intelligence and positive energy that brightened our workplace. His readiness to assist anyone in need and his insightful contributions made him an invaluable part of our team. We deeply miss Ralph's kindness, wisdom, and the uplifting spirit he brought to our daily lives. We will always remember him, honor his legacy, and carry on his mission.

The Bruker EPR Team

May 2024, Bruker BioSpin, Ettlingen, Germany, EPR Applications Meeting. From left to right: Yu-Kai Liao, Ralph Weber, Frederic Jaspard, Kalina Ranguelova, Sylwia Kacprzak, Hideyuki Hara, Thilo Hetzke, Alvaro Montoya, Dmitry Akhmetzyanov, and Donald Mannikko.

Demystifying Phase Noise

Timothy J. Keller

Bruker Biospin Corporation, Billerica, Massachusetts 01821, United States

As an EPR spectroscopist, you may hear about an esoteric term called "phase noise". This term is often used to describe the quality of the microwave source in the spectrometer bridge. The phase noise is critical for CW EPR and important for pulse EPR experiments. In this article we will discuss the concept of phase noise in EPR spectroscopy, and the role phase noise plays in determining the performance of an EPR spectrometer.

An EPR spectrometer relies on a radio frequency (RF) or microwave source to induce the transitions between spin states. An ideal source has a perfect sinusoidal output with no amplitude or phase modulations. A "real" microwave source, however, will have small fluctuations in the phase and amplitude of the output. The phase and frequency are closely related by a derivative (the derivative of the phase is equal to the instantaneous frequency of the microwave source). Therefore, any modulation in the phase of the source will result in a corresponding broadening of its frequency spectrum. In Figure 1, we show the frequency spectrum of an ideal source as a single tone and the "real" source as a broadened line. Any contribution to the frequency broadening is lumped together into a parameter called the phase noise. Many things contribute to phase noise including thermal noise, flicker noise, temperature fluctuations and microphonics. At low offset frequencies, flicker noise (or 1/f noise) dominates. Thermal noise (also called Johnson noise) is independent of offset frequency and sets the baseline noise level of the frequency spectrum for the microwave source.

The phase noise of an RF source is defined as the noise power relative to the carrier power in a 1 Hz bandwidth at a specified carrier frequency offset. The phase noise of a phase locked loop (PLL) based synthesizer operating at 9.5 GHz is shown in Figure 2. You can see that the phase noise tends to decrease at higher frequencies. Flicker noise can be identified by a decrease in phase noise of 30 dB per decade. Because the phase noise depends on the offset frequency from the carrier, it is important that all phase noise values are given with a corresponding frequency offset.

The phase noise at 1 kHz offset frequency and 100 kHz offset frequency can be drastically different for a given microwave source. For example, a typical PLL synthesizer (such as shown in Figure 2) has a phase noise of would have a phase noise of approximately −82 dBc/Hz at 1 kHz offset and −90 dBc/Hz at 100 kHz offset.

The phase noise of a microwave source can be measured with a spectrum analyzer or phase noise analyzer. A spectrum analyzer phase noise measurement will be limited by the phase noise of its internal reference. A phase noise analyzer will use a cross-correlation method which will allow measurement of the phase noise down to −180 dBc/Hz at 100 kHz offset. By convention, the phase noise values on the positive side of the frequency spectrum, also called the upper side band, are reported.

At X-band frequencies (8–12 GHz), there are many options for a microwave source. Various sources and their typical phase noise performance are listed in Table 1. For high performance EPR spectrometers, a specialized cavity stabilized Gunn diode source is used which has extremely good phase noise performance. Alternative sources which are commercially available are YIG tuned oscillators and phase locked loop (PLL) based frequency synthesizers. Klystrons are a vacuum electronic device which were commonly used in the early days of EPR spectroscopy but are now largely obsolete except in cases where high power is needed at W-band and mm-wave frequencies.

The phase noise requirements are very different for CW and pulsed EPR applications. In CW-EPR, where field modulation and a

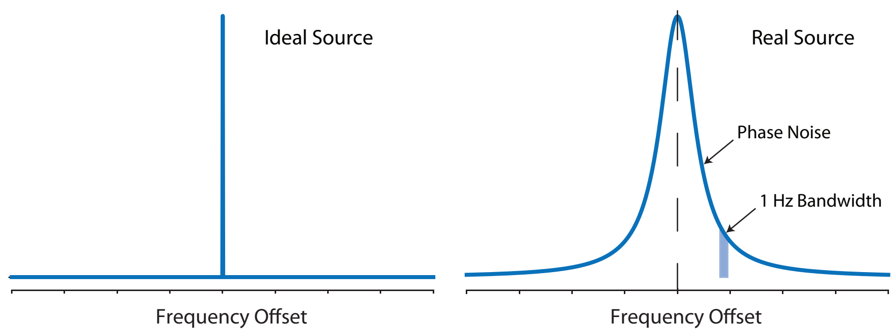

Figure 1: An ideal source showing a single frequency (left) and a real microwave source with frequency broadening caused by phase noise (right).

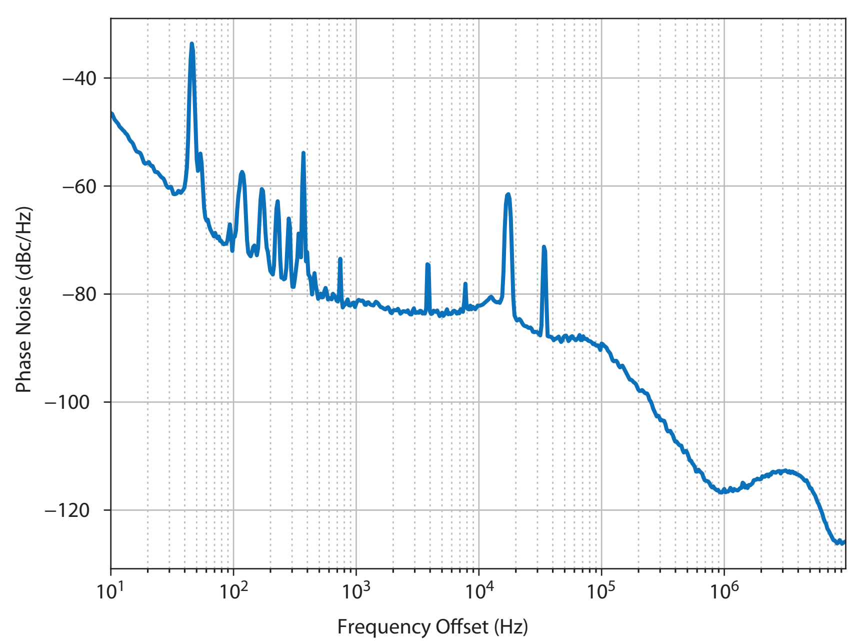

Figure 2: Measured phase noise of PLL synthesizer at 9.5 GHz. The positive side band of the frequency spectrum is shown. The peaks are spurious tones generated by the phase frequency detector of the PLL.

Table 1: A summary of microwave sources for X-band EPR spectroscopy.

Source	Typical Phase Noise at 100 kHz offset (dBc/Hz)	Price	References
Gunn Diode	–120 to –150	$$$	[1, 2]
YIG	–110 to –130	$$	[3, 4]
PLL Synthesizer	–90 to –125	$	[5]
Klystron	–100	$$$	[6]

lock-in detector are used, the phase noise at the field modulation frequency is critical. In most cases this is 100 kHz, so we need to consider the phase noise at 100 kHz offset from the carrier. The microwave sources with the best phase noise at this offset frequency are Gunn diodes or YIG sources. In a CW EPR measurement, the phase noise can be thought of as raising the noise floor of the instrument. A lock-in amplifier will narrow the detection bandwidth, but the baseline noise level is determined by the phase noise, thermal noise, and receiver noise figure. In high Q-factor resonators any frequency modulation from phase noise results in amplitude modulation at the detector, so it is particularly critical to use an ultra-low phase noise source for applications with high Q resonators. In high performance CW EPR spectrometers, a single ended Schottky diode waveguide mixer is used for detection. If the signal and LO for the mixer are coherent, as is the case for an EPR spectrometer, the mixer has the benefit of cancelling out some of the phase noise [7]. However, this doesn't cancel out noise from sources uncommon to the signal and reference arm paths (e.g. the resonator, attenuator, circulator, etc.).

You may consider increasing the modulation frequency to reduce the effect of phase noise. This is in fact a common method to decrease contributions from 1/f noise, however, there are other important considerations for EPR spectroscopy. If field modulation is used, the modulation coils present a significantly inductive load which makes driving them at high frequencies difficult. The modulation coils are "tuned" by adding a series capacitor to cancel out the reactive inductance of the modulation coils, but at very high frequencies the skin depth and proximity effect substantially increase the impedance of the modulation coils. This makes driving the modulation coils at frequencies above several hundred kHz impractical. In addition, the relaxation times of the electron spins set a maximum modulation frequency limit. In the case of very narrow EPR signals (<50 mG), 100 kHz field modulation will produce sidebands in the EPR spectrum, so a lower modulation frequency is necessary to avoid distorting the EPR line shape [8].

In the case of pulsed EPR, the phase noise of the microwave source is much less critical. The microwave pulses are typically very short and less than several hundred nanoseconds. The phase of the microwave source does not have enough time to change from the start to the end of the pulse sequence. The signal typically decays fast enough that the phase noise does not make much difference. In addition, any long pulsed EPR experiments (e.g. inversion recovery) are typically incoherent (only z-component of the magnetization is important) so long-term effects of phase noise will not affect the experiment. For pulsed EPR measurements, a PLL based frequency synthesizer can be used.

A closely related parameter to phase noise is "jitter" which is important for pulsed EPR systems. There are several closely related definitions of jitter, but most commonly it is defined as the root-mean square (RMS) jitter in units of time. The RMS jitter of an RF source is closely related to the phase noise. The jitter can be calculated by integrating the phase noise over a defined frequency range, so a larger phase noise would directly translate to higher jitter. The jitter in digitizers is important to minimize if using an intermediate frequency for detection. The digitizer phase shift can be calculated from the RMS jitter by $\Delta\phi = 2\pi\, t_{\mathrm{RMS}} f_{\mathrm{IF}}$, where $\Delta\phi$ is the RMS phase shift in radians, t_{RMS} is the RMS jitter and f_{IF} is the intermediate frequency.

For high frequency EPR, frequency multiplication is often used to generate frequencies in the several hundred GHz range. When the frequency of a source is multiplied, phase noise degrades by $20\log_{10}(N)$, where N is the multiplication factor [9]. For example, if the frequency is multiplied by 2, the phase noise will degrade by approximately 6 dB. Thus, for high frequency CW EPR applications, it is common to use a microwave source with ultra-low phase noise due to the degradation of phase noise that will occur when the frequency is multiplied.

In summary, this article provides a general overview for the concept of phase noise in EPR spectroscopy. The phase noise is an important consideration when deciding the microwave source for a CW-EPR spectrometer. In certain cases, such as with low Q-factor resonators and pulsed EPR, the phase noise is not as critical and other design considerations will determine the spectrometer performance.

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The 13th Asia-Pacific ESR/EPR Symposium (APES2024)

October 19–23, 2024, Hangzhou, China

The 13th Asia-Pacific EPR/ESR Symposium (APES2024) was successfully convened from October 19th to October 23rd in Hangzhou, China. The symposium was co-hosted by University of Science and Technology of China and Zhejiang University, attracting over 100 experts and scholars from universities and research institutes worldwide and across China.

The symposium focused on the cutting-edge development and application research of EPR/ESR science and technology, with themes covering a wide range of disciplines including fundamental physics, materials, chemistry, biology, and quantum information. Participants came from countries in the Asia-Pacific regions such as China, Japan, Russia, Australia, India, and the United States, as well as European countries like Germany, Switzerland, and Poland. The five-day event featured 5 plenary lectures, 28 invited lectures, 2 Young Scientist Award presentations, 7 oral presentations, and 20 poster presentations.

The five plenary lectures were made by world-renowned scientists in the EPR/ESR community, which included: "EPR for probing electrostatics in a DNA repair enzyme and peptides in cells" by Prof. Elena Bagryanskaya from Russia, "In vivo tumor extracellular pH mapping using electron paramagnetic resonance" by Prof. Hiroshi Hirata from Japan, "Radical-functionalized materials: New EPR approaches and applications" by Prof. Matvey Fedin from Russia, "Distance distributions for ensemble modelling of the disordered human proteome" by Prof. Gunnar Jeschke from Switzerland, and "Electron Spin Resonance: from spin ensemble to single spin" by Prof. Jiangfeng Du from China. To encourage outstanding young researchers and graduate students, the symposium awarded 2 Young Scientist Awards, 3 Best Oral Presentation Awards, and 5 Best Poster Presentation Awards. Dr. Zhang Qi from Zhejiang University and Assistant Professor Yuya Ishikawa from Fukui University in Japan were honored with the 2024 APES Young Scientist Awards.

President of APES Society, Prof. Jiangfeng Du delivering opening remarks.

The conference received support from the National Natural Science Foundation of China, and was sponsored by EPR/ESR equipment manufacturers including CIQTEK, CryoPride, LBTEK, Kelvince, Bruker, Dojindo, etc. The successful hosting of this conference is beneficial for enhancing academic exchanges between Chinese and internationally renowned scholars, fostering interdisciplinary and collaborative research across various fields.

At the General Meeting held on October 22 during the symposium, the following researchers nominated at the Council Meeting were elected as the APES Council Members for Term 2024–2026.

Officers:
President: Prof. Jiangfeng Du (China)
Vice President: Prof. Kazuhiro Marumoto (Japan)

APES2024 Group photo.

Prof. Elena Bagryanskaya presenting APES2024 YSA Award to Dr. Zhang Qi (left) and Dr. Yuya Ishikawa (right).

APES2024 Best Poster Presentation awardees and awarders.

Vice President: Prof. Fazhan Shi (China)
Immediate Past President: Prof. Elena Bagryanskaya (Russia)
Secretary: Ms. Ying Rui (China)
Founder President: Prof. Czesław Rudowicz (Poland)
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Country/Regional Representatives:
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China: Prof. Shangda Jiang
India: Prof. Balachandra G. Hegde
Japan: Prof. Akio Kawai
Philippines: Dr. Marvin Jose F. Fernandez
Republic of Korea: Prof. Sun Hee Kim
Russia: Prof. Matvey Fedin

Advisory Council Members:
Prof. Hitoshi Ohta (Japan, former President & Vice President APES)
Prof. Hiroshi Hirata (Japan, former Vice President of IES)

Asia-Pacific EPR/ESR Symposium is the highest-level academic conference initiated by Asia-Pacific EPR/ESR Society, held biennially since 1997. It has been hosted in various locations including Hong Kong, Hangzhou, Kobe, Bangalore, Novosibirsk, Cairns, Jeju, Beijing, Nara, Irkutsk, Brisbane, and Hefei (online). During this symposium, APES Society's council meeting decided that Prof. Jiangfeng Du would continue to serve as the President for the new term, and it was agreed that the 2026 International Symposium would be hosted by Saitama University in Japan.

Professor Jiangfeng Du,
President of Asia-Pacific EPR/ESR Society,
and
Ying Rui,
Secretary of Asia-Pacific EPR/ESR Society

The 63rd Annual Meeting of the Society of Electron Spin Science & Technology

November 2–4, 2024, Fukui, Japan

The 63rd Annual Meeting of the Society of Electron Spin Science & Technology (SEST2024) was held from November 2nd to 4th, 2024, at Bunkyo campus, University of Fukui, Fukui, Japan. The Society of Electron Spin Science & Technology (SEST) in Japan was established in 2002 in Tokyo where the joint conference on the 41st ESR Symposium and the 7th *in vivo* ESR Workshop was held. Since then, SEST has held scientific meetings annually in various cities in Japan, and in 2024, the annual meeting SEST2024 was held in Fukui for the first time.

The total number of participants to the scientific part of the meeting SEST2024 was 171 including 71 graduate or undergraduate students. We had 44 oral and 60 poster presentations in addition to 3 plenary lectures, 4 award-winning lectures and 2 mini-symposia consisting of a total of 12 talks. One of the symposium lectures was held as a free public lecture. Both the number of presentations and the number of participants were comparable to those at recent annual meetings. The timing was good as the Hokuriku Shinkansen line extension to Fukui opened in March 2024, allowing people to come directly to Fukui from Tokyo.

In the afternoon of November 3rd, the SEST annual general meeting (AGM) was held. Board members of SEST reported the current status & activities, and the future plans of the society to the members. Further, SEST welcomed Dr. Seiji Miyashita, who has made outstanding achievements in theoretical studies of spin systems, as a new honorary member. After the AGM, award ceremonies and award lectures for the SEST Awards, SEST Academic Award and Young Investigator Award were held. The SEST Awards were given to two researchers. Prof. Kazunobu Sato (Osaka Metropolitan University) received the SEST Award for his achievement entitled "Development and Application of Pulsed Electron Spin Multiple Resonance Technology", and Dr. Toshikazu Nakamura (Institute for Molecular Science) received the SEST award for his achievement entitled "Magnetic Resonance Study of Functional Molecular Assemblies". SEST Academic Award was given to one researcher: Prof. Kazuhiro Marumoto (University of Tsukuba) for his achievement entitled "Development of operando electron spin resonance method and exploration of novel phenomena in organic-inorganic devices". The Young Investigator Award was given to one researcher: Dr. Tsubasa Okamoto (Kobe University) for his achievement entitled "Elucidation of Electronic Functions in Photoresponsive and Bio-related Materials Using Advanced Spin Measurement and Analysis Techniques".

In this annual meeting, three researchers from overseas were invited for plenary lectures. Dr. Sergey Vasiliev (University of Turku, Finland) presented interesting quantum phenomena in phosphorous doped silicon observed with his excellent techniques of mm-wave ESR measurements under the title of "Dynamic nuclear polarization in silicon at ultra-low temperatures". Dr. Malcolm Forbes (Bowling Green State University, USA) presented his cutting-edge research on stable and transient radicals in unusual environments under the title of "Influence of topology, architecture, and environment on spin polarization transfer: implications for quantum information science". Dr. Lloyd L. Lumata (University of Texas at Dallas, USA) presented his excellent dissolution dynamic nuclear polarization system using a microwave irradiation at cryogenic temperatures which is utilized to improve cancer diagnostics under the title of "Dissolution dynamic nuclear polarization: Enhancing NMR and MRI signals by >10,000-fold for metabolic assessment of cancer".

We had two mini-symposia. The first mini-symposium on the morning of November 3rd was entitled "High power light sources

SEST award winners, from left to right: Kazuhiro Marumoto (SEST Academic Award), Toshikazu Nakamura (SEST Award), Tadaaki Ikoma (SEST President), Kazunobu Sato (SEST Award) and Tsubasa Okamoto (Young Investigator Award).

Poster Presentation and Excellent Presentation award winners at SEST2024, from left to right: Nana Tomita, Sota Tsujimura, Tsukasa Sakai, Yuto Hamada, Mai Taguchi, Sae Fukui (Poster Presentation Awards), Akane Yato, Naoko Iizuka (Excellent Presentation Award) and Tadaaki Ikoma (SEST President).

pioneer the frontier of magnetic resonance", organized by Dr. Yuya Ishikawa (University of Fukui). After the short introduction by the organizer, five speakers were scheduled. The first talk was "State-of-the-art of development of high-power, high-frequency gyrotrons" by Prof. Yoshinori Tatematsu (University of Fukui). Note that "gyrotron" is one of the most powerful light sources in far-infrared (or terahertz) region and University of Fukui is known as one of the world's leading centers for gyrotron development. The following four speakers presented applications of gyrotrons to magnetic-resonance measurements, and their expectations and potential applications for the future: "Current status of the development of high-frequency pulsed ESR systems" by Prof. Seitaro Mitsudo (University of Fukui), "High-frequency and high-field ESR studies on metalloproteins by using high power gyrotron" by Dr. Masaki Horitani (Saga University), "Electrical detection of antiferromagnetic dynamics" by Prof. Takahiro Moriyama (Nagoya University), and "Methods and instruments for high-field MAS DNP toward intracellular structural biology" by Dr. Yoh Matsuki (Osaka University). The second mini-symposium on the morning of November 4th was entitled "Understanding life phenomena opened up by spin" organized by Prof. Ken-ichi Yamada (Kyushu University). After the short introduction by the organizer, five speakers were scheduled: "Development of MRI Contrast Agents Based on Organic NO Radicals" by Dr. Satoru Karasawa (Showa Pharmaceutical University), "Quantum Monitoring of Cellular Functions Through Nanoscale Spin Control" by Dr. Hitoshi Ishiwata (The National Institutes for Quantum Science and Technology), "Cancer cell damaging effect and reactive oxygen scavenging activity of a planar catechin analog" by Dr. Hiromu Ito (The National Institutes for Quantum Science and Technology), "Imaging brain metabolic alterations in immune-fatigue model mice using hyperpolarized ^{13}C spin" by Dr. Shingo Matsumoto (Hokkaido University), and "Thinking about Fat 'Rust'" by Prof. Ken-ichi Yamada (Kyushu University). Since the last talk was held as a free public lecture, the speaker gave it from a very easy-to-understand level. It was good also for non-specialist researchers, because SEST involves researchers from a wide range of fields related to electron spin science.

SEST recognizes several young members with two types of presentation awards, the Excellent Presentation Award and Poster Presentation Award, in every annual meeting to encourage young researchers. The winners of these awards are selected by judging processes from among presenters who have applied in advance. The Excellent Presentation Award is given to young researchers under the age of 32 who give outstanding oral presentations. In SEST2024, this award went to Naoko Iizuka (Showa Pharmaceutical University) "Development of radical-based particles to establish MRI quantitative for Ascorbic Acid" and Akane Yato (Kagoshima University) "Measurement of structural flexibility of enzymes using spin labeling-ESR" out of 6 candidates. The Poster Presentation Award is given to students who presented their research results with well-prepared posters. The recipients of this award were Nana Tomita (Hokkaido University), Sota Tsujimura (Kobe University), Tsukasa Sakai (Osaka University), Yuto Hamada (Kobe University), Mai Taguchi (Hokkaido University), and Sae Fukui (Saitama University).

The reception of the meeting was held at Fukui Palace Hotel near University of Fukui in the night of November 3rd. 110 participants greatly enjoyed the food and drink, including local dishes and sake from local breweries. Among the sake that was served, the limited brewed Kokuryu "Shizuku" and Hanagaki "Shigoku no Hanagaki" were particularly valuable and hard to find, which were supplied with the cooperation of a local sake shop. Everybody was very happy to have face-to-face mutual communications.

The meeting would not have succeeded without the support of University of Fukui, the Fukui Tourism Federation, and the sponsorship of 12 companies including top sponsors Bruker Japan K.K., JEOL Ltd., and Vega Technology Inc.

The next annual meeting is scheduled in November 21st–23rd, 2025, in Kiryu, Gunma prefecture, Japan. We are looking forward to lively discussions there.

Yutaka Fujii, Professor,
Chair of SEST2024,
Seitaro Mitsudo, Professor,
Vice-chair of SEST2024,
Yuya Ishikawa, Senior Assistant Professor,
General clerk of SEST2024,
University of Fukui

Time for a Shift

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"...spin exchange ... which has major contribution to our understanding of bimolecular collisions in solutions ... has undergone a minor revolution since 2016 led by the theoretical work by Salikhov..."

Barney L. Bales and others
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Ever since I published "Fundamentals of Spin Exchange. Story of Paradigm Shift" in 2019 I intended to have an open discussion about the merits of a paradigm shift.

Understanding of this paradigm shift is important for those who:

- are involved in interpreting the shape of EPR spectra recorded under stationary conditions and the time dependence of the signal response in pulsed EPR experiments;
- use the spin probe method to determine the frequency of bimolecular collisions in gases, liquids, polymer solutions, biological environments, filters, etc;
- use the effect of dynamic nuclear polarization (DNP) to increase the sensitivity of nuclear magnetic resonance (NMR) spectroscopy, including to increase the resolution in medical magnetic resonance imaging scanners.

For decades, the spin exchange has been analysed through the lens of established understanding, which sometimes was not sufficient to explain experimental results.

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It's my pleasure to invite you to participate in an **online conference** 17–20th of June 2025, where we will:

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The intention is to reflect together on the scientific reasons a paradigm shift is needed.

You are invited to be part of the evolution of spin exchange, which is undergoing a paradigm shift.

Materials of the conference will be available in different formats:

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We invite presentation submissions and registrations for this online conference and are looking forward to welcoming many of you there.

Prof. Kev M. Salikhov
05.05 2025

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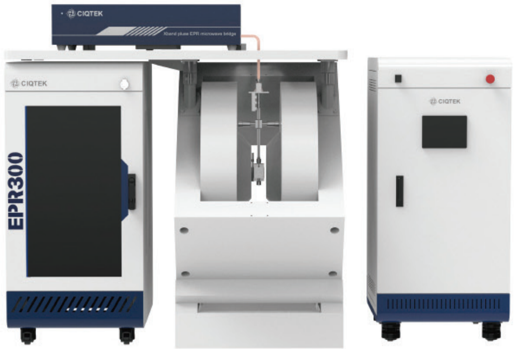

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Temperature stability: ±0.2 K

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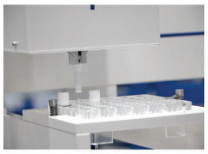

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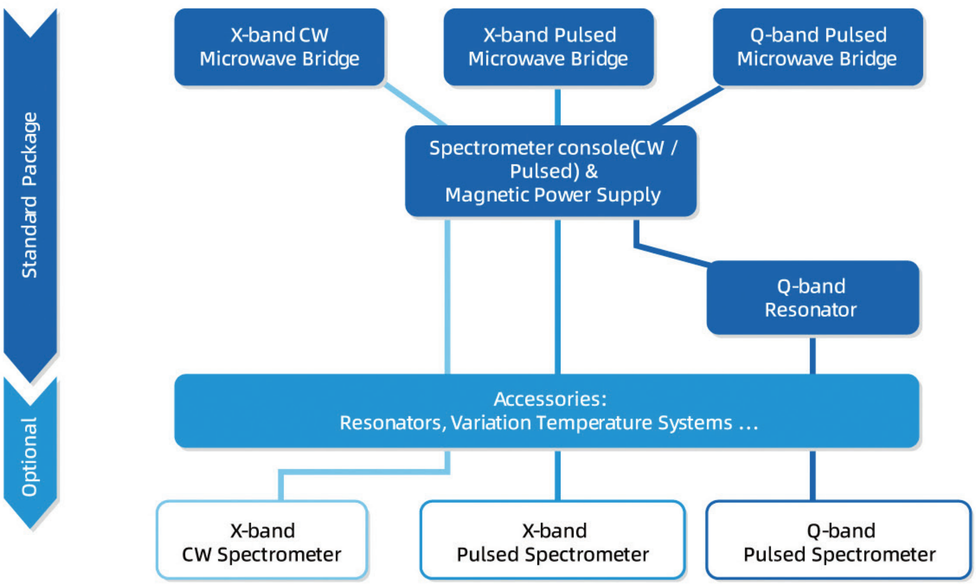

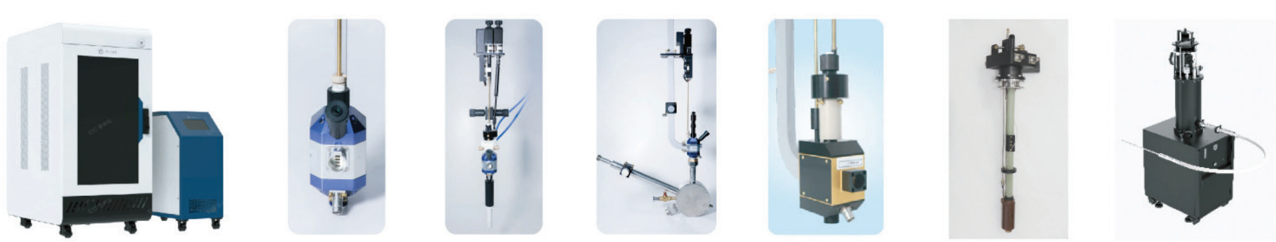

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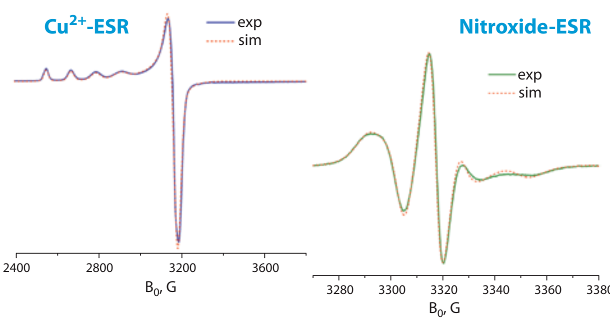
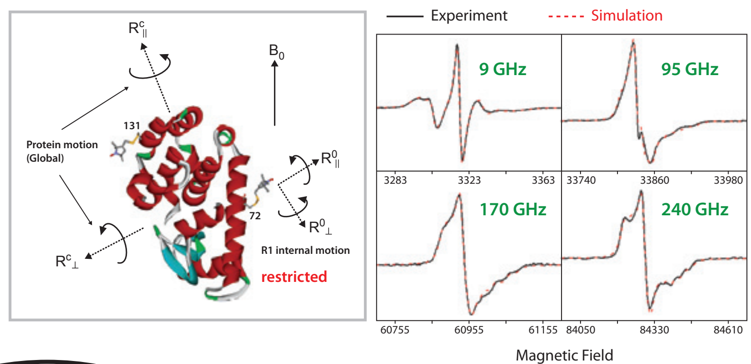
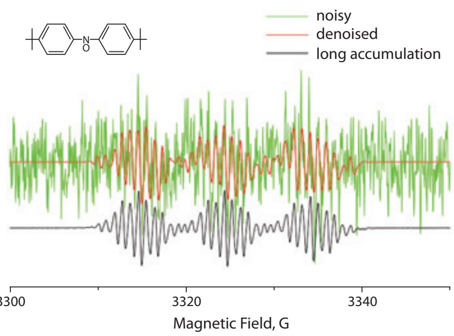


Multifrequency ESR

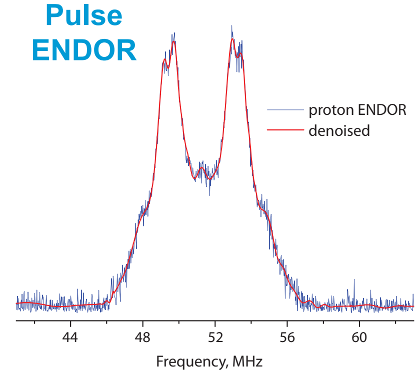


Denoising

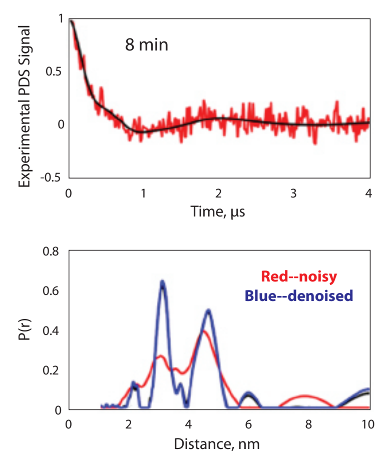


1) Perform ESR Measurements
2) ESR Data Analysis
3) Advice on ESR Experimental Design
4) Standard Samples
5) Contact Info Above

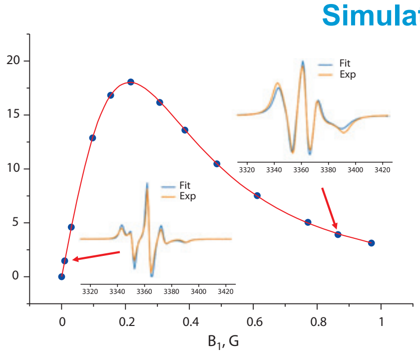
Pulse ENDOR



DEER & DQC



Simulation



Saturation Curve

2D ELDOR