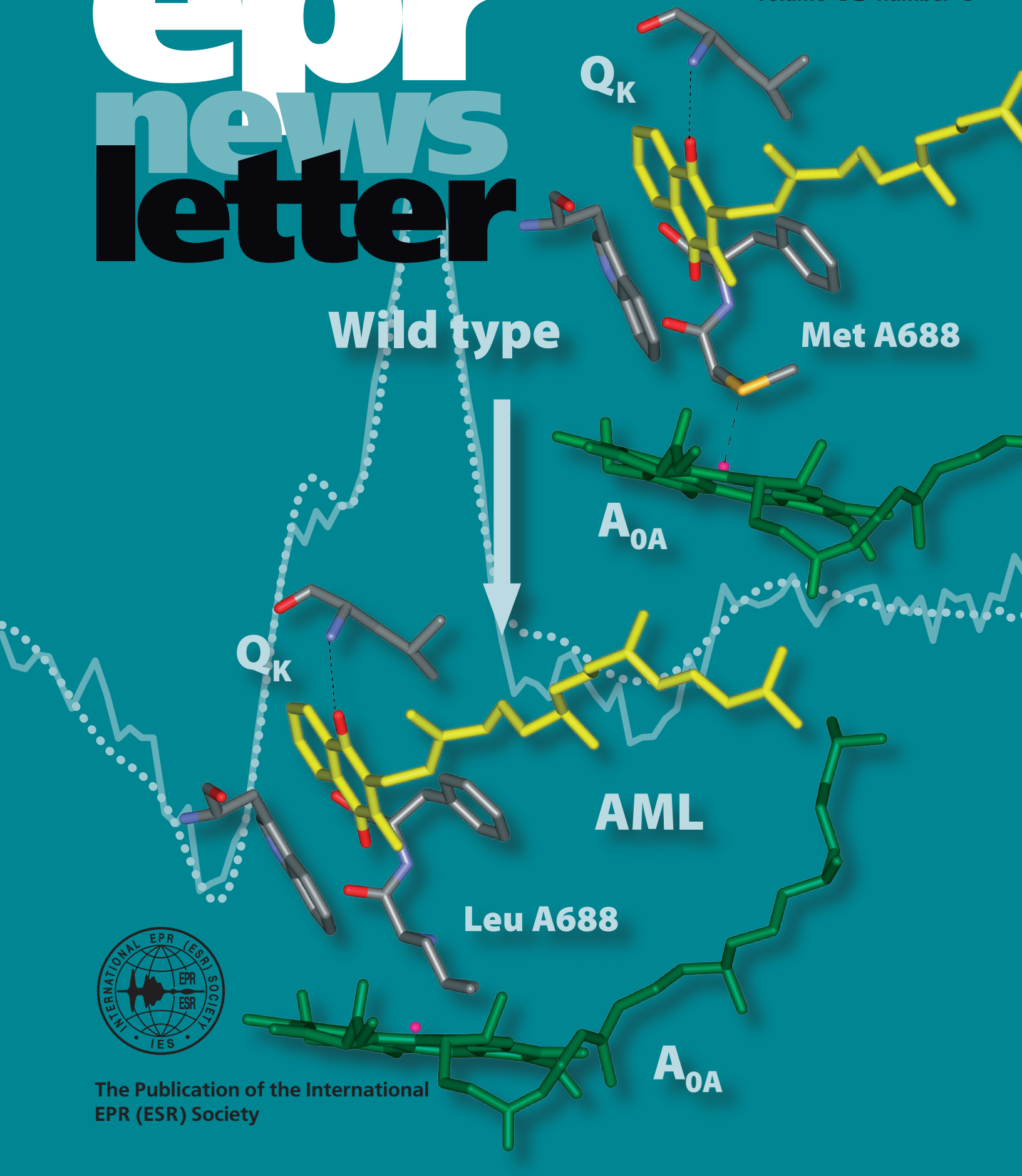
epr newsletter

2006
volume 15 number 4



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

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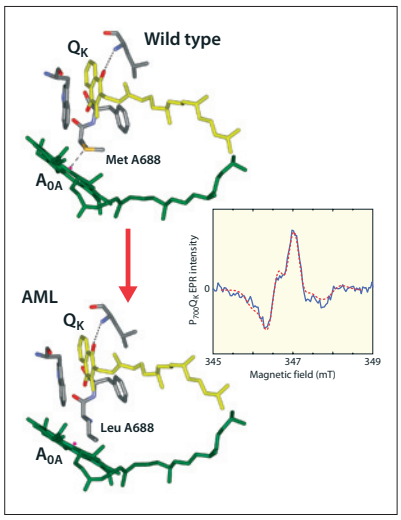
Please feel free to contact us with items (news, notices, technical notes, and comments) or ideas for the *EPR newsletter*.

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

PRINTING: LaPlume and Sons Printing, Inc.
One Farley Street, Lawrence MA 01843 USA
phone: (978) 683-1009, fax: (978) 683-4594



The cover picture illustrates a recent research example of the stimulating and long-standing cooperation of Kev Salikhov (Kazan) with the experimental group of Dietmar Stehlik (Berlin), Zavoisky Awardees 2004. The structure pictures show details of the reaction center environment of photosystem I (1JB0) around the primary electron acceptor A_0, a chlorophyll (Chl a) molecule. In Wild type it is ligated by an unusual Mg-S ligand bridge provided from the side chain of a methionine amino acid. Mutation of this particular methionine (Met) residue to the nonreactive leucine (Leu) side chain in the A-branch of the two symmetric electron transfer pathways (AML mutant) modifies the A_0 acceptor properties. In fact, the lifetime of the charge-separated state, with an unpaired electron (and hole) at the primary donor P700 and a transferred electron at A_0, is slowed down from about 50 ps to about 2 ns in the AML mutant. The corresponding change in the electron spin polarization pattern (observed with time-resolved EPR after the electron moved from A_0 to the quinone acceptor Q_K) is shown together with simulation based on the model of consecutive radical ion pair states as described in detail in Salikhov K.M., et al.: Appl. Magn. Reson. **24**, 467–482 (2003). The observed spin polarization pattern depends strongly on the lifetime of the unpaired electron spin on A_0. The best simulation is obtained for 1.5–2 ns.

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The Publication of the International EPR (ESR) Society

volume 15 number 4 2006

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

It is with deepest regret that
we have to inform you that
Arthur Schweiger
passed away
on January 4, 2006

An obituary will follow in a later issue

photo of the issue

see page 17

TAKE OUR QUIZ!

The Photo of the Issue shows a beautiful flower with a mysterious fivefold symmetry (see the article by Alex Müller, p. 6) in the daylight (left), and in the UV light (right). Guess who can see the flower as it is shown on the right. Send an e-mail message to the editor with your answer. Deadline March 15, 2006. If we will get more than one correct answer, a raffle will be held to decide who is the prize winner. The prize is a package of seeds of lovely fivefold-symmetry flowers.

Our quiz of *EPR newsletter* 15/2

Unfortunately, we have to announce that the relevant photo of the issue reminded our readers of nothing related to EPR and we got no answer to the quiz. "Science meets Arts", the lovely Bruker calendar, stays at the desk of the editor.

Editorial

Dear colleagues,

When I first met Alex Müller in person on August 15, 2004 in Kazan at the International Scientific Forum dedicated to the 200th anniversary of the Kazan State University and the 60th anniversary of EPR, I gave him the printout of the Nobel issue 14/1-2. Two days later he told me that he studied this issue with great interest and that he was amazed to read Richard Ernst's article about Tibetan tangkas, and to find a fivefold mandala in this essay (14/1-2, p. 16). To answer an unasked question in my eyes, he clarified that he is fascinated with the fivefold symmetry. As an example, he told me what made the USA and the USSR paint fivefold stars on their missiles. This time it was me who was amazed. As a little girl, I wondered why my country and the USA, as different as they were, had the same symbol on their ammunition and it was fantastic to get the answer to this question many years later from a Swiss Professor at an EPR conference in a conversation seemingly so far from this matter. I was fortunate that Alex Müller presented me with the opportunity for an extensive discussion on various subjects during his stay in Kazan and finally he agreed to think of preparing a relevant article for the 'Another Passion' column (p. 6). Having recently read Dan Brown's "The Da Vinci Code", I liked Alex Müller's article much more than this bestseller (see also the fivefold-symmetry book in the Arthur Schweiger's column, p. 18). Frankly, it was a particular delight to communicate with Alex Müller. A great man, he emanated wisdom, cleverness, friendliness and a wonderful sense of humor. These feelings are exactly what I recollect from my meeting with Harden McConnell when he came to Kazan for his Zavoisky Award 2000. He was great, had unaffected manners and the charming smile of a man with a good sense of humor. The '*EPR newsletter* Anecdotes' column (p. 10) featuring stories by Larry Berliner, Betty Gaffney, Brian Hoffman, Wayne Hubbell, and Harden McConnell, provides an exciting insight into the life of McConnell's lab and into the personality of Harden McConnell.


TAKEN BY ARTHUR SCHWEIGER

TAKEN BY ARTHUR SCHWEIGER

We part with 2005, the year of the 100th anniversary of Einstein's Annus Mirabilis. Albert Einstein and the city of Zurich are intimately intertwined. Einstein studied at the ETH Zurich (see a photo of the house where he lived as a student). Later, he was a professor at the University and – following an excursion to Prague – a professor at the ETH. 2005 is also the year of the 150th anniversary of ETH Zurich (see an article by Richard R. Ernst, 15/1, p. 12). In honor of this occasion ETH Zurich made the Zurich years of Albert Einstein accessible to the public (see a photo of a poster of the exhibition "Einstein in Zurich").

In the New Year 2006, I wish you all good health and further discoveries in EPR, this fascinating field of science. Let the EPR newsletter have an increasing flow of contributions and enhanced feedback from our dear readers!

Laila Mosina

Are you interested to become a member of the International EPR (ESR) Society? Please find the registration/information form for new/continuing members of the IES and non-credit-card payment instructions for individual members on this Web site: www.epr-newsletter.ethz.ch/contact.html

Keith A. McLauchlan's Fellowship of the IES

The award of Keith A. McLauchlan's Fellowship of the IES was made by Klaus Möbius at a special Symposium in Keith's honour on the final afternoon (Friday, 16 September) of the 9th Spin Chemistry Meeting (11–17 September, 2005) held in St John's College and the Physical & Theoretical Chemistry Laboratory, University of Oxford. The Symposium took the form of invited lectures from 7 of Keith's former students, former postdocs, colleagues and friends. It was followed by the Conference dinner in St John's College, which was also in Keith's honour. Further information on the conference can be found at: scm2005.chem.ox.ac.uk/SCM2005ConferenceBook.pdf

Peter Hore

Klaus Möbius (left) and Keith McLauchlan (right)

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Awards

The Zavoisky Award 2005 to Hal Swartz

The Zavoisky Award 2005 in Electron Paramagnetic Resonance Spectroscopy was awarded to Professor Harold M. Swartz (Dartmouth Medical School, Hanover) in a ceremony marking his outstanding contribution to the development of in vivo spin-trapping EPR and EPR oximetry for clinical applications.

The ceremony was preceded by the Annual Workshop "Modern Development of Magnetic Resonance", 26–28 September 2005.

The Zavoisky Award was presented on September 28, 2005 in Kazan, the capital city of the Republic of Tatarstan. It was there that academician E. K. Zavoisky discovered EPR in 1944. The Zavoisky Award consists of a Diploma, a Medal and one thousand US dollars.

The Zavoisky Award was established by the Zavoisky Physical-Technical Institute of the Russian Academy of Sciences with support from the Kazan State University, the Springer-Verlag Publishing House, the Republic of Tatarstan, the Tatarstan Academy of Sciences, the AMPERE Society and the International EPR Society. The Award Selection Committee consisted of well-known experts in EPR: Professors G. Feher (La Jolla), D. Gatteschi (Florence), H. M. McConnell (Stanford), K. A. McLauchlan (Oxford), K. Möbius (Berlin), A. Schweiger (Zurich), and the Chairman, K. M. Salikhov (Kazan). The selection of the Awardee was made after consultations with the Advisory Award Committee which comprises B. Bleaney (Oxford), Yu. N. Molin (Novosibirsk), and Yu. D. Tsvetkov (Novosibirsk).

R. F. Muratov (left), K. M. Salikhov (center), and H. M. Swartz (right)

Previous winners of the Zavoisky Award were: W. B. Mims (1991), B. Bleaney (1992), A. Schweiger (1993), J. R. Norris, Ya. S. Lebedev and K. Möbius (1994), J. S. Hyde (1995), G. Feher (1996), K. A. Valiev (1997), J. H. Freed (1998), J. H. van der Waals (1999), H. M. McConnell and Bruker Analytik GmbH (2000), K. A. McLauchlan (2001), W. Lubitz (2002), W. L. Hubbell (2003), and K. M. Salikhov and D. Stehlik (2004).

The selection of Professor Harold M. Swartz was made from many nominations solicited from international experts in EPR.

The Award Ceremony starting in the afternoon of September 28 was attended by about 200 people, among them were the scientists who had participated in the preceding Workshop.

The ceremony was chaired by Professor K. M. Salikhov. He, as the Chairman of the Award Committee, announced the decision of the Zavoisky Award Committee. The presentation was made by the Deputy Prime Minister of the Republic of Tatarstan R. F. Muratov. The Rector of the Kazan State University, Professor M. Kh. Salakhov, the Vice-Chairman of the Presidium of the Kazan Scientific Center of the Russian Academy of Sciences, Professor O. G. Sinyashin, the Vice-President of the Tatarstan Academy of Sciences, Professor Sh. M. Chabdarov, and the representative of the Kazan city administration A. A. Tutaeva warmly congratulated the laureate.

Letters of congratulations from Professor H. W. Spiess, President of the AMPERE Society, Professor Yu. D. Tsvetkov, President of the International EPR Society, and Professor A. Bax, President of ISMAR, were handed to Professor Harold M. Swartz.

H. M. Swartz gave his Zavoisky Award lecture in which he discussed the development of biological applications of EPR from biophysics to in vivo clinical applications. A concert by a string quartet preceded and followed the ceremony. The event was concluded with a Banquet in honor of Professor H. M. Swartz and his outstanding contributions to EPR. During their stay in Kazan the laureate and his spouse visited the museum of history of the Kazan State University, the places of historical and cultural interest in Kazan, and the Volga-Kama Nature Reserve.

The Organizing Committee owes special thanks to the Russian Academy of Sciences, Russian Foundation for Basic Research, and the NIOKR Fund of the Republic of Tatarstan.

Nominations Open for the Zavoisky Award 2006

The Zavoisky Award 2006 will be presented at the annual Workshop "Modern Development of Magnetic Resonance" to take place in Kazan in September 2006.

This prestigious award is given in recognition of an outstanding contribution to the development of electron paramagnetic resonance. It is presented by the Kazan Zavoisky Physical-Technical Institute of the Russian Academy of Sciences, Kazan State University, the Tatarstan Academy of Sciences, and Springer-Verlag Wien New York. The lecture of the award-winner will be published in the journal "Applied Magnetic Resonance".

Nominations are being sought from the EPR community worldwide. A brief presentation of the applicant covering 1–2 pages is expected. The final decision is made by the Award Selection Committee which comprises G. Feher (La Jolla), D. Gatteschi (Florence), H. M. McConnell (Stanford), K. A. McLauchlan (Oxford), K. Möbius (Berlin), A. Schweiger (Zurich), and the chairman, K. M. Salikhov (Kazan). The selection of the Awardee is made after consultations with the Advisory Award Committee which comprises B. Bleaney (Oxford), Yu. N. Molin (Novosibirsk), and Yu. D. Tsvetkov (Novosibirsk).

Nominations should be submitted to

Dr. Laila V. Mosina

Executive Secretary of the Zavoisky Award Committee

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Fax: 7-843-2725075

The deadline for submission of nominations is April 1, 2006.

The IES Gold Medal to Wolfgang Lubitz

Wolfgang Lubitz (left) and Yuri Tsvetkov (right)

For details, see this newsletter, p. 16.

Some Words to the Symmetry and Symbolism of the Number Five*

K. Alex Müller

In the field of the symbolism of integer numbers Carl Gustav Jung and Marie Louise von Franz dedicated a substantial part of their work to number three and four [1]. In the following contribution I will refer to the meaning of the number five and how it manifests historically, in modern physics and also as a five-pointed star on flags. Considering the famous Shri Yantra Mandala from Nepal (Fig. 1), around its center (Bindu) four triangles are arranged in one direction, but five triangles in the other direction, an attempt of such an extension seems to be justified.

In 1960, the essay "The World State" (Der Weltstaat) by Ernst Jünger [2] was published. This writing has stimulated my reflections, which I intend to report here. In his essay Ernst Jünger tried to interpret the world historical situation, in particular, the specific West-East problem. On page 24, Jünger states that both Russians and Americans painted a star on their intercontinental ballistic missiles. It should be mentioned that Jünger studied zoology and in his works often refers to the resemblance of species meaning characteristic aspects. He noticed the following in the symbolism of the star on rockets: If both superpowers paint a similar symbol on their weapons, they must possess something in common. In this connection he discusses the flags and standards of the European nations and realms during the Middle Ages, in

Fig. 1. Famous Shri Yantra Mandala from Nepal.

which often, but not always, the cross stood out. A. Ribi submitted in 1968 at the C. G.-Jung-Institut his excellently documented thesis with the title "The Flag as a Symbol" (Die Fahne als Symbol) [3]. On page 72, he states: "The flag is a symbol in the actual sense". Here I focus my attention on the modern, present symbols and in particular on the 'symmetry of signs' in the sense of the work "Number and Time" (Zahl und Zeit) by Marie Louise von Franz [4].

Now back to the stars, which were and still are visible on the nuclear weapons of the two superpowers. As a physicist it was of interest for me what kind of a star the Soviet Union painted on their rockets: it is a five-pointed red star, and the Americans use a five-pointed white star. For this reason in 1960 after reading "The World State" [2] I began to pay attention to other flags, particularly looking for possible symbols in common. First let us consider the "Stars and Stripes" of the Americans: Here the five-pointed star appears 50 times. The flag of the People's Republic of China (Fig. 2) shows a large, five-pointed golden star and in addition four smaller, similar five-pointed stars arranged in a red field. If we take the smaller stars away, we get nearly the flag of the Red Army of the former Soviet Union, which shows a golden star in the red field.

I asked myself, what the number five could mean with respect to the symmetry symbols in flags. In "Psychology and Alchemistry" (Psychologie und Alchemie) by Jung [5] one finds the following remark: "... distorted Mandalas occur occasionally [in the dreams of patients]. All forms belong to this, which deviate from the circle or the square or the isosceles cross; likewise those, whose basic number is not four, but three or five. A certain exception of this are the numbers six and twelve. Twelve can refer to four and three. The twelve months and the twelve zodiacs are circle symbols, which are at disposal. Likewise the number six is a well-known circle symbol. The number three refers to the supremacy of idea and will (Trinity) and the number five refers to the physical human (materialism)."

This is the only remark by Jung in this field, which I got to know. However, the Jung remark on symbolism might be ap-

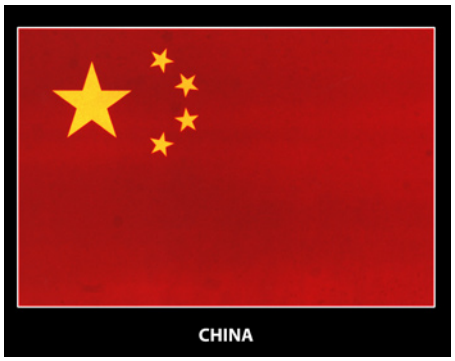

Fig. 2. Flag of the People's Republic of China.

* Adapted from Müller K. A. in: Der Pauli-Jung-Dialog (Atmanspracher H., Primas H., Wertenschlag-Birkhäuser E., eds.), pp. 275–294. Berlin: Springer 1995.

plicable to flags. In the majority, these are the flags of the socialist countries, showing a five-pointed star. The fact that the materialism is particularly stressed there might be clear to everyone.

There are many newer flags with stars, including the one of former Yugoslavia. It is a three-colored, traditional national flag, in which a star with five-fold symmetry is inserted. Now the State of Yugoslavia broke apart, and its flag does not exist any longer. Also different countries of the former Eastern Block have enormous problems. This clearly shows that giving up of a symbol, even of a materialistic one, may bring much troubles and suffering. In the flag of the European Community, which gains importance, five-pointed stars are placed in a circle in the blue field. Personally, this pleases me very much: the circle symbol and the stars. They impart an optimistic picture of the coming Europe for me.

The flag of Turkey again contains a five-pointed star. The five-pointed star is embraced by the crescent. This would be possibly also worth a discussion.

Very recently it was believed that the fivefold symmetry can only be observed in organic matter, as, for example, in flowers. Therefore the astonishment was great when Shechtman and his coworkers observed the fivefold symmetry in metallic alloys of 14% aluminum in manganese [6]. The observation that in solid-state physics fivefold symmetry can exist was unexpected, since already Kepler had shown geometrically that no periodic crystal lattice can exist with such a symmetry. There is obviously a border on the atomic level. One therefore speaks of quasicrystals which under special conditions may develop and can be observed.

In the meantime one came to the understanding of the inner working of the symmetry of quasicrystals. Already ten years before the above-mentioned experiments, Roger Penrose, a physicist-theoretician, who was mainly active in the field of relativity and cosmology, had made an interesting discovery. He showed that when building up long and broad rhombuses according to special rules polyhedrons with fivefold symmetry appear (Fig. 3) [7]. Here however the continuation is not periodic, although the polyhedrons are developed according to an exactly given mathematical description.

With quasicrystals, which result from quenching a melt of aluminium manganese, aperiodic Penrose patterns arise not only in the plane, but also in the three-dimensional space. It is amazing that the Roentgen diffraction patterns of such a sample show sharp reflexes, since usually one obtains such reflexes only if a periodic continuation of the atoms in the crystal exists. How can it be explained that they show nevertheless sharp Roentgen reflexes? This was pointed out by Kalugin, Kitaev and Levitov [8], as well as by Bak [9]. If one goes from our common three-dimensional space to the six-dimensional space, then one gets an answer to this question: A six-dimensional, regular cube as a unit cell of the periodicity of a lattice, if projected onto the third dimension, can result in a Penrose pattern. That is, in a higher-dimensional space we have a cubic symmetry. One can understand the sharp Roentgen reflexes: The total lattice is periodically arranged in a higher-dimensional space. It is remarkable that this order is based on a six-dimensional, cubic unit cell. According to Jung one could relate this symbolically with the six-dimensional image of the ego, which cannot be differentiated from the picture of God.

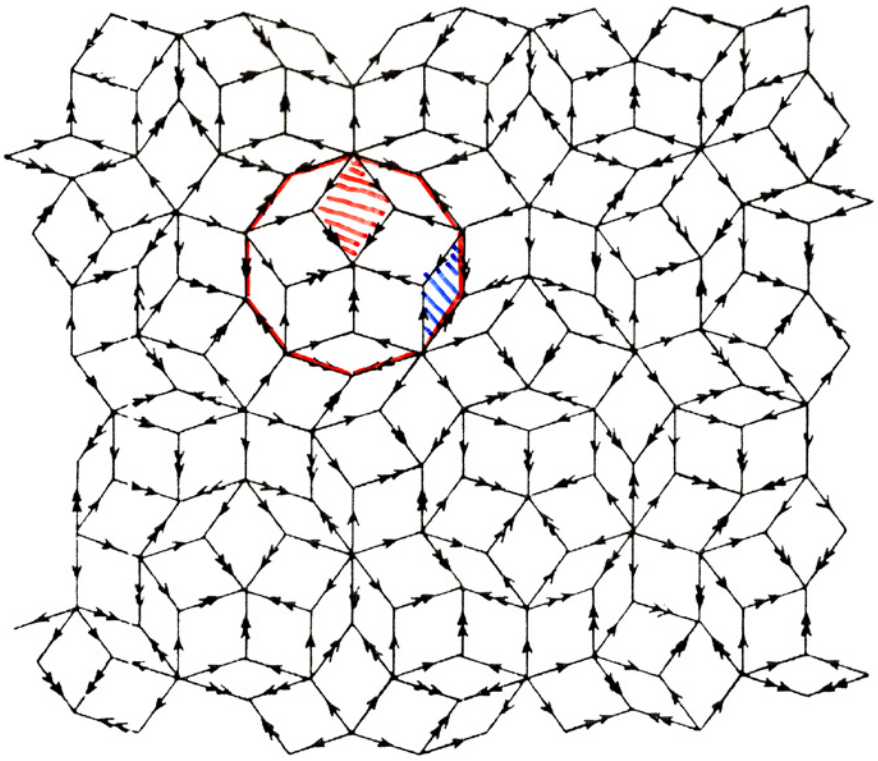

Fig. 3. Penrose pattern and the rule of its construction.

Recent high-energy experiments at the large electron-positron collider (LEP) at CERN in Geneva make it probable that for the unification of the electromagnetic with the weak and the strong nuclear force one needs a theory with five (so-called color charge characteristics) quantum fields. However, this so-called SU(5)-theory has to be extended supersymmetrically [10, 11], i.e., to each particle with half-integer spin (fermions) corresponds one with integer spin (bosons). Mentioning of this minimum, supersymmetrical SU(5)-model in the context discussed here seems to be important to the extent that similar as with the quasicrystals, also from the high-energy-physics point of view a substantial extension of the description of nature can be obtained possibly with the number five.

For this there exist also mathematical examples. A general algebraic equation of the fourth degree

$$x^4 + a_3x^3 + a_2x^2 + a_1x + a_0 = 0$$

is analytically solvable. Already G. Cardano (1501–1576), a mathematician, physician and natural philosopher, published its solution.

Only in 1826 Niel Henrik Abel (1802–1829) succeeded to show that the general equations of the fifth degree

$$x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0 = 0$$

cannot be solved by rational and root operations. Thus, there is a qualitative jump with the transition from four to five also from a purely mathematical point of view.

In conclusion, I would like to mention the considerations of T. Abt concerning the symbolism of integers [12], particularly

Fig. 4. Peter Birkhäuser's picture "The Queen of the Night".

the part refering to the number five. In the Middle Ages, this number had the meaning of magic on one hand; but on the other hand, also the meaning of a human being: the four extremities and the head. In addition, the five-pointed star represented a female divinity, namely, Venus. The relationship of the Arab World with the five-pointed star is of interest as well: as in the flag of Turkey, the crescent embraces the Venus symbol. In this respect I would like also to mention the considerations of Herbert van Erkelens: "In Holland there is a flower called *Teunisbloemen*. I am married to Inge Teunissen. Eva Wertenschlag visited us once and looked at the *Teunisblume* and said: "This is the queen of the night". This made me happy; I was married to the queen of the night, so to speak. Then Eva Wertenschlag sent us a copy of Peter Birkhäuser's picture "The Queen of the Night" (Fig. 4) [13]. It shows a cat face with slanting eyes and a light on its forehead, which is arranged of different pentagons in a 'flower' manner: the light of Venus. So, the fivefold star has, as most symbols, a double aspect, the divinity of the feminine, and the sign of materialism of our times as outlined at the beginning of my essay.

Acknowledgement

I thank indeed Laila Mosina for translating, compacting and editing the essay from the original German publication (see footnote).

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McConnell & His Lab

Notes on the McConnell Lab at Stanford

Larry Berliner

When I started as a graduate student at Stanford in Physical Chemistry, there were just a few choices for research directors, none of whom interested me at the time. Paul Flory's work was exciting, but my interests were more oriented towards building and using instruments. Another first-year graduate student colleague, Bob Hughes, mentioned to me that he'd heard that a new professor was moving from CalTech to Stanford the following summer and was doing some interesting research. To make a long story short, Bob and I were McConnell's first Stanford graduate students, which was perhaps a minor shock to Harden, compared to the typical CalTech graduate student at the time. Both Bob and I started off in the molecular crystals/triplet exciton area, which culminated with a nice publication in J. Chem. Phys. within a year.

However, I wanted to move into the biological area and, by fate and serendipity, became McConnell's first 'spin label' graduate student, but was joined shortly by several new graduate students who entered in the next year. For me, the challenges were interesting. My 'assignment' was to look at spin-labeled polypeptides or polymers oriented in an electric field, which I determined was either too difficult to do at the time [many decades later, Wayne Hubbell, working with Wojcic Froncisz in Krakow, succeeded at this experiment]. The second 'assignment' was chymotrypsin. In McConnell's group, you took a problem with a very brief description and were assigned to learn something about it and open up a new field, a concept which was the key to success. I had to synthesize new nitroxide labels in an environment of chemical physicists who knew only slightly less than I did about organic synthesis. However, I had two roommates who were in synthetic organic groups and their help and advice spirited me on to success in elementary organic synthesis. In addition, I had to learn how to handle proteins and enzymes, grow and analyze protein crystals, as well as a few other techniques that the lab had no prior experience with. Overall, you learned and succeeded by the 'tail of your pants' since learning is very much doing things on your own.

There were, of course, amusing times as well as difficult times. Like the time one of the postdoctorates converted a refrigerator into a 'cold room' by outfitting it with electrical outlets through the light receptacle inside for running stirring motors. In order to keep power on inside the box, he drilled a hole in the door so that the button for the light circuit would stay on. But he never accounted for the fact that the motors heat up the box and the compressor shuts off; this resulted in damage to several thousand dollars worth of enzymes and proteins stored in this refrigerator. The best story, which none of us ever got straight, regards a 'toxicology' study of nitroxides on a fish. The fish survived the high concentrations of nitroxide in the tank where he swam, but met his fate when either hot water slowly dripped into his tank or he went 'overboard' and down the drain.

Needless to say, my experiences were fantastic in this vibrant laboratory. The mix of graduate students, many foreign postdoctorates [many of whom are in prominent academic positions around the world] and the relative openness of the Stanford Chemistry Department all added to very profitable research experiences. However, without the insights and good judgments of our mentor, Harden McConnell, the experiences would never have been as rewarding.

Such is research in the McConnell lab: "we're always learning new concepts and techniques in every area of science."

Notes on postdocing with Harden McConnell

Betty Gaffney

Harden moved from CalTech to Stanford during the time that I was a graduate student with Harry S. Mosher. There was much excitement in the Chemistry Department that there was a REALLY BIG idea being developed in the McConnell lab and there was kind of a top-secret air about it. Two lucky guesses provided my ticket to meet the new star. In both cases, O. Hayes Griffith was the catalyst. Apparently Hayes left the University only once a week to buy enough groceries so he could work 24/7 (as we would say now), so he got to know all of us who sometimes worked late in various labs. One night he asked me to help explain an organic reaction that he was working on: why did he end up with a five-membered ring when he started with a six-membered one? It turned out that I had recently written a chapter on ring-contraction for Carl Djerassi's class, so I was able to reply: "It's the Favorskii rearrangement." According to Hayes, the boss was pleased to have the organic chemistry input. Another time, Hayes dropped by when I was adding a ketone to a Grignard reagent and there was a transient red color as each drop was added. Hayes asked about the red color and I guessed wildly 'ketyl radicals'. He challenged me to prove it. We were busy recording EPR spectra of ketyl radicals early the next Saturday morning when we thought no one would be around and suddenly a booming voice asked "who's the stranger in my lab?" After a moment of severe panic, I noticed a smile and got introduced. EPR seemed like a pretty interesting technique and the group of people in Harden's lab were definitely interesting – especially Mac. It was particularly fun to join a McConnell lab party at the 'ranch' where we all got to plant Christmas trees and get poison oak.

It was three years later (late 1968) before I got back to Harden's lab. Hemoglobin was all the rage when I began my postdoc in his group. Unfortunately, I just missed overlapping with Ruth and Reinhold Benesch who had spent a sabbatical with Harden. But their ▶

discovery of DPG as an allosteric regulator of hemoglobin was still very much in everyone's thinking. My first project was to prepare spin labeled hemoglobin to be sent to Keith Moffat (at the MRC) who was to do the X-ray structure of the labeled protein. I got a brief run down of how to wash red cells with 0.9% salt and began my prep. The next time Harden walked in I had just added my first wash to cells and the solution suddenly turned from cloudy to clear – the cells had lysed. Well, that's how Harden gave me the nickname 'double-0-nine' (I had used 0.9 g in a liter). It all worked out eventually – and there is a structure of spin labeled hemoglobin in the literature. Those of us working on hemoglobin spent entire summers in the 15 degree C room that housed one of Varian's first E104 EPR instruments and a Cary UV-vis so that optical and EPR measurements were perfectly matched. There were a dizzying number of other projects besides spin labeled hemoglobin: micelles, membrane dynamics, superconductivity and theory. I guess everyone has a time in their life when they make the most life-long friends and that time for me was 1969–1973 in the McConnell lab. What is so unique about the long list of friends and colleagues from 'the McConnell connection', besides Harden himself, is the range science their careers span – from Rick Horwitz, cell biologist, to Harris Silverstone, quantum chemist. That range reflects the spirit of the McConnell lab.

Some memories of the McConnell laboratory

Brian Hoffman

Harden McConnell has not had one 'career', but several, sometimes overlapping. Any one would have been sufficient for most people! Correspondingly, he has had many times several 'labs', because a scientific lab is defined not by space, hardware, and chemicals, but by the people in the space who build the hardware and synthesize the chemicals. I, myself, was a part of two labs, the last McConnell lab before his move to CalTech and the first one after it.

In thinking about those days, the first memory stream is less about McConnell himself, than of the 'lab'. On the trivial level, I remember chasing Marty Itzkowitz down the street, threatening him with bodily harm unless he stopped singing a Mozart aria he had revised with doggerel lyrics. If I'd allowed him to sing it through, he'd have trashed that opera for me forever. Another recalls the fury which Zoltan Soos directed at me after I'd managed to stumble through one of his solo theoretical papers, and then said to him, "That's not so hard." Years later, having finished a bit of my own arithmetic, I recalled the event and realized that he was furious, of course, because it really isn't so hard to follow a trail that someone else has hacked through uncharted jungle. And there's the stream of memories of interactions with Harden, himself. And they too have their trivial and amusing currents. Thus, for many years after I'd left the lab, the wall over a doorway in Stanford's Stauffer I building bore a McConnell inscription in black marker, like hieroglyphics: "Hoffman electronics", plus an enigmatic arrow in black, pointing to nothing in particular. Fortunately for me, nothing was left to reveal that the arrow once pointed to a burnt-out power resistor!

Harden's early career – of the McConnell equations (NMR) and McConnell relation (EPR) – had concluded by the time I joined his group at CalTech in the fall of 1962. His career in the fundamentals of molecular-electronic structure, whose highlights included EPR studies of the Jahn-Teller effect in cyclic aromatics, was still highly productive, but 'retirement' from that work was in the air for those with a good nose. His 'solid-state' career was probably near its zenith. This was a time of ongoing work on triplet excitons, and exciting new ideas for achieving high-T_c superconductivity. For those who may be more familiar with Harden's wisdom than his wit, let me recount an incident during a CalTech Physics Department Colloquium that Harden gave on the exciton work. Richard Feynman sat in the front row and heckled. It was my impression that they knew each other reasonably well and that this probably occurred in private as well as public (Harden knew him not well, but well enough). Regardless, the sparring generated intellectual sparks! The climax of the contest came when, after a Feynman remark, Harden silently walked to the 'pointer', a sharply pointed, rather massive wooden object about 6 feet long (no green lasers then!), which was lying unnoticed on the bench at the front of the room. Oh so slowly and gently, he nudged its back end until the point stuck out over the edge straight at Feynman. The tension dissolved in laughter and the laurel was Harden's. (Harden's daughter Jane was born the morning of the seminar, so he felt a little impatient!).

What Soos, Itzkowitz, Metzger, and I did not know when we signed up was that the group was about to undergo two changes that were extraordinary, even for McConnell. The lesser one was announced in the Fall of 1962: the move to Stanford, to occur during the summer of 1964 and to be completed by that Fall. As my contribution to the historical record regarding that move, the only reason I heard Harden give for it was, "The integral of smog, dt." Presumably, the delay between announcement and implementation involved the building of the Stauffer I building. Even so, none of us there can have forgotten the moment when Harden arrived on campus and was greeted by the Assistant Chair in charge of making things happen. We were standing outside the building, about noon, in bright sunshine. The AC made a flowery speech, welcoming us. Harden replied, "Where's the water for my magnets!" A little nonplussed, the AC continued in the same vein while Harden waited for him to run down. He then said, "Where's the water for my magnets!" I don't recall whether that did it, or if another round was necessary, before the AC slunk off to find water.

The major change, of course, was the launching of perhaps Harden's longest career, as biophysicist, with the invention of nitroxide spin labelling. My perspective on that is untainted by personal involvement, but alas, the historians of science won't benefit much from my disinterestedness and must look to the memories of Berliner, Gaffney, and Hubbell. Although it is probably the EPR technique that has done most to broaden the appreciation and application of EPR, my sharpest memories are of Stone synthesizing nitroxides used in the first labelling paper. In those days of political and health incorrectness smoking was far more common than now, not even forbidden in laboratories. And Stone was a heavy smoker. I would watch, mesmerized, as he completed a reaction and peered into the flask contain-

ing his product, cigarette dangling from his lips, an inch or more of ash on the cigarette. Would the ash drop into the flask, ruining all? Watch the show; delicious disaster might strike at any moment! But it never did. I occasionally look back and wonder if Stone used the Clarence Darrow trick, and had a wire in his cigarette to secure the ash. I prefer to believe he didn't, and just had the nerve of a high-wire artist.

As I continue to reflect, the memory stream turns to flood, and some memories might actually provide useful insights into McConnell's work and his contributions to EPR. However, I was asked for brief reminiscences not a book. And perhaps to recount them would miss the larger point, anyway. It seems to me that the McConnell we knew never was restricted by the tools he used. He defined a problem, selected or invented the necessary tools, and attacked those problems with an intellectual intensity that carried the rest of us along with him to the best of our abilities. Thus I mostly think of labmates, but in a lab dominated by Harden's spirit of inquiry. I doubt I'm the only one who unconsciously conducts his science, and even directs his own lab, guided by Harden McConnell's example, if without the gifts he brought to the enterprise.

Notes on the time in McConnell's laboratory at Stanford

Wayne Hubbell

There is no question that the brief 4 years I spent in McConnell's laboratory as a graduate student were the most important of my entire life of 62 years. My scientific values and a philosophy of research that have served me well were completely established during that period. McConnell never discussed these matters directly, but one learned by observation of how 'the Boss' functioned. It seemed that everything was motivated by the pure excitement of 'finding things out'. The intensity was wonderful; not the kind of intensity that produces stress, but an intrinsic one derived from McConnell's infectious dedication and knowing that the tools to solve important problems in biophysics were at hand in the laboratory, and time was the only limit (still is). Together with McConnell's uncanny ability to sort out the scientific wheat from the chaff, this atmosphere produced daily discoveries.

My first encounter with this intensity came after I had been in the lab a few months. I had been assigned to explore a protein with the new technique of spin labeling, one of McConnell's many contributions to biophysics. I don't remember the protein, but it was not going well, and I began to moonlight on another side project; the synthesis of a spin label that would bind to biological membranes (just for fun). Through the assistance of another graduate student (Richard Hoagland, who subsequently founded Molecular Probes, Inc.), I learned enough organic chemistry to synthesize a nitroxyl amide derivative of palmitic acid that bound to lipid vesicles and gave an unusual EPR spectrum that meant little to me at the time. One afternoon, McConnell walked by my desk and spotted the spectrum and demanded "What's that? Bring it into my office." I was certain that I was in trouble because it had nothing to due with the protein I was assigned to study. As it turned out, McConnell recognized that the lineshape showed evidence of anisotropic motion, and he soon outlined the framework for understanding this class of spectra in terms of an effective Hamiltonian. That gave rise to a tremendous flow of new ideas (mostly from McConnell), new molecules to make, new systems to explore, and a lot of excitement. When he would see me leaving the building he would yell down the hall "be careful on the way home!" When he was away at a meeting, there would be daily (or more frequent) calls to relay new ideas and receive new data. On weekends he would sometimes be off to plant trees at his ranch. On more than one occasion he asked that I come along, not that he wanted help planting trees; in fact he refused to let me work. Rather, I was there to discuss science so time would not be wasted. At the end of such days, I was mentally exhausted trying to keep up with the train of thought.

At his 65th birthday party, attended by many past students and notable scientists (including Linus Pauling), McConnell gave a talk describing his recent thoughts on pattern formation in lipid systems; it seemed pretty esoteric. Norman Davidson, his mentor in graduate school at CalTech (McConnell was his first student), stood up and asked "Harden, why are you doing this?" The reply was "because it is interesting". Davidson responded "I don't believe it; there must be more, something of value." Maybe Davidson didn't believe it, but I did.

Early biophysical studies of membranes, with nitroxide spin labels, 1965–1985

Harden McConnell

It is a pleasure to hear from former graduate students and colleagues who have enjoyed their time in my laboratory. Their perspective on past events is often amusing, sometimes sobering, and always interesting. In respect to early spin label work here at Stanford, the history as I recall it is fairly clear. Nitroxide free radicals were known to be relatively stable. At CalTech graduate student Hayes Griffith had become interested in using these radicals as probes to study micelles, and when he came to Stanford with me he determined the nitrogen isotropic and anisotropic hyperfine interactions in an organic inclusion compound [J. Chem. Phys. **43**, 2909–2910 (1965)]. The combination of a well-defined spin Hamiltonian and the potential for chemical synthetic versatility with nitroxides was an open invitation to use these free radicals as biophysical probes.

Early work involved both proteins and membranes, but for brevity I only discuss the membrane work. Examples include one of the first measurements of the lateral diffusion of phospholipids in lipid bilayers by postdoc Philippe Devaux [J. Am. Chem. Soc. **94**, 4475–4481 (1972)], and the first ▶

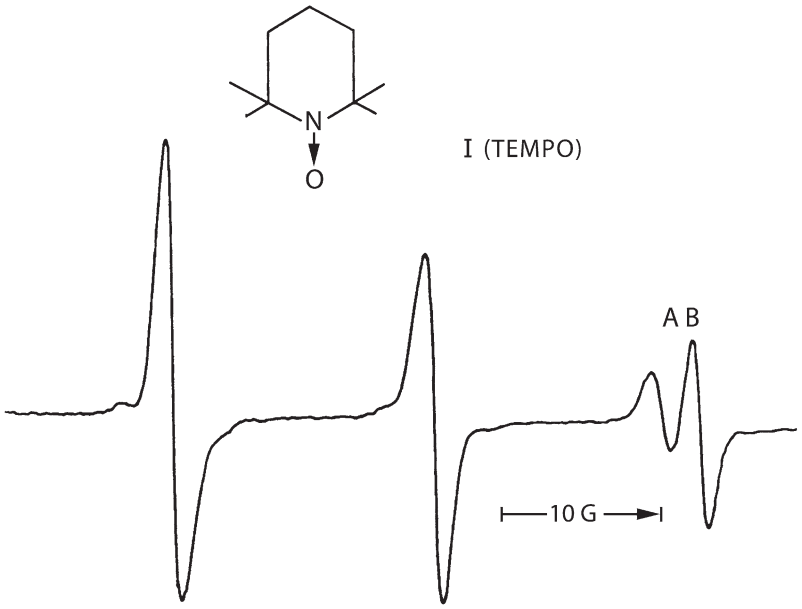

Figure 1. Paramagnetic resonance spectrum of the spin label TEMPO in the fluid hydrophobic region of the rabbit vagus-nerve fiber (A) and in the surrounding aqueous solution (B).

measurement of the rate of phospholipid flip flop in bilayers by graduate student Roger Kornberg [Biochemistry **10**, 1111–1120 (1971)]. The fatty acid chain flexibility gradient in phospholipid bilayers was discovered at Stanford and was the subject of a number of studies by graduate student Wayne Hubbell [J. Am. Chem. Soc. **93**, 314–326 (1971)], and postdocs Joachim Seelig [J. Am. Chem. Soc. **92**, 3881 (1970) and Betty Gaffney (McFarland) [Proc. Nat. Acad. Sci. USA **68**, 1274–1278 (1971)].

One of the curious things about this early work at Stanford is that it was exciting, largely successful in our own eyes, but strangely isolated from much of the world outside. Many physical scientists at that time were not interested in biophysical problems, and certainly many biochemists had no familiarity with paramagnetic resonance. I will illustrate the last point with a single example.

When Wayne Hubbell joined my research group in 1966, he indicated he was interested in neurobiology. Doubtless in part because of this interest a paramagnetic resonance experiment was ultimately carried out using the spin label Tempo, and the rabbit vegus nerve fiber. The resonance spectrum shown in Fig. 1 was published in 1968 [Proc. Nat. Acad. Sci. USA **61**, 12–16 (1968)]. The splitting of the high field hyperfine signal is due to distinct locations of the Tempo molecule. Some molecules are in the aqueous phase (giving signal B) and some are in a fluid hydrophobic environment (giving signal A). (At X-band the two other hyperfine line splittings are not resolved.) From this we deduced that the cell membranes provided a fluid, liquid-like hydrophobic environment. In the summer of 1968 Wayne and I gave a joint seminar at a Gordon conference on energy transduction in biochemical systems. Since very little was known about the structure of biological membranes at that time, and the audience had no familiarity with resonance line narrowing due to motion, our talk had little effect on the audience. In fact, Wayne and I had quite an argument with Jon Singer who disagreed with our conclusion. At this meeting Singer had proposed a model of membranes in which the fatty acid hydrocarbon chains were entangled, but not liquid-like. Singer of course later became famous with his paper with Garth Nicolson entitled the "Fluid Mosaic Model of Membranes" [Science **175**, 720–731 (1972)]. Figure 2 shows a photo from that meeting where I can be seen in the second row far right, and Hubbell and Singer can be seen in the first row, second and third from the right. Wayne and I also ran into stiff opposition to our views from some quarters here at Stanford as well.


Figure 2

(Speaking of stiff opposition I should also mention the stiff opposition Seiji Ogawa and I had to our studies of spin labeled hemoglobin that clearly conflicted with the popular two-state concerted allosteric model [Nature **220**, 787–788 (1968)].)

These early days were great: the students and postdocs were great, the experiments worked rather quickly and well, and the results were ultimately found interesting and significant by the outside world. This was all possible because the lab was blessed with students and postdocs with complementary skills, synthetic organic chemistry (Betty Gaffney McFarland, Carole Hamilton, Wayne Hubbell), physical chemistry (Pier Nordio, Hayes Griffith), protein chemistry (Larry Berliner) and even immunology (Gill Humphries). However, during the course of all this work, I as a physical chemist could not resist the temptation to have graduate students work on the phase diagrams for lipid mixtures using spin labels. A number of spin label studies of cholesterol-phospholipid mixtures led ultimately to the 1981 proposal with postdoc Dieter Rechtenwald that these mixtures may form co-existing liquid phases, and that such immiscibility might be found in biological membranes [Biochemistry **20**, 4505–4510 (1981)]. This immiscibility has now indeed been found in a number of monolayers as well as bilayers, and is of current wide interest in connection with cell membranes.

Hanns Fischer (1935–2005)

Nobody has raised the profile of the field of transient organic free radical kinetics in liquids as much as Hanns Fischer. His name is linked to innovations related to studies of photochemical radical generation and the mechanisms and kinetics of radical termination, to detailed analysis of polar and steric effects in radical addition reactions, to *controlled* or *living* radical polymerization kinetics, as well as phenomena like CIDNP and CIDEP.

Hanns Fischer passed away on 22 February 2005 after several months of severe illness. He obtained his PhD (1963) and his Habilitation (1966) at the Technical University of Darmstadt in Germany. From 1960 to 1969 he worked at the German Polymer Institute in Darmstadt. In 1969 he became Associate and 1971 Full Professor of Physical Chemistry at the University of Zürich, Switzerland, where he served until his retirement. He continued active scientific work in several extended periods as a visiting professor at the Universities of Bologna, Marseille, Carnegie-Mellon in Pittsburgh and at the CSIRO in Melbourne.

It was in the 60s of the past century when Fischer started his academic career, just at the time when studies of organic free radicals by means of ESR became an issue in chemistry. He picked up on it and made it the subject of his scientific work for life. Starting off with radicals in irradiated polymers, he quickly moved to liquid phase systems where narrower lines and a homogeneous environment provided the well-defined conditions that he needed for quantitative work. He switched from radical generation via irradiation with ionizing radiation to in-situ UV and later laser photolysis. Furthermore, he soon complemented his ESR studies with other experimental methods such as NMR, optical spectroscopy and muon spin resonance (μSR). In-situ photolysis in an NMR spectrometer led to the discovery of emission lines and thus to chemically induced dynamic nuclear polarization (CIDNP, with J. Bargon, 1967).

It was Fischer's working style that he identified a question or problem and then focused on it persistently until he had an answer that was in every sense satisfactory, careful and profound. Some of the subjects to which he devoted major efforts include the following: He proved that termination reactions of carbon-centred radicals are diffusion controlled and that the termination rate constant is reduced from its purely diffusion controlled value by a spin statistical factor of 0.25. With his coworkers, he then determined a large set of experimental Arrhenius parameters of rate constants for addition reactions of carbon centred radicals to alkenes. These data served as a basis for a profound theoretical understanding, developed together with Leo Radom, of the factors controlling these reactions. His last significant undertaking consisted in a kinetic analysis with analytical treatment of the persistent radical effect in controlled radical polymerisations which are of fundamental but also of tremendous practical importance to the polymer community. With this topic he returned to polymers, coming back close to the point where he started off his scientific work and closing the cycle of his scientific life.

For his work, he received several special honours, including the Jan Servais Stas Medal of the Belgian Chemical Society (1971), the Centenary Medal and Lectureship of the Chemical Society London (1973/74), the Bruker Lectureship of the British ESR Society (1988), the Silver Medal of the International EPR Society (1997) and the Distinguished Guest Medal of IUPAC (Paris, 2004).

The same care that characterised his scientific work also applied to his teaching. He devoted many weekends to the reorganisation of the Introductory Laboratory Course, standing in the lab and trying out the new experiments personally. One of the aims was a reduction of the chemical waste of the laboratory course by a large factor, increasing the awareness of the students for *green chemistry*. Moreover, he was a passionate lecturer who presented complex matter with the utmost clarity.

Hanns Fischer supervised and guided 50 PhD and Diploma Theses, and seven of his former coworkers are now in academic positions. I have no doubt that this ensures that his ethical principles for accurate and responsible science continue to live in further generations.

Emil Roduner
University of Stuttgart

6th meeting of the Australian and New Zealand Society for Magnetic Resonance **ANZMAG 2006**

Murramarang National Park, Australia
February 12–16, 2006
www.anzmag.com.au/anzmag06/index.html
(previously announced in *newsletter* 15/3)

The 39th Annual International Meeting **Advanced Techniques & Applications of EPR**

University of Edinburgh, Edinburgh
April 2–5, 2006
www.esr-group.org.uk
(for details see forthcoming issues)

2nd International Conference on Biodosimetry and 7th International Symposium on ESR Dosimetry and Applications

Uniformed Services University of the Health Sciences (USUHS), Bethesda, Maryland, USA
July 10–13, 2006

This conference will focus on passive dosimetry systems that provide dose information following some form of quantitative measurement (e.g., concentration of spin flips, number of dicentrics) that may be performed minutes to millennia following the exposure. Topic areas proposed will emphasize synergy among various methods and the time frames in which they yield dose data.

- Dosimetry in biological systems (e.g., ESR on teeth and bone, lymphocyte-dicentric assay, etc.)
- Physical dosimetry (e.g., ESR on alanine and other materials such as carbonates for dating.)
- Standardization and intercomparisons
- Automation and field deployability
- Emerging technologies

To assist in organizing the program, interested colleagues are kindly requested to send an email to biodos@rad.usuhs.mil with suggestions for topic areas or a presentation title and/or topic areas.

Conference information will be posted at website epr.usuhs.mil, where format guidance for abstracts can be found. Deadline for abstract submission is January 30, 2006. Papers presented at the meeting will be peer-reviewed and published.

Local organizing committee
Dr. Chad A. Mitchell, USUHS
(Chairman) cmitchell@usuhs.mil
Dr. Anne Skinner, Williams College
(Program Chairman)
Anne.R.Skinner@williams.edu

Joint Conference of British NMR-DG, AMPERE and EENC **EUROMAR**

University of York, UK
July 16–21, 2006
www.euromar.org

The UK Royal Society of Chemistry NMR Discussion Group, AMPERE Congress and the EENC have combined their International NMR conferences to form an annual Magnetic Resonance Meeting, called EUROMAR. The program includes all areas of Magnetic Resonance and is intended to appeal to the whole Magnetic Resonance Community including practitioners of ESR, MRI and NMR.

Topics:

- BioSolids
- Imaging
- Pharmaceutical Applications
- High Sensitivity Magnetic Resonance
- Solid State Physics
- Bio-macromolecules
- Paramagnetic Systems
- Catalysis
- Methods in Solids
- Frontiers

Keynote Lectures: Silvio Aime (Italy); Frederic Allain (Switzerland); Michael Anderson (UK); Marc Baldus (Germany); Claude Berthier (France); Ferdinando Borsa (USA); John Brown (UK); Jacques Courtieu (France); Kees Elsevier (The Netherlands); Lyndon Emsley (France); Lucio Frydman (Israel); Klaes Golman (Sweden); Bob Griffin (USA); HongWen Jiang (USA); Alan Koretsky (USA); Yishay Manassen (Israel); Sir Peter Mansfield (UK); Klaus Moebius (Germany); Giorgios Papavassiliou (Greece); Thomas Prisner (Germany); Dan Rugar (USA); Jan Schmidt (The Netherlands); Robert Tycko (USA); Gerhard Wagner (USA); Tony Watts (UK); Stephen Wimperis (UK); Joerg Wrachtrup (Germany); Peter Wright (USA); Kurt Zilm (USA).

In addition each session will include oral presentations selected from submitted abstracts. Posters will be on display during the conference.

Local Organizing Committee
Simon Duckett
(Chair of Local Organizing Committee)
Elaine Wellingham
(Conference Secretary)
For further information:
fax: +44 (0) 1275 853311
e-mail: esw@confsec.co.uk

Specialized Colloque AMPERE and AvH-Workshop: Advanced Materials as Studied by Spectroscopic and Diffraction Techniques

Vilnius, Lithuania
September 16–21, 2006
www.ff.vu.lt/ampere

The Specialized Colloque AMPERE and AvH-Workshop will be organized by the Vilnius University (Lithuania) in collaboration with the Darmstadt University of Technology and the Leipzig University (Germany) as a part of joint research projects sponsored by Alexander von Humboldt Foundation.

Topics of the conference:

- Structure and phase transitions
- Intermolecular and molecular-ionic interactions in aqueous and ionic solutions
- Nanostructures and porous media
- Biological systems
- Advanced materials
- Dielectric, NMR, ESR, vibrational and optical spectroscopy
- Light, X-ray and neutron scatterings
- Modern theoretical calculations (quantum chemistry, molecular dynamics, etc.)

The further information concerning scientific program, procedure for submission of abstracts and full papers for publication in a special issue, conference costs (the registration fee will be EUR 260), discounts for the young scientists, special status of the partners of the AvH projects, hotel reservation, social program, accompanying person's program, etc. will be given in the 2nd circular.

All people who are interested to receive the 2nd circular, which will be available in April 2006, are kindly asked to complete the Preliminary Registration Card and return it (by post or e-mail) to the Organizers before April 15, 2006.

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1st Joint Working Group Meeting of the COST P15 Action on "Advanced Paramagnetic Resonance Methods in Molecular Biophysics"

Budapest, Hungary, October 26-28, 2005

On October 26–28, the COST P15 Action on "Advanced Paramagnetic Resonance Methods in Molecular Biophysics" held its first joint Working Group meeting in the beautiful city of Budapest, Hungary. This new European Union Action is a 5-year European network program that aims to initiate a concerted European effort to develop new EPR instruments and methodologies to determine the structure, dynamics and structure-function relationships in biological systems. The meeting concentrated on the three main themes or Working Groups associated with the Action: instrument and methodological development (concentrating on high field and pulsed EPR), natural biological paramagnets (metalloproteins and biological radicals) and the use of spin labeling and spin probing to investigate biological systems.

Undoubtedly, we are experiencing a tremendously exciting time in EPR at the moment, with very significant advances in instrumentation, methodologies and applications. However, it is often difficult for many European groups to get access to specialist equipment and expertise is diluted across many groups. The vision behind the COST P15 program is to increase the accessibility of European spectroscopists to the different EPR facilities and EPR expertise in Europe as well as seeking to provide training for young scientists. The Action aims to provide small travel grants to members to promote or initiate small-scale collaborations within the EU and its associated countries, as well as help to run small training schools for young scientists. We also have limited funding to organize or support meetings with the purpose of providing a discussion forum for EPR scientists.

This was the first joint Working Group meeting of the Action and we were delighted by the feedback from the participants. The scientific program was very interesting and included contributions of research groups from 17 different countries. It is clear that many new collaborations have resulted directly from the event. The chairs of the three individual Working Groups played a very large part in this success. In the COST P15 Action, Arthur Schweiger (ETH Zürich) and Gunnar Jeschke (MPI Mainz) lead the working group on advances in instrumentation and methodology, Sun Un (CEA Saclay) and Yiannhs Deligiannakis (University of Ioannina) are in charge of the working group on paramagnetic metallo-proteins and radical centres in biomolecules, and Heinz-Jürgen Steinhoff (University of Osnabrück) and Janez Štrancar (Jožef Stefan Institute, Ljubljana) manage the working group on the study of diamagnetic proteins and membrane systems using spin labeling and spin probing.

Sabine Van Doorlaer and Graham Smith (chair and vice-chair of the COST P15 Action)

During the meeting, Yuri Tsvetkov presented the International EPR (ESR) Society gold medal award to Wolfgang Lubitz (MPI Mülheim) for his outstanding achievements in the field of EPR. This event marked also the end of Yuri Tsvetkov's tasks as president of the IES and Yuri also used the opportunity to officially hand over the presidency of the IES to Wolfgang Lubitz. On behalf of the COST P15 Action, we want to thank Yuri Tsvetkov for the outstanding work that he has done on behalf of the EPR community. We also want to congratulate Wolfgang Lubitz, both for his prize and for the presidency of the IES. We are convinced he will be an excellent successor of Yuri Tsvetkov.

The success of the meeting in Budapest was also largely due to the local organizers, Antal Rockenbauer, László Korecz and Nóra Nagy, and on behalf of the COST P15 Action we would also very much like to thank them for their marvelous hospitality. During the banquet, the scientists of the Chemical Research Center of the Hungarian Academy of Sciences in Budapest, also wowed the audience and showed-off their multi-talented skills by singing different Hungarian and international folk songs.

The Action is run by a Management Committee consisting of two representatives from each participating country. The Management Committee meets at least once a year to decide overall strategy and allocate resources. At present, the Action has representatives and research groups from 17 COST member countries (Belgium, Croatia, Denmark, France, Germany, Greece, Hungary, Israel, Italy, Norway, Portugal, Poland, Slovenia, Spain, Switzerland, the Netherlands, and the United Kingdom). It also includes two non-COST participating institutes from Novosibirsk and Kazan (Russia). In 2005 the Action gave strong support to the EF EPR summer school in Wiesbaden (July 17–24, 2005). In 2006, part of the Action's budget will be used to organize two small training schools for students. The first school will be held at ETH Zürich on March 5–8 and will be focused on the practical aspects of EasySpin. The second school, to be held in St Andrews (April 6–7, 2006), will be devoted to practical training in ELDOR spectroscopy. Furthermore, the Action will hold a Working Group meeting on spin-labeled EPR as part of the RSC ESR meeting in Edinburgh (April 2–5, 2006) and integrate its 2nd joint Working Group meeting in the 6th EF EPR groups meeting in Madrid (September 5–8, 2006).

More information on the meeting and on other activities of the COST P15 Action can be found on the website www.st-andrews.ac.uk/~costp15.

S. Van Doorslaer and G. Smith

Magnetic Resonance Workshop **Recent Progress in Magnetic Resonance**

Hirschegg, Austria, September 18–22, 2005

For the second time the Graduate College on Advanced Magnetic Resonance Type Methods in Materials Science in Stuttgart organized its annual scientific meeting as a joint workshop together with external research groups. This time the EPR and NMR groups of S. Wijmenga, A. Kentgens (University of Nijmwegen/Netherlands) and E. Groenen (University of Leiden/Netherlands) attended the workshop. Altogether, almost 50 students, postdocs, senior researchers and group leaders from over a dozen different countries joined the workshop.

The scientific scope ranged from aspects of instrumentation for magnetic resonance setups to applications in biological systems and solid state chemistry and 'exotic' topics like mechanical detection of NMR. Invited lectures were given by the three group leaders from the Dutch universities who reviewed the research done in their groups. Shorter ▶

lectures on special subjects were presented by students and postdocs. The opening session was dedicated to aspects of theoretical EPR. V. Malkin, an invited speaker from the University of Bratislava, gave a lecture on this topic. Two poster sessions in the evenings gave the young scientists the chance to present their newest results and discuss them amongst the participants of the workshop. Details about the program as well as pictures are found on the homepage of the Graduate College under www.uni-stuttgart.de/gkmr/news/Hirscheg_2005.html.

Last but not least, such a workshop is also a social event. The afternoons were reserved for hiking tours in the mountains. Unfortunately the weather was not too good during the first days, so the organizers shifted the scientific program of Wednesday to Tuesday afternoon. Almost the whole of Wednesday could be used for hiking – and for the first time the sun came out and made the day perfect for mountain tours. That magnetic resonance has a lot to do with magic (and not just magic angle spinning) was shown by G. Denninger from Stuttgart, who is not only an enthusiastic scientist but also a very talented magician, as we saw in his highly entertaining magic show.

Traditionally the workshop of the Graduate College is organized by student members, this time together with young scientists of the Dutch groups. They did an excellent job and in the name of all participants I want to thank them once again for organizing a highly stimulating and inspiring meeting in midst of the impressive environment of the Austrian Alps.

Christian Remenyi, Würzburg

4th International Conference on Nitroxide Radicals: Synthesis, Properties and Implications of Nitroxides **SPIN-2005**

Akademgorodok, Novosibirsk, Russian Federation
September 20–24, 2005

After three successful meetings in Pécs 1979, Novosibirsk 1989 and Kaiserslautern 2001, we were proud to host the Conference in the second time. Traditionally, the meeting was organized by Novosibirsk Institute of Organic Chemistry in cooperation with International Tomography Center, Institute of Chemical Kinetics & Combustion and Novosibirsk State University.

The conference location was Akademgorodok – Novosibirsk Research Center, the main unit of Siberian Branch of Russian Academy of Science. Research department of Novosibirsk Institute of Organic Chemistry consists of 7 research groups and 17 laboratories, including the Laboratory of Nitrogen Compounds. The laboratory founded by Prof. Volodarsky in 1980 and headed now by Prof. Grigor'ev, is one of the leading groups in Russia and in the world working in the field of the synthesis and application of nitroxide radicals.

The topics covered during the meeting were: EPR spectroscopy of nitroxides – new methodologies / Synthesis / Site-directed spin labeling / Nitroxides in chemistry, biochemistry, biomedicine and polymer sciences / Molecule-based magnets / Spin trapping / NO donors and EPR NO detection.

113 scientists from different countries (Austria, The Netherlands, Switzerland, Hungary, Denmark, Germany, France, Israel, Slovenia, Poland, United Kingdom, Italy, Belarus, Japan, USA, and Russia) were participating in the meeting. The contributions during the SPIN-2005 included oral communications and poster session. In the poster session, one of the graduate students, Katerina Makarova from Belarusian State University, were granted with the best-poster prize instituted by the organizers of All-Russian EPR Spectroscopy School.

World-leading scientists in the field of nitroxides and EPR applications, to name a few, Yury Tsvetkov (Russia), Klaus Möbius (Germany), Peter Nesvadba (Switzerland), Harold M. Swartz (USA), Wolfgang Trommer (Germany), Alex I. Smirnov (USA), Alexander Kokorin (Russia), Shin'ichi Nakatsuji (Japan), Lucedio Greci (Italy), Dmitry Grishin (Russia), Gertz I. Likhtenshtein (Israel), Howard J. Halpern (USA), Alexander Wasserman (Russia), Ronald Mason (USA), Rui Tamura (Japan), Sergey Dzuba (Russia), gave outstanding talks in the meeting.Paul Rey, SEA-Grenoble, presented a lecture in Memory of pioneering nitroxide chemist Andre Rassat.

The Conference was held with the support of INTAS, RFBR, InterLab Inc., Alexis Biochemicals, Magnettech Ltd., Varian Inc., Bruker-BioSpin GmbH, and Institute of Antioxidant Chemistry of Novosibirsk State Pedagogical University. Nineteen participants from NIS and INTAS countries, including three graduate students, were awarded partial travel support, sponsored by INTAS.

Prof. Lucedio Greci from Marche Polytechnic University, Incona, Italy, kindly offered to host the next Conference in 2008.

Maxim Voynov, Program Secretary

photo of the issue

A HELLO FROM FIVEFOLD SYMMETRY

For Your Perusal

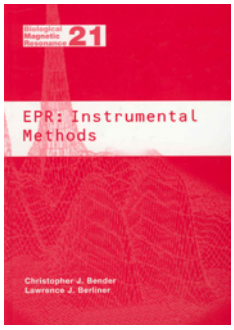
Collected by Arthur Schweiger

In this column, new books, journals and reviews on EPR, or literature closely related to EPR, as well as literature related to other columns in the *newsletter*, are presented and briefly reviewed. "For your Perusal" usually covers material published during the last two years; completeness with respect to the EPR literature is not claimed.

Books

EPR: Instrumental Methods (Biological Magnetic Resonance 21)

Christopher Bender and Lawrence J. Berliner (eds.)



Price: $ 165 (Hardcover)
Publication date: January, 2004
Publisher: Springer
442 pages

Volume 21 of *Biological Magnetic Resonance* contains a collection of articles about modern EPR spectroscopy. Most of the chapters are mainly of interest for researcher working in the field of EPR instrumentation, but not all of them do well fit the title "Instrumental Methods".

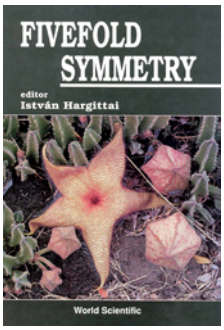
From the book description: Electron magnetic resonance spectroscopy is undergoing something akin to a renaissance that is attributable to advances in microwave circuitry and signal processing software. EPR: Instrumental Methods is a textbook that brings the reader up to date on these advances and their role in providing better experimental techniques for biological magnetic resonance. Chapters in this book guide the reader from basic principles of spectrometer design through the advanced methods that are providing new vistas in disciplines such as oximetry, imaging, and structural biology.

Contents:

- Microwave engineering fundamentals and spectrometer design
- EPR spectrometer at frequencies below X-band
- ENDOR coils and related radiofrequency circuits
- The generation and detection of electron spin echoes
- Convolution-based algorithm: From analysis of rotational dynamics to EPR oximetry and protein distance measurements
- 1D and 2D electron spin resonance imaging (ESRI) of transport and degradation processes in polymers
- Peptide-aggregation and conformation properties as studies by pulsed electron-electron double resonance

Fivefold Symmetry

István Hargittai (editor)



Price: $ 91 (Hardcover)
Publication date: March, 1992
Publisher: World Scientific Publishing Company
580 pages

A book proposed to all those readers of the 'Another Passion' column "Fivefold Symmetry" by Alex Müller in this newsletter, who want to know more about this fascinating subject.

From the book description: Fivefold symmetry is common in flowers, fruits, molecules, logos, and buildings, but it is a forbidden symmetry in the world of crystals. A few years ago, the so-called quasicrystals were discovered displaying fivefold symmetry, and it caused a minirevolution in crystallography. There has been increased awareness of fivefold symmetry in all domains of human interest ever since. The present book brings together authors and ideas on a common theme from mathematics, the sciences, design, and anthropology to history, literature, and the arts.

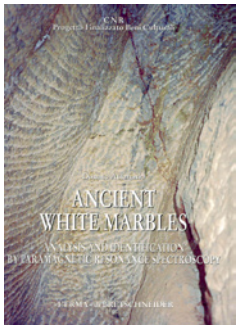
From the Contents:

- Fivefold Symmetry in Mathematics, Physics, Chemistry and Beyond
- Pentagonal Chaos
- The Icosahedral Design of the Great Pyramid
- Albrecht Dürer and the Regular Pentagon
- Hawaiian Flowers with Fivefold Symmetry
- An Islamic Pentagonal Seal

and many other contributions

Ancient White Marbles: Analysis and Identification by Paramagnetic Resonance Spectroscopy

Donato Attanasio
(Studia Archaeologica 122)
Price: 170 Euro (Hardcover) includes CD ROM



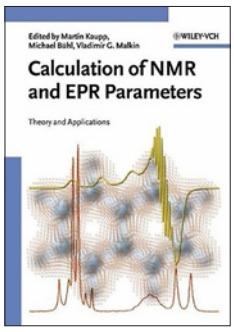
Publication date: 2003
Publisher: L'Erma di Bretschneider
284 pages

This beautifully illustrated book demonstrates once more the wide scope of applications of EPR, this time in the field of archaeology.

From the introduction: Electron resonance spectroscopy permits the measurement of particular properties of marble, or more specifically their impurities, which vary according to the quarry from which the sample was extracted. This method alone, as with others described in the literature, is not a fail-safe method for determining origin. Discrimination is improved by examining additional characteristics such as isotopic or petrographic properties and the need to use two or more provenancing techniques combined together is now firmly established.

Calculation of NMR and EPR Parameters: Theory and Applications

M. Kaupp, M. Bühl, and V. G. Malkin (editors)



Price: $ 182 (Hardcover)
Publication date: July 13, 2004
Publisher: John Wiley & Sons
621 pages

A timely book with many articles about quantum chemical methods to calculate NMR and EPR parameters, written by the top experts in the field.

From the book description: This is the first book to present the necessary quantum chemical methods for both resonance

types in one handy volume, emphasizing the crucial interrelation between NMR and EPR parameters from a computational and theoretical point of view. Here, readers are given a broad overview of all the pertinent topics, such as basic theory, methodic considerations, benchmark results and applications for both spectroscopy methods in such fields as biochemistry, bioinorganic chemistry as well as with different substance classes, including fullerenes, zeolites and transition metal compounds. A must-have for all chemists, physicists, biologists and materials scientists who wish to augment their research by quantum chemical calculations of magnetic resonance data, but who are not necessarily specialists in these methods or their applications.

Reviews

Spin Distribution and the Location of Protons in Paramagnetic Proteins

D. Goldfarb and D. Arieli
Annu. Rev. Biophys. Biomol. Struct. **33**, 441–468 (2004)

A review article about high-field EPR applied to studies of proteins with paramagnetic sites, which also stresses on the importance of using quantum chemical calculations for the interpretation of the experimental data.

From the Abstract: Two current frontiers in EPR research are high-field EPR and high-field ENDOR. This review focuses on recent advances in high-field ENDOR and its applications to the study of proteins containing native paramagnetic sites. It concentrates on two aspects; the first concerns the determination of the location of protons and is related to the site geometry, and the second focuses on the spin density distribution within the site, which is inherent to the electronic structure. Both spin density and proton locations can be derived from ligand hyperfine couplings determined by ENDOR measurements. The last part of the review presents a brief discussion of the interpretation of hyperfine couplings using quantum chemical calculations, primarily density functional theory (DFT) methods. Such methods are becoming an integral part of the data analysis tools, as they can facilitate signal assignment and provide the ultimate relation between the experimental hyperfine couplings and the electronic wave function.

Pulsed EPR Structural Studies in the Nanometre Range of Distances

S. A. Dzuba
Russian Chemical Reviews **74**, 619–637 (2005)

An overview which describes the different approaches used in EPR to determine distances between two unpaired electrons, and their potential of applications.

From the Abstract: The possibilities of investigations of the nanostructure of matter by pulsed EPR spectroscopy based on the measurement of the dipole-dipole coupling between the spins of unpaired electrons are considered. Using these methods, one can determine the conformations of long-chain organic biradicals and biomolecules (either doubly spin-labelled or containing paramagnetic metal ions) and study the supramolecular structure of matter, i.e., peptide clustering, heterogeneity of polymer packing, structural details of photosynthetic reaction centres and other complex systems. Investigations of the photo-induced spin-correlated radical pairs also reveal the regularities of charge transfer in these systems. The methods are characterised by high accuracy of measurements (0.03 nm) and can be used for measuring distances in the 1.5–10 nm range.

Market Place

POSITIONS

Research Assistant Professor or Research Associate
Immediate openings (4) at Dartmouth Medical School in the Electron Paramagnetic Resonance (EPR) Center for the Study of Viable Systems for Research Assistant Professor (2) and Research Associate (2). For the Research Assistant Professor positions a PhD is required with expertise and experience in EPR instrumental development and/or microwave engineering. The selected individuals should be capable of independently carrying research developments that are consistent with the research directions of the EPR Center and eventually should be able to secure external funding for related research. For the Research Associate positions (requires MS or the equivalent in experience) the skills needed include expertise in at least one of the following: Tumor or Cell Biologist; EPR Instrumentalist; and microwave engineering skills. Submit complete curriculum vitae, statement of pertinent experience, and request three references be sent to: Harold M. Swartz, Dartmouth Medical School, 702 Vail, Hanover, NH 03755, fax: 603-650-1717, e-mail: harold.swartz@dartmouth.edu. *Dartmouth Medical School is an equal opportunity/affirmative employeer and encourages applications from women and members of minority groups.*

EPR Spectroscopist Position
The Department of Chemistry at The University of Alabama seeks an outstanding individual with expertise in EPR spectroscopy to fill a tenure-track position at the Assistant or Associate Professor rank. Successful candidates are expected to have a PhD and postdoctoral training in chemistry or closely allied field, to develop a vigorous, externally funded research program, and to provide faculty oversight and leadership for the UA EPR facility (consisting of 4 CW and pulsed EPR and ENDOR instruments working at X-, Q-, and W-band frequencies). Commitment to excellence in both undergraduate and graduate teaching is also required. An appointment at advanced rank requires an established, internationally visible research program that complements the Department's needs. Further information on the Department and EPR facility is available at www.bama.ua.edu/~chem. Women and members of groups under-represented in science are especially encouraged to apply. All candidates should provide a curriculum vita including publication list, research plans (2-3 pages), teaching plans (1-2 pages), and arrange to have 3 letters of recommendation sent to the EPR Spectroscopist Search Committee, Department of Chemistry, The University of Alabama, Box 870336, Tuscaloosa, AL 35487. Review of applicants began **December 1** and will continue until the position is filled. *The University of Alabama is an equal opportunity/affirmative action employer.*

Postdoctoral Position in EPR Studies of Bio/Nano Systems
Applications are invited for a postdoctoral position in the Department of Physics at Boise State University to work in the area of electron paramagnetic resonance spectroscopy. The successful

applicant will employ EPR in the studies of biomolecular and nanoscale systems in collaboration with researchers from biology, chemistry, materials science and engineering disciplines at Boise State University, and with scientists at national level EPR user facilities. Applicants must have a PhD in physics, chemistry, materials science, or a related field, and significant experience in the EPR samples preparation, data collection, analysis, and spectral simulations of solid and liquid samples. Experience with EPR studies of proteins and other biomolecular systems, spin labeled systems and/or bio/nano sensors will be a plus. Women and minorities are encouraged to apply.

To be considered, the following materials are required: (i) Vitae and list of publications, (ii) A summary of previous/current research in relation to the above-mentioned areas (maximum of 2 pages), (iii) copies of two most important EPR-based publications, and (iv) a list of three references.

Applications may be submitted by e-mail: apunnoos@boisestate.edu, or mail to Dr. Alex Punnoose, Department of Physics, Boise State University, Boise, ID 83725-1570.

The appointment is for one to three years, depending on project funding and performance.

Research Associate
Chemistry of EPR Oximetry Materials

We seek a motivated individual with background in EPR (ESR) spectroscopy, chemistry or physics to join a research team developing and evaluating materials for in vivo quantification of O_2 (oximetry). The project involves preparation of paramagnetic materials that are carbon-based (chars) and/or built on molecular scaffolds, and characterization of their physical, electronic and magnetic resonance properties. The biological and clinical performance of these materials will be evaluated through collaborative studies at the EPR Center for Viable Systems at Dartmouth Medical School (www.dartmouth.edu/~eprctr/). Salary will be commensurate with training and experience.

Please contact: Prof. Dean Wilcox, Department of Chemistry, Dartmouth College, Hanover, NH 03755 (603-646-2874; dean.wilcox@dartmouth.edu) or Prof. Harold Swartz, EPR Center for Viable Systems, Dartmouth Medical School, Hanover, NH 03755 (603-650-1955; harold.swartz@dartmouth.edu)

Postdoctoral Positions Available at Davis Heart and Lung Research Institute, The Ohio State University

A position is available for a scientist with experience in magnetic resonance instrumentation development and application. The candidate should have experience in EPR/MR hardware or software development and applications to chemical or biological systems. Salary commensurate with experience. Please reference PA06 in your application.

A position is available for a scientist with experience in cardiac NMR spectroscopy or imaging research to perform isolated heart and in vivo studies of alterations in myocardial energetics and metabolism in the postischemic heart. Salary commensurate with experience. Please reference PA07 in your application.

The Ohio State University is an equal opportunity/affirmative action employer. Qualified women, minorities, Vietnam era veterans and individuals with disabilities are encouraged to apply.

Send CV to:

Dr. Jay Zweier, 473 West 12th Avenue, Room 110, Columbus, Ohio 43210 or zweier-1@medctr.osu.edu.

Full Time Research Associate Position at The University of Chicago

The University of Chicago's Department of Radiation and Cellular Oncology is seeking a qualified applicant for full time Research Associate position. The primary activity of a Research Associate is academic research in associate with faculty member or team. An opening currently exists in a research team studying and developing of novel Electron Paramagnetic Resonance based images of aspects of the physiologic milieu, particularly quantitative images of oxygen concentrations in the tissues of a living animal. This is part of the Center for EPR Imaging in Vivo Physiology, a federally funded multi-institutional research resource. The person selected for this position will work with a consortium of medical phsysicists, chemists, engineers and biologists.

The work will involve developing

- instrumentation for novel EPR spectral spatial imaging strategies using both continuous wave and pulsed acquisition techniques at radiofrequency (~250 MHz)
- novel projection acquisition strategies to increase the image resolution and sensitivity per unit time
- new magnet technologies for rapid and flexible projection acquisition
- novel analysis strategies to optimize the extraction of information per unit time
- novel resonant structures for enhancement of EPR imaging with continuous wave and pulsed instrumentation
- standards and novel phantoms to test both spatial and physiologic parameter resolution of images

and coordination and the obtaining of animal MRI studies to correlate anatomic images with the physiologic images obtained with EPR.

Qualified applicants must possess:

- A doctorate degree in physics, physical chemistry, or related field
- Expertise in EPR instrumentation and theory
- Expertise in programming and, in particular, in development of acquisition and analysis algorithms
- Expertise in computer control of data acquisition
- The ability to supervise and manage up to ten researchers involved in a wide variety of EPR experiments is crucial
- Willingness to work with animal subjects
- The ability to maintain a calm but critical work environment

Desirable attributes for applicants include:

- Experience with tomographic image acquisition and analysis
- Experience with MatLab programming environment
- Experience with National Instruments Labview
- Experience in the obtaining of MRI images

Applicants should fax (773)702-5940 or e-mail h-halpern@uchicago.edu a letter and Curriculum Vitae to Dr. Halpern, Department of Radiation and Cellular Oncology, The University of Chicago.

The University of Chicago is an equal opportunity/affirmative action employer.

EQUIPMENT

Do You Need Help in Design and Construction of EPR Electronics?

The University of Denver can supply electronic design and construction services for EPR applications. Low-noise pulse amplifiers, low-noise 100 kHz preamplifiers, boxcar integrators, and pulse timing systems are available.

We also supply a conversion kit to convert Varian field-control units to voltage-controlled scan operation. A 6-digit 1-ppm frequency counter is available in X-, C-, S-, L-band, or MHz versions.

Complete microwave/RF bridges from 150 MHz to L-, S-, or C-band are available from designs previously built and tested at the University of Denver.

Please contact:
Richard W. Quine rquine@du.edu
phone: 1-303-871-2419

For Sale:

65 GHz components including Gunn oscillators, isolator, wave meter, attenuator, magic tee, phase shifter, amplifier, wave guide.

Please send enquires to:
kreilick@chem.rochester.edu

Available: Isotope-Containing Spin Probes

A wide assortment of special ^{15}N- and/or ^{2}H-containing spin probes is available at moderate price.

For a catalog and a price list of available compounds **please contact:** Prof. Igor Grigor'ev grig@nioch.nsc.ru, Institute of Organic Chemistry, Novosibirsk 630090, Russia. In the US **please contact:** Dr. Sergei Dikanov dikanov@uiuc.edu.

EPR Accessories and Supplies Available

We have some excess EPR accessories and supplies that might be of use to other labs. For example, we have two EG&G 9825-200 fast digitizers, a lot of chart paper, pens and ink for older recorders, and some spare parts and accessories such as VT Dewars for older spectrometers. If you need something for an older-style Varian or Bruker spectrometer, ask us – we might be able to help. Most items are available for shipping costs.

Gareth R. Eaton geaton@du.edu

For Sale: Varian Equipment

Resonance Instruments has available:

1. Replacement klystrons for Varian EPR bridges (at reduced prices) and other klystrons.

2. Varian V4500-41A low/high power microwave bridge with new klystron – excellent condition.

For more information on these units **please contact:** Clarence Arnow, President rii1@earthlink.net, phone: 1-847-583-1000, fax: 1-847-583-1021.

For Sale: NMR Magnetometer

Sentec Model 1001, including 3 standard probes covering the range of 1 to 10 kG. In good working order, this 1981 model (uses NIM bin!) includes 7-digit display, 0.01 Gauss resolution, accuracy: 10^{-6} relative, 10^{-5} absolute, has automatic peak search feature, BCD output, etc. Can be bought with or without NIM bin and CRT display. Make an offer!

Please contact: Prof. E. J. Knystautas ejknyst@phy.ulaval.ca, Physics Department, University Laval Quebec City (Quebec), G1K 7P4
phone: 1-418-656-5569
fax: 1-418-656-2040

Available: Used Varian EPR Equipment

1. Varian E-104 EPR spectrometer with vertical style bridge and e-line fieldial.

2. Varian E-9 EPR spectrometer.

Both available with warranty and continued service support.

3. Varian TM cavity with flat cell holders and flat cells.

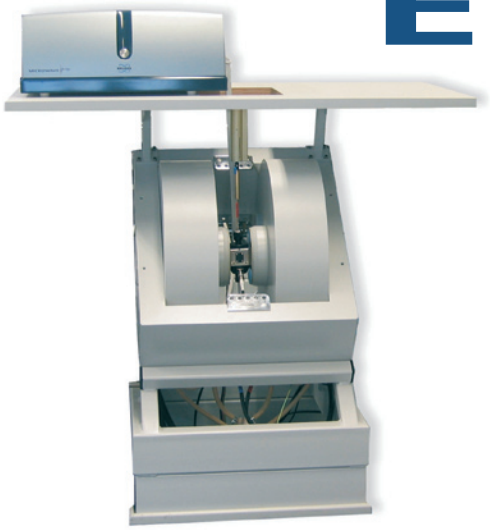
4. Varian E-257 variable temperature controller with heater sensor and insert holder.

5. Varian E-272B field/frequency lock accessory.

Please contact: James Anderson, Research Specialties, 1030 S. Main St., Cedar Grove, WI 53013, USA
phone/fax: 1-920-668-9905
e-mail: janderson36@wi.rr.com

The new way to do CW-EPR

EMX plus



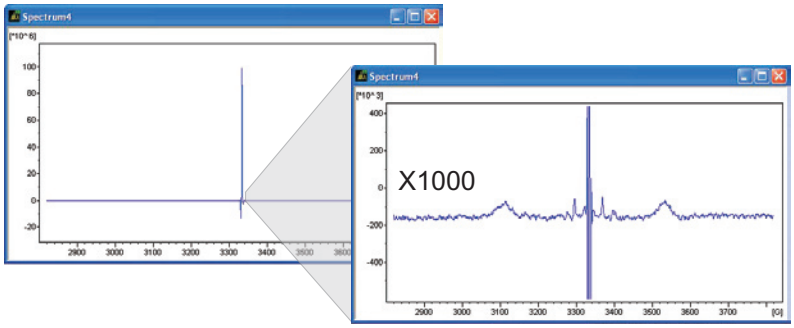
Simplified spectrum collection with 24-bit resolution

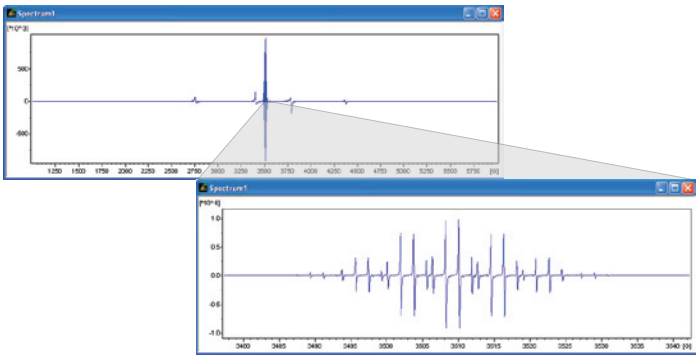
Amplitude

- Fast or slow sweeps with same resolution
- No need to optimize receiver gain for weak signals

Field

- Resolve small and large features in one sweep
- Unrestricted sweep resolution over sweep range

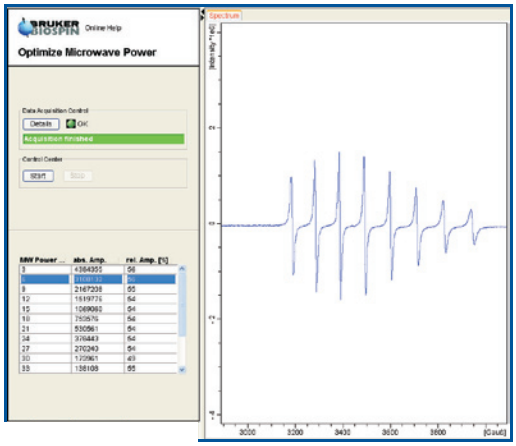




WIZ EPR

assists in each aspect of spectrum collection:

- Built-in routines for optimization of sweep time, microwave power, and modulation amplitude
- Save experiments as templates for future use
- Integrate data processing into experiment templates

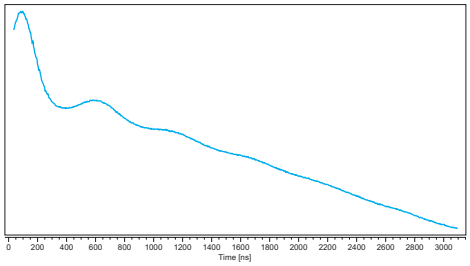


The Solutions in EPR

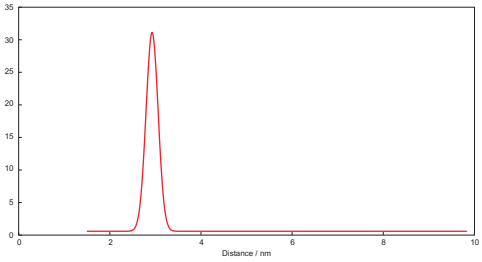
ELEXSYS -&- EMX plus

Structure Determinations

- **Distance Determinations 0.5-6 nm**
- **Extract Distance Distributions**



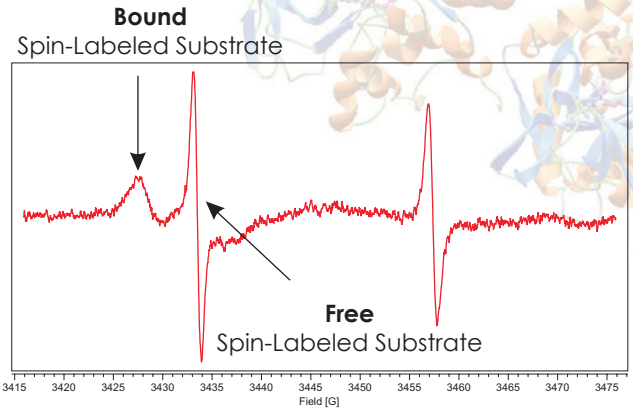
- **Determine Number of Interacting Spins**
- **Detect Conformation Changes**



Exploiting the dipolar coupling between electrons via CW and Pulse EPR techniques yields a wealth of information to assist in elucidating complex structural characteristics.

Motional Dynamics

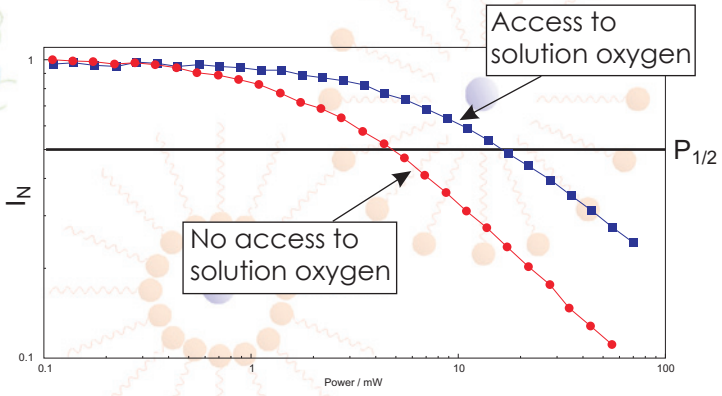
- **Global Tumbling Rates**
- **Internal Motions**
- **Conformation Changes**



EPR spectroscopic techniques are indispensable when complex local or global motional dynamics are to be studied.
EPR techniques provide specificity in both localization and time scale, via spin label position and microwave frequency, respectively.

Probing the Environment

- **Compartment pH**
- **Solvent Accessibility**
- **Local Temperature**
- **Local Polarity**



EPR spectroscopy combined with spin labeling techniques offer a powerful tool for the pinpoint measurement and monitoring of local environmental characteristics.