HISTORY

A Short History of Optical NMR

This is a very brief account of the history of optically enhanced NMR or ESR. The technique was proposed at Cornell and developed at Zurich by M. W. Evans. Despite a little scepticism, it was successfully demonstrated at Princeton by Warren et alia, who obtained funding for it, presented it at conferences and published their results in "Science", "Chemical and Engineering News" and "Optics and Photonics News". At that point the President of Optical Ventures, a venture capital firm based in Connecticut, became interested and has forged many links with the NMR industry on my behalf. Lately these contacts were extended to York University, Toronto, Canada.

The optically induced shifts at Princeton can be reproduced satisfactorily with the theory presented and developed in the third volume of "The Enigmatic Photon", and the phenomenon is now understood far better than in the pioneering days of the early nineties. The critically important breakthrough is the realization (circa 1995) that the beam conjugate product A(1) x A(2) interacts with the fermion spinor DIRECTLY. This inference has been checked by Olivier Costa de Beauregard, and if preferred, can be accepted without involving B(3). In my opinion, of course, A(1) x A(2) is directly proportional to B(3)*.

It is now clear that the data obtained at Princeton were at the extreme edge of what is possible, because I / omega squared was very small, because omega was of the order of 10 power 15, (argon ion laser). Harris and Tinoco of Berkeley have come to the same conclusion as I have, that the effect is proportional to I / omega squared, but missed the fact that A(1) x A(2) interacts directly with the spinor. This mechanism is just an extension of the inverse Faraday effect to the spin angular momentum of the fermion, and is described in chapters one and two of EP volume three. The I / omega squared dependence comes from the fact that:

A(1) x A(2) = (c / omega) squared B(1) x B(2)

and is therefore proportional to I / omega squared. Here I is intensity (watts per square metre); omega is angular frequency (radians / second).

My B(3) theory (December 1991) sprang out of attempts to understand the first ONMR results. In recent correspondence, Professor Olivier Costa de Beauregard describes the A(1) x A(2) dot sigma(3)* term as "the a priori expected strong coupling". Therefore there is agreement on the expected optical induced ESR and NMR phenomena. Prof. Costa de Beauregard was for many years a co-worker of Prof. de Broglie at the Institut Henri Poincare in Paris, where Prof. Vigier also worked.

The most exciting thing about this strong coupling term is that with the use of a radio frequency instead of a visible frequency pump beam, resonance can be picked up with a broad band IFS 113v probe beam at very high frequencies, dramatically enhancing the ESR or NMR resolution. This was the original intent of the theory at Cornell and Zurich and the experimental work at Princeton. Any offers to cooperate or any expressions of interest will be most welcome, and further details can be sent.

If we get our team off the ground in York University, Toronto we will be able to make the expected breakthrough and isolate ESR lines in the infra red to visible. It will take a very modest amount of backing to try out this idea, especially if a Bruker IFS 113v is already available.

Of course the interest and cooperation of other groups in this venture would be welcomed. If successful it would change ESR and NMR out of recognition, because it would do away with the need for large, homogeneous magnets. The new technique is actually a prediction of the

Dirac equation for a fermion in a circularly polarized electromagnetic field (M. W. Evans, J.-P. Vigier, S. Roy and S. Jeffers, "The Enigmatic Photon" (Kluwer, Dordrecht, 1995), volume three, chapters one and two.)

WANICLE

BIBLIOGRAPHY OF ELECTROMAGNETICALLY INDUCED ESR AND NMR.

Recommended Reading.

Chapters One and Two of: M. W. Evans, J.-P. Vigier, S. Roy and S. Jeffers, "The Enigmatic Photon: Theory and Practice of the B(3) Field." (Kluwer, Dordrecht, 1996), volume three.

Other Books on Optically Enhanced NMR

{1} M. W. Evans, "The Photon's Magnetic Field." (World Scientific, Singapore, 1992), with prize-winning animation cassette available from Chris Pelkie, Cornell Theory Center, Ithaca, NY 14853, USA.

{2} M. W. Evans and S. Kielich (eds.), "Modern Nonlinear Optics." a special topical issue of I. Prigogine and S. A. Rice (series eds.), "Advances in Chemical Physics." (Wiley Interscience, New York, 1992, reprinted 1993), vol. 85(2); prizewinning three volume monograph in top 2% of citation index.

(3) A. A. Hasanein and M. W. Evans, "The Photomagneton in Quantum Field Theory." (World Scientific, Singapore, 1994).

(4) M. W. Evans, J.-P. Vigier, S. Roy, S. Jeffers, and G. Hunter, "The Enigmatic Photon" (Kluwer, Dordrecht, 1994 to present), first four volumes in the acclaimed van der Merwe Series "Fundamental Theories of Physics".

Trade articles on ONMR written by journalists.

1) "Optics and Photonics News", 2(12), 42 (1991).

2) "Chemical and Engineering News", 1991.

Articles on ONMR and OESR in Learned Journals.

Theoretical Papers, 1991.

1) M. W. Evans, "Optical Phase Conjugation in Nuclear Magnetic Resonance: Laser NMR Spectroscopy.", J. Phys. Chem., 95, 2256-2260 (1991).

2) M. W. Evans, "Spectral Splitting due to a Circularly Polarized Pump Laser: Laser Zeeman Spectroscopy", Mod. Phys. Lett., 5B, 1065-1073 (1991); also Cornell Theory Center Report CTC91TR79.

3) M. W. Evans, "Laser Zeeman and NMR Spectroscopy: Effective Torque and Laser Larmor Precession." Int. J. Mod. Phys., 5B, 1263-1272 (1991).

4) M. W. Evans, "Theory and SImulation of Optically Induced Line Shifts in NMR." Chem. Phys., 157, 1-24 (1991).

5) M. W. Evans, "Optical NMR and ESR.", J. Mol. Spect., 150, 120-136 (1991).

6) M. W. Evans, "Molecular Dynamics Computer Simulation of Magnetization by an Electromagnetic Field." Phys. Lett. A, 157, 383-390 (1991).

Theoretical Papers, 1992.

7) M. W. Evans, "Simulation and Symmetry in Molecular Dynamics and Spectroscopy." Adv. Chem. Phys., 81, 361-702 (1992), top 2% of citation index.
8) S. Wozniak, M. W. Evans and G. Wagniere, "Optically Induced Static Magnetization near Optical Resonances in Molecular Systems, Part 1: Inverse Faraday Effect (IFE).", Mol. Phys., 75, 81-98 (1992).
9) M. W. Evans, S. Wozniak and G. Wagniere, "Field Applied Molecular Dynamics (FMD) Simulation of the Inverse Faraday Effect." Physica B, 176, 33-53 (1992).
10) M. W. Evans, "Optical NMR and ESR - Dipole/Dipole and Fermi Contact Interactions." Physica B, 176, 254-262 (1992).
11) M. W. Evans and C. R. Pelkie, "Optical NMR Theory, Simulation and Animation.", J. Opt. Soc. Am., B - Opt. Phys., 9(7), 1020-1029 (1992).
12) M. W. Evans, "Laser Enhanced Optical NMR Spectroscopy, The Role of Atomic Hyperpolarizability." Physica B, 179, 157-170 (1992).
13) M. W. Evans, "The Coupling of Three Angular Momenta in the Optical NMR and ESR of Atoms." Physica B, 179, 342-348 (1992).
14) M. W. Evans, "The Light Magnet, Coupling of Electronic and Nuclear Angular Momenta in Optical NMR and ESR in Atoms: Quantum Theory." J. Mol. Spect., 154, 1-11 (1992).
15) M. W. Evans, "Quantum Theory of Optical NMR and ESR in Atoms." Physica B, 179, 237-248 (1992).
16) M. W. Evans, "The Elementary Static Magnetic Field of the Photon", Physica B, 182, 227-237 (1992). (First paper on B(3)).

The First Experimental Paper in 1992.
17) W. S. Warren, S. Mayr, D. Goswami and A. P. West, Jr., Science, 255, 1683 (1992). Reports small positive results with visible frequency pump.

1993
18) Several papers in "Advances in Chemical Physics", volume 85(2).

1994.
19) Volume One of "The Enigmatic Photon" (1994), experimental chapter.
20) D. Goswami, Experimental Ph. D. Thesis, Princeton University, 1994.

1995.
21) Series of confidential reports and patent by M. W. Evans as visiting professor at York University, Toronto, on the key new development of radio frequency induced ESR and NMR.

1996.
22) Theory of RF NMR and ESR given in chapters one and two of the third volume of "The Enigmatic Photon."

Note: A copy of this book is available at York University, Toronto.

1994 - 1996 : Theoretical Discussion of ONMR.
23) R. A. Harris and I. Tinoco, Jr., J. Phys. Chem., 101(11), 9289 (1994); A. D. Buckingham and L. L. Parlett, Science, 264, 1748 (1994); M. W. Evans, Found. Phys. Lett., submitted, preprint sent to Profs. Hunter and Jeffers at York University. Material currently being studied by Dr. Crow at the U.S. National Bitter Magnetic Laboratory.

Overall Conclusion

RF NMR is potentially much more effective than optically induced NMR.

M. W. Evans, 13th June, 1996.

BRUKER

Subject: Enquiry from Bruker Canada in Response to my Overture re Support
Date: 10-Jun-96 at 08:48
From: Evans, 100561,607

TO: Geoffrey Hunter,INTERNET:FS300022@Sol.YorkU.CA

Prof. Geoffrey Hunter,
Associate Professor of Chemistry,
York University, Toronto,

Message for Bruker Spectrospin of Canada.

Dear Geoff,

Many thanks for the two messages, which are very helpful and encouraging. Stanley has some confidential reports and a patent on RF NMR, which is fully described in volume three of "Enigmatic Photon".

Essentially, a circularly polarized radio frequency beam is used to cause proton or electron resonance through the interaction of the beam's conjugate product and the spinor. The resonance frequency is proportional to I / omega squared, where:

I = beam intensity (watts per square metre)
omega = beam angular frequency (radians per second).

There are plans to assemble at York University a critical mass of scientists: G. Hunter; S. Jeffers; R. Smirnov Rueda; M. W. Evans and possibly D. Ahluwalia, plus students. Among other things theoretical, they would attempt the prototype ESR experiment with an r.f. beam directed at an electron beam. Resonance to be detected with an FT IR, e.g. the Bruker IFS 113v. The apparatus is currently being assembled by Professor Stanley Jeffers of Physics.

This is therefore a pump / probe experiment: the pump is the circularly polarized r.f. beam; the probe is the FT IR spectrometer.

THE MAJOR ADVANTAGE IS THAT ELECTRON OR PROTON RESONANCE CAN OCCUR AT VERY HIGH FREQUENCIES IF CONDITIONS ARE TUNED PROPERLY. ESR OR NMR RESONANCE COULD ACTUALLY BE DETECTED BY AN INFRA RED FT SPECTROMETER WITHOUT MAGNETS, A SPECTACULAR ADVANCE IN THE SUBJECT.

If this prototype ESR experiment works, it would open the door for a prototype NMR experiment. Stanley Jeffers has a copy of chapter two of volume three of "Enigmatic Photon" in which the theory appears in detail. The I / omega squared dependence agrees with the theory of Harris and Tinoco of Berkeley. Appended is a short paper on the subject.

Finally, this experiment would be very important evidence for the existence of longitudinal modes in radio frequency e/m radiation.

thanks again,
Myron:

BRuK 2

Subject: IBM, Bruker, Longitudinal Field
Date: 10-Jun-96 at 12:36
From: Evans, 100561,607

TO: Geoffrey Hunter,INTERNET:FS300022@Sol.YorkU.CA

Experimental Methods.

The experimental methods used to detect optically induced resonance shifts at Princeton are available in the Ph. D. Thesis of Debu Goswami, 1994, who went on to Harvard and Brookhaven.

The experiment proposed now, RF ESR, is much simpler in principle, and uses a radio frequency pump beam interacting with an electron beam. The appended files discuss some actual expected results from a very simple resonance equation given in chapter two of volume three of "Enigmatic Photon". The major features expected are as follows:

a) Resonance frequency proportional to the pump intensity, I and inversely proportional to the pump frequency squared.
b) Disappearance of the signal if the pump loses circular polarization, i.e. is linearly or incoherently polarized.
c) Autoresonance when the pump and resonance frequencies are the same.

One possible arrangement is a triple beam arrangement in which the pump is in X; electron beam in Y; probe beam in Z.

The PUMP BEAM can be pulsed if the detector of the probe is fast enough to respond. Otherwise the pump can be used in the steady state and the probe be used as in normal FT IR spectrometry. The IFS 113v is the research standard instrument of Bruker and I think has a range from about 10 wavenumbers to the visible.

HOMOGENEITY of the pump beam is not a critical factor, as discussed in EP volume three. This is because population differences are very much greater than in ordinary NMR, in which the magnet has to be shimmed, i.e. homogeneous to one part in ten million. Homogeneity of about 13% in the pump should be sufficient.

PROBE BEAM is the beam of the IFS 113v spectrometer as it passes through the sample compartment of the instrument on its way from the beam splitter of the Michelson interferometer to the detector, probably a Rollin helium cooled Josephson junction of the type I helped develop at NPL in Teddington. Mutually perpendicular to the probe beam is the electron beam and the circularly polarized radio frequency pump beam. (I did my Ph. D. on a Grubb Parsons prototype interferometer and am a pioneer of Fourier transform far infra red spectroscopy.)

WHERE IS THE MAGNET? There is no magnet, because the pump beam plays the role of the magnetizing agent through the conjugate product. The most exciting feature of the whole experiment is the I / omega squared dependence, and because r.f. instead of visible frequencies are used in the PUMP, repeat PUMP, we are increasing I / omega squared by FIFTEEN orders of magnitude for constant I. This gives a massive advantage over the Princeton experiment. The I / omega squared feature is clearly seen also in the theory of Harris and Tinoco of Berkeley, and comes from STANDARD, repeat STANDARD, fundamental non-linear optics.

WITH WHAT DOES THE PUMP BEAM INTERACT? With the spinor of the electron, which has two topological states. Technically the beam conjugate product A(1) x A(2) forms a dot product with the electron's sigma(3)*, Pauli spinor three of the electron. This feature emerges from the Dirac equation.

HOW DOES RESONANCE OCCUR? Between the two energy states caused by interaction between the pump beam and the spinor, a kind of optical Zeeman effect in other words. The effect is, actually, the radio frequency induced optical Zeeman effect from one electron. Obviously, there is going to be an analogous Zeeman effect in atoms and molecules with a spare electron. ESR, after all, is a Zeeman effect at the simplest level of understanding.

HOW IS RESONANCE DETECTED? As an absorption of the probe beam anywhere in the range from 10 wavenumbers to the visible.

WHAT ADVANTAGES ARE THERE OVER ORDINARY ESR? The resonance frequency is shifted enormously to higher frequencies, from the 100 MHz range of ordinary ESR to the infra red or visible, with enormous enhancement of resolution. This is what the industry is laboriously trying to do with expensive superconducting magnets.

IS IT COST EFFECTIVE? Given that Bruker manufactures the IFS 113v itself, it is possible with a few simple adjustments to use the same technology for ESR, a great advance in cost effectiveness because infra red Fourier Transform spectrometers are much cheaper than NMR spectrometers. Ultimately one can package a combined IR / NMR spectrometer and capture the world market.

DOES THE THING WORK? Yes, because textbooks such as that by P. W. Atkins, "Molecular Quantum Mechanics" (Oxford Univ. Press, 1982) report the ability of radiation to permanently magnetize, the "inverse Faraday effect".

WHAT ABOUT NMR? The same set up can be used, but obviously, the sample cannot be an electron beam, it could be an atomic beam or a sample containing protons. We have to simplify things to the core first and use an electron beam, cleaner than plasma as pointed out by Professor Jeffers.

WHAT ABOUT TWO-D NMR? There appears to be no objection, but all that must come later, after experience has been gained.

WHY DIDN'T PRINCETON LATCH ON? Because they were at completely the wrong pump frequency, in the visible, and the theory was not fully developed. It takes time and experience to get the right configuration. A big effort was put in nonetheless at Princeton, and they received several hundred thousand dollars in NSF and other funding.

WELL PROVE IT THEN. O.K., given the chance.

ABSTRACT

Subject: Key Features
Date: 13-Jun-96 at 20:29
From: Evans, 100561,607

TO: Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca

Short Summary for Bruker Spectrospin.
Key Features of Chapters One and Two of Volume Three.

("The Enigmatic Photon" by M. W. Evans, J.-P. Vigier, S. Roy and S. Jeffers (Kluwer, Dordrecht, 1996), volume three).

The Main RF NMR Equation

om (res) = 1.532 x 10 power +25 I / (om squared)

om (res) = probe resonance angular frequency
om = pump angular frequency
I = pump intensity (watts per square metre)

Example Results for I = 10 watts per square centimetre and for one unshielded proton are as follows.

Pump Frequency	Probe Resonance Frequency	Note
5,000 wavenumbers	0.28 Hz	(a)
500 wavenumbers	28.0 Hz	
1.8 GHz	1.8 GHz	(b)
1.0 GHz	6.18 GHz	
0.1 GHz	20.6 wavenumbers	(c)
10.0 MHz	2060.0 wavenumbers	(d)
1.0 MHz	206,000 wavenumbers	(e)

(a) Order of experimental results of Warren et alia, Science 1992.
(b) Autoresonance in the microwave.
(c) Far infra red resonance peak, radio frequency pump.
(d) Infra red resonance peak, radio frequency pump.
(e) Ultra violet resonance peak, low radio frequency pump.

Homogeneity Requirements in Pump (Page 38)

For a pump in the radio frequency to microwave range of intensity 100 watts per square centimetre, for example at 100 MHz at 293 K, the population ratio of the up and down states of the Pauli spinor is 0.87, indicating a 13% population difference in spin population between the two fermion states, using a Maxwell Boltzmann analysis. This compares with about 7 parts per million for a contemporary conventional NMR instrument at 293 K with a 1.0 tesla magnet. The applied radio frequency field does not have to be manufactured to greater than the order of 10% homogeneity. This is another major advantage of the new technique.

ARES

Subject: Microwave Induced ESR
Date: 18-Mar-96 at 14:48
From: Evans, 100561,607

TO: Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca
Sisir Roy,INTERNET:sisir@isical.ernet.in

Microwave Induced ESR

The equation in this case is:

om (res) = 1.007 x 10 power +28 I / om squared ---(1)

where om is the pump angular frequency, om(res) the probe res. freq. The autoresonance condition in eqn. (1) is

om(res) = om ----- (2)

Prototype Conditions.

1) Let us assume the use of a sample consisting of an electron beam. Eqn. (1) is written for one electron in S.I. units. Assume that

I = 10 watts per square centimetre
= 10 power plus five watts per square metre (S.I. unit)

2) The autoresonance frequency is 15.97 GHz in the microwave.

3) If we use a 16 mm pump waveguide, then f(pump) = 18.75 GHz and f (res) = 11.6 GHz for this intensity.

Please check these calcs for any numerical error, using:
om = 2 pi f; lambda f = c. (O.K., checked by Stanley.)

So a 1.6 cm (16 mm) circularly polarized waveguide should produce autoresonance at the right I, which is 16.33 watts per square centimetre. This means that a 16 mm microwave beam, perfectly circularly polarized, with an intensity of 16.33 watts per square centimetre, directed at an electron beam, produces resonance at its own wavelength, 16 mm.

These numbers should obviously be checked independently using eqns. (1) and (2). I worked them out on a calculator today.

Presumably this means that there will be an absorption spike as the intensity I is swept through 16.33 watts per square centimetre because at exact resonance, the pump beam is itself absorbed as it flips the spinor over in the term sigma dot A x A*. So we would need just two beams, a microwave 16 mm standard, and an electron beam.

The only remaining difficulty would be in circularly polarizing the 16 mm standard (off the shelf) waveguide.

Expected Results

The spike should be of equal intensity for right and left polarization, and should disappear in linear or otherwise scrambled or incoherent polarization. This appears to be the simplest and quickest test of the very simple one electron theory giving eqn. (1). Eqn. (1) is the result of the Dirac equation with complex A applied to one electron with assumed Lande factor 2.002.

SOME AUTORESONANCE CONDITIONS.
MICROWAVE INDUCED ESR.

Subject: Microwave ESR
Date: 19-Mar-96 at 19:00
From: Evans, 100561,607

TO: Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca
Sisir Roy,INTERNET:sisir@isical.ernet.in

Some Microwave Induced Electron Spin Autoresonance Data

Rule of thumb, I = 10 power - 32 om cubed watts per square centimetre,
where I = autoresonance power density
om = autoresonance angular frequency (rad / s = 2 pi f)

Some Sample Predictions.

f / GHz	lam / cm	om / (G r / s)	I / (W / cm sq.)
9.25	3.24	58.09	1.96
17.6	1.70	108.8	12.88
34.3	0.88	212.0	95.28
68.12	0.44	421.0	746.18
111.1	0.27	697.7	3400.7

Also: For I fixed at 10 watts per sq. cm, the autoresonance frequency is 16 GHz; wavelength of 1.875 cm.

For a carbon dioxide Q switched laser at about 1500 wavenumbers in the mid infrared, the I needed is enormous, 1.8 x 10 power 12 watts per square centimetre for autoresonance.

At autoresonance the pump frequency is the same as the probe frequency, so absorption of pump radiation takes place.

Checks

1) The I / om squared factor has been given also by Harris and Tinoco.
2) The sigma dot A x A* factor has been found in another context by Riccardo Brun del Re in the relativistic quantum field theory of Dirac. The above are predictions of the Dirac equation.

Subject: High Power RF Systems
Date: 13-Jun-96 at 14:58
From: Evans, 100561,607

TO: Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca

Proposed FAx

RF

Titan Beta Corporation,
6780 Sierra Court,
Dublin,
CA 94568, U.S.A.
fax 510 828 4054; tel. 510 828 0555.

Dear Titan Beta,

Following your advert in "Physics Today" I am interested to know whether your high power r.f. systems can produce accurately circularly polarized radiation which can be directed into an electron beam, thus causing magnetization - the inverse Faraday effect. The advert describes pulsed output to 500 megawatts in the range 0.45 to 18 GHz, with associated waveguides WR1800 to WR62.

The inverse Faraday effect occurs only if the radiation is accurately circularly polarized, and I wish to ask whether you have off the shelf components for this purpose. My colleague Prof. Stanley Jeffers has designed this experiment to analyze details of the expected magnetization for a novel field of electromagnetic radiation, the B(3) field. My colleague Prof. Geoffrey Hunter is also interested and is committed to cutting edge physics of this nature.

I am also interested in the detector technology used to deal with these intense pulses. The sample in our case would be the above-mentioned electron beam, and I assume that a SQUID would be too slow to deal with your pulse. Therefore I assume that the detector would be an oscilloscope picking up the signal from an induction coil.

We have also designed auto-resonance set ups which if positive will produce radio frequency induced ESR. If an ion beam is used we would hope to detect radio frequency induced NMR. I note that ion beams are manufactured by Commonwealth Scientific Corp., 500 Pendleton Street, Alexandria, VA 22314, U.S.A., tel 703 548 0800, fax 7405.

Naturally I would be glad to send further details if you are interested.

Sincerely Yours,
Myron Evans
(Dr. M. W. Evans, Visiting Professor, York University, Toronto, Canada).
Copied Profs. Jeffers and Hunter.

SOURCE

Subject: Letter to "Amplifier Research"
Date: 13-Jun-96 at 13:52
From: Evans, 100561,607

TO: Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca

Proposed Fax.

Amplifier Research,
160 School House Road,
Souderton,
PA 18964-9990, U.S.A.,
fax 215 723 5688; 1-800-933-8181

Dear Amplifier Research,

Following up your advert in "Physics Today" I would be interested in advice on an inverse Faraday effect system as follows.

1) RF Source, your 500A100 from 10 kHz to 100 MHz at 500 watts power.
2) Circular polarizer for the r.f. radiation for accurate 100% right or left circular polarization.
3) Waveguides that keep circular polarization; or some practical alternative.
3) Faraday induction coil wound around an electron beam sample.
4) Lock-in amplifier and modulator.

The experiment consists of passing an electron beam through a Faraday induction coil. The chopped r.f. beam is used to produce the inverse Faraday effect in the electron beam, the signal in the induction coil is picked up with a lock in amplifier and oscilloscope.

The inverse Faraday effect should be proportional to I / omega squared at the higher frequencies, and relativistic corrections should become visible at the lower frequencies. Here I is beam intensity and omega beam angular frequency. This is one of many possible designs for the proposed Jeffers Experiment, named after my colleague, Professor Stanley Jeffers at York University, Toronto. Your Model 500A100 looks perfect for this purpose, and I wonder whether there is any chance of cooperating with the Toronto group in some kind of grant application. My colleague Professor Geoffrey Hunter is also interested and committed to this type of research at York University.

This same set up can be used for auto-resonance, which we will be pleased to describe in more detail. Ultimately, this leads to optically induced ESR and NMR, and new technology.

Sincerely Yours,
Myron Evans
(Dr. M. W. Evans, Visiting Professor, York University, Toronto).

SQUID

Subject: Radio Frequency Magnetization
Date: 13-Jun-96 at 14:23
From: Evans, 100561,607

TO: Conductus,INTERNET:simon@conductus.com

Dr. J. M. Rowell,
Conductus Corporation, U.S.A. fax (408) 523 9999

Dear Dr. Rowell,

In response to your advert in "Physics Today", I am interested in using a high temperature SQUID to detect magnetization in an electron beam by a radio frequency field - the inverse Faraday effect. For example, an Amplifier Research Model 500A100 produces r.f. from 10 kHz to 100 MHz at 500 watts. I have asked them whether this output could be circularly polarized accurately and directed into the electron beam, thus causing the inverse Faraday effect (magnetization by light).

This is the essence of the Jeffers Experiment, proposed by my colleague Prof. Stanley Jeffers at York University, Toronto in cooperation with my colleague Prof. Geoffrey Hunter of the same Campus.

I would like to ask whether a high temperature SQUID could be used to detect the expected magnetization of the electron beam, whose characteristics we plan to use to isolate a new component of electromagnetic radiation known conveniently as the B(3) field. You mentioned in your advert that you sometimes loan out a SQUID with some financial backing, and I wonder whether one could be loaned to YU if it is suitable to pick up magnetization in an electron beam. I assume that it is because a superconducting quantum interference device works with a ring which could be assembled around the electron beam.

This system could also be used to detect auto-resonance, which we are designing at YU, and of course we are prepared to send you further details if you are sufficiently interested, with an eye to obtaining a grant to purchase a SQUID from you if the idea works.

Sincerely Yours,
Myron Evans
(Dr. M. W. Evans, Visiting Professor of Physics, York University).
Copied Profs. Jeffers and Hunter.

BRUKL

Subject: Configuration
Date: 26-Jun-96 at 08:18
From: Evans, 100561,607

TO: Prof. Geoffrey Hunter,INTERNET:fs300022@sol.yorku.ca
Stanley Jeffers,INTERNET:FS300017@SOL.YORKU.CA
Dr. L. Pozhar,INTERNET:pozhar@cheme.cornell.edu

Key Reference: Volume Three of "The Enigmatic Photon" (Kluwer, Dordrecht, 1996), by M. W. Evans, J.-P. Vigier, S. Roy and S. Jeffers.

RF ESR CONFIGURATION

All hardware elements for this Mark One prototype are available off the shelf, i.e.
1) RF generator, CW up to 400 watts power throughout the RF / microwave.
2) Electron beam generator.
3) IFS 113v probe.
4) Circular polarizer for (1).
5) Peripheral electronics.

All theoretical elements are also in place, i.e. the Dirac equation can be solved exactly for one fermion in the classical field. The key theoretical insights are as follows:
1) The Pauli spinor sigma(3) forms an interaction hamiltonian eigenvalue through a dot product with the conjugate product A(1) x A(2). This forms part of the energy eigenvalue of Dirac's original 1926 equation. Paul

Dirac discarded this term because he used real A. In a circularly polarized beam A(1) x A(2) is non-zero and produces magneto-optics.
2) Resonance can occur at very much higher frequencies than available in conventional ESR, because of the I / omega squared dependence of the pump (the r.f. generator), where I is its intensity, or power density, in watts per unit area; omega is its angular frequency in radians per second.
3) A fifteen order of magnitude advantage is gained for constant I by reducing omega from the visible (circa 10 power 15) to the r.f. (circa ten power 8). This advantage is practicable because an r.f. generator typically produces an I that is greater than a visible laser, (400 watts cf. a watt CW).
4) This enormous advantage over the early Princeton experiments can be exploited experimentally. The Dirac equation, unsurprisingly in retrospect, also produces the order of magnitude of the Princeton experiments. (There were a long series of careful experiments with several different set-ups, funded by NSF, NIH, etc.)
5) Criticisms by Buckingham (now retired), Barron etc. completely missed the key interaction term, sigma(3) dot A(1) x A(2).

Elements not in Place

It is crucial to the success of the experiment to have available the help of the best experimentalists and technical back-up staff, preferably from industry. For ESR the sequence of samples should be: 1) Electron beam; 2) Ion beam; 3) molecular beam; 4) liquid and solid samples.

End Result

An ESR spectrum in the infra red / visible range, completely changing ESR spectroscopy. The Prototype Mark Two experiment would seek the same end result for NMR with different nuclei. Protype Mark II with 2-D NMR technology; or the new 2-D FTIR technology currently coming on line.

Personally I am interested in being employed by Bruker in some way to advise in all this at York University, Cornell and Cornell Business Park.

MWE, copied interested colleagues.