Introduction: History of the $\mathbf{B}^{(3)}$ Field

The inference of the $\mathbf{B}^{(3)}$ field was made in December 1991 after my return to Cornell from a year at the University of Zurich working on the inverse Faraday effect. Its subsequent history is recorded here to illustrate the lack of objectivity among some physicists in the present era. The erosion of the traditional right of reply is also illustrated by these events.

The first papers on $\mathbf{B}^{(3)}$ were published in *Physica B*, 182, 227, 237 (1992) after some revision. They were probably refereed by Peter Atkins of Oxford, but I cannot be sure of this. The referee made the usual comment that the hypothesis should be tested experimentally.

Shortly after my move to University of North Carolina at Charlotte as a tenured professor of physics, I received a preprint from Laurence Barron of Glasgow claiming that the $\mathbf{B}^{(3)}$ field violated C symmetry. This was debated in *Physica B*, 190, 307 and 310 (1993), after Barron s claim had been dismissed out of hand by Justin Huang of Missouri, who described it in a private communication as totally wrong . It is now known that the **B** cyclics are covariant and therefore CPT conserving, so Huang was correct in his estimation.

So far OK. Fair criticism, fairly answered. It is sadly well known that this standard of debate was not maintained. The problem started with a paper by Barron, essentially identical to the above, submitted to David Buckingham s journal *Chemical Physics Letters*, based at Cambridge. In over forty exchanges of messages, Buckingham blocked my draft reply to Barron, until the late Mansel Davies intervened with a plea for open debate. Buckingham reacted by refusing to print Barron or myself, in a show of fairness, but *simultaneously*, submitted a paper with Barron to *Physica B*, which rejected it. Still not satisfied, Barron complained to Wiley about my award winning *Modern Nonlinear Optics* (now in paperback) and submitted the same manuscript once more to *Foundations of Physics Letters*, where it was rejected twice, after an apparent complaint by Barron to the Editorial Board.

Having failed in traditional open debate, the attacks on $\mathbf{B}^{(3)}$ went underground with papers appearing in print without my knowledge many times. This puerile conduct was catalyzed by Lakhtakia and Grimes in *Physica B*, 191, 362 and 367 (1993), which I first saw by accident in the library at UNCC. They were eventually replied to in *Found. Phys. Lett*., 8, 563 (1995), together with other papers which had in the meantime been published in *Science*, also without my knowledge, by Buckingham and Parlett, *i.e*. 264, 1748 (1994) and 266, 665 (1994). I was not allowed to reply in *Science* or *Physica*. Akhlesh Lakhtakia also attacked in *Found. Phys. Lett*., and was replied to (8, 183, 187 (1995)). The $\mathbf{B}^{(3)}$ was famously described as ghastly , a horrendous pun on ghostly .

These papers contain some interesting material, but do not address the central and very simple **B** cyclic theorem, which is covariant and CPT conserving, and do not address the fact that $\mathbf{B}^{(3)}$ is observed in the inverse Faraday effect. The articles by Buckingam in *Science* had the disastrous effect of fomenting so much doubt at UNCC about my sanity that I was forced to resign. The process of pressuring my resignation is recorded in all detail on the website (URL:www.europa.com/~rsc/physics/B3/evans), together with evidence for falsification of charges of misconduct and neglect of duty. Also recorded are very positive student comments on my teaching.

The debate between Steven van Enk and myself was carried out in the accepted way, and appears in *Found. Phys. Lett*., 9, 183, 191 (1996). Here van Enk makes some good points of criticism, but again does not address the central issue, the **B** cyclic theorem. This debate is well worth reading nevertheless.

The debate between Gert Rikken and myself was conducted once more in the underground, which is why it appears in two different journals (*Opt. Lett*., 20, 846 (1995), and apparently a paper in *J. Applied Phys*. just published without my knowledge (see the @ *issue* section, current issue); and in *Found. Phys. Lett*., 9, 61 (1996)). Rikken claims non-existence of $\mathbf{B}^{(3)}$ on the grounds that he failed to detect the optical Faraday effect, first predicted in the early sixties by the late and very great Stanislaw Kielich. Rikken fails to understand that $\mathbf{B}^{(3)}$ interacts with matter through the conjugate product $\mathbf{A}^{(1)} \times \mathbf{A}^{(2)}$. This point has been clear for several *years* by now. (I may have been guilty of not formulating the theory instantly and fully in final form, and of not realizing this in 1991, but by now it is very clear.)

Eliahu Comay s paper in *Chem. Phys. Lett*. (edited by the impeccably impartial David Buckingham) was published in 261, 601 (1996) and after numerous exchanges my reply was blocked. (All recorded on the website.) It was eventually published with Stanley Jeffers in *Found. Phys. Lett*., 9, 587 (1996). Comay has joined the underground movement and has published in *Physica B*, 222, 150 (1996). I have just submitted a reply in another journal and broadcast it on web and internet. These two papers by Comay are essentially identical and claim, erroneously, that $\mathbf{B}^{(3)}$ is not irrotational or divergentless. While giving the impression of fairness in the *Chem. Phys. Lett*. debate Comay had clearly submitted simultaneously to *Physica B* on virtually the same material.

To bring the saga of debates up to date, the erroneous claim by Comay that the **B** cyclic theorem is not covariant will be published shortly in *Found. Phys. Lett*., with my reply and an impartial and independent comment by Valeri Dvoeglazov of Zacatecas.

In the meantime the $\mathbf{B}^{(3)}$ theory has been developed in several volumes and many papers, and has catalyzed thought on longitudinal solutions *in vacuo* and their relation to photon mass. Even though fully aware of the atrocities at UNCC, the critics have continued a campaign of secretive publishing. A review of *The Enigmatic Photon*, first three volumes, appears in this issue. The impression I get is one of intolerance and dogmatism, ending in a complete failure to demonstrate that the **B** cyclic theorem is in any way in contravention to the accepted laws of physics. Thus $\mathbf{B}^{(3)}$ is a magnetic field which signals the need for a revision of electrodynamics at the fundamental level. Other longitudinal solutions of Maxwell are by now freely available, and are developed in this special issue.

After approximately five and a half years of development and discussion of unprecedented intensity it seems that the following may be expected from $\mathbf{B}^{(3)}$ theory and the more general non-Abelian

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electrodynamics being consolidated now by several groups and described in the volumes of *The Enigmatic Photon*.

1) In *Unified Field Theory* the electromagnetic sector becomes non-Abelian. Its internal symmetry is ((1), (2), (3)) in contrast to the scalar symmetry of the received U(1) group. Photons develop gluon structure, the electromagnetic, colour and flavour fields become non-Abelian gauge fields, and it becomes easier to tie in the electromagnetic field with the gravitational field. Some progress towards this has been achieved in recent papers in *Foundations of Physics* and *Foundations of Physics Letters*.
2) In *Cosmology*, $\mathbf{B}^{(3)}$ allows finite photon mass, with several already inferred consequences for red shifts, tired light, big bang theory and the Michelson-Morley experiment. The last is further developed by Vigier in this Special Issue, showing that the ether drift hypothesis is compatible with the results of the experiment, and showing that photon mass is feasible. The existence of $\mathbf{B}^{(3)}$ and a non-Abelian gauge symmetry for electromagnetism makes photon mass a natural consequence, and if the photon is particulate it is almost certainly massive.
3) In *ESR* and *NMR*, $\mathbf{B}^{(3)}$ allows considerable practical development of these important analytical techniques, in the hope of providing the medical community with vastly improved NMR technique based on irradiation rather than magnets as at present. By solving the Dirac equation it is straightforward to show that the interaction of $\mathbf{B}^{(3)}$ with the fermion spinor allows nuclear magnetic resonance to take place in the infra red to visible if irradiation takes place in the range of radio frequencies.
4) In *Quantum Field Theory*, the $\mathbf{B}^{(3)}$ theory probes the fundamental assumptions of the subject, and forces the logical abandonment of the U(1) gauge symmetry group in quantum electrodynamics. The U(1) symmetry is restricted to the Lagrangian, the phase is defined through Z, an element which is not contained in the space group of U(1). The Q.E.D. theory becomes non Abelian, Q.E.D. This immediately gives rise to the $\mathbf{B}^{(3)}$ field.
5) In *Non-Linear Optics*, the $\mathbf{B}^{(3)}$ theory forces the revision of the fundamental semi-classical equations, for example the conjugate product becomes $iB^{(0)}\mathbf{B}^{(3)*}$ and the received view of $\mathbf{B}^{(1)} \times \mathbf{B}^{(2)}$ being a U(1) variable is abandoned. Non-linear optics becomes just that, *i.e.* becomes a rigorously non-Abelian gauge theory. Otherwise we do not have non-linear optics, we do not have the conjugate product as observed. In other words the conjugate product was introduced phenomenologically, and the way to introduce it rigorously is through $\mathbf{B}^{(3)}$.
6) In *Soliton, Instanton, Tachyon, Contact Interaction*, and *Action-at-a Distance* theories, the $\mathbf{B}^{(3)}$ field allows the transverse waves of vacuum electromagnetism to be replaced entirely by longitudinal (*i.e.* azimuthal) observables, of which $\mathbf{B}^{(3)}$ itself is the fundamental intrinsic spin, akin in concept to the half integral fermion spin. In this radically new view, albeit prefectly logical, the usual transverse $\mathbf{B}^{(1)} = \mathbf{B}^{(2)*}$ are defined only within a random phase under coordinate rotations, the only sharply defined variables in the *classical* theory are $\mathbf{B}^{(3)}$ and the eigenenergy, the energy of the electromagnetic field. Of course, this is ordinary angular momentum quantum theory within $\hbar$.
7) The empirically supported existence of the $\mathbf{B}^{(3)}$ field forces the revision and development of the topologically based theory of *Relativistic Field Helicity*, making it consistently non-Abelian. In the received view, the well known definitions of azimuthal variables such momentum (Poynting s vector); orbital angular momentum; helicity; and the $\mathbf{B}^{(3)}$ s intrinsic angular momentum all take place through conjugate products. The latter introduce the indices (1), (2) and (3) of the spherical representation of tensors, and make the gauge almost subconsciously non Abelian. In other words people have been working with a non Abelian gauge theory, albeit incomplete, since Poynting, whose vector is proportional to $\mathbf{E} \times \mathbf{B}^*$, which is $\mathbf{E}^{(1)} \times \mathbf{B}^{(2)}$, giving the momentum in axis (3). This is *not* a U(1) gauge theory, it is a non-Abelian gauge theory. The U(1) gauge theory defines everything within its own group space, which is a circle. It defines $\mathbf{E} \times \mathbf{B}$ only, and $\mathbf{E} \times \mathbf{B}$ is *zero* for plane waves. Similar considerations apply for the received view of helicity, which is proportional to $\mathbf{A} \times \mathbf{E}$ which in U(1) is again zero for plane waves. It has been shown in *Physica A* by Evans and again by Dvoeglazov that the beam helicity vanishes if there is no $\mathbf{B}^{(3)}$. It is glaringly obvious in angular momentum theory that if $\mathbf{B}^{(3)}$ vanishes, so does $\mathbf{B}^{(1)} = \mathbf{B}^{(2)*}$ and the energy: we have nothing at all.
8) It forces the development of all spin equations such as those of Weinberg. In fact, it seems that in a recent lecture, Weinberg is beginning to advocate a 1 + 1 representation of the electromagnetic sector, which is nothing but $\mathbf{B}^{(3)}$, the only sharply defined intrinsic spin variable of the vacuum electromagnetic field. It is time to ask ourselves whether the $\mathbf{B}^{(3)}$ has impact in quantum flavourdynamics and quantum chromodynamics; it ($\mathbf{B}^{(3)}$) certainly makes unification easier because the electromagnetic sector is non-Abelian, its indices being ((1), (2), (3)). One can easily express $\mathbf{B}^{(3)}$ as a component in SU(3), one can easily see that it is made up of gluons.
9) The $\mathbf{B}^{(3)}$ field is compatible with equally important and equally interesting developments by other colleagues, which are all summarized in volumes of *The Enigmatic Photon* series, beginning with volume four. Some are also summarized in this Issue. In chronological order of development we mention firstly the Lehnert monopole, the non-zero divergence of the vacuum electric field. This is as feasible as Maxwell s own famous displacement current, and is capable of explaining failures of standard theory. Similar to this is the convective vacuum displacement current of Chubykalo and Smirnov-Rueda, which give $\mathbf{B}^{(3)}$ from a wholly different starting hypothesis. Thirdly we have available now the careful and scholarly developments by Dvoeglazov, who has probably pressed the theory of the link between $\mathbf{B}^{(3)}$ and photon mass furthest of all. He has also rigorously corroborated the nature and existence of $\mathbf{B}^{(3)}$, and shown with equal rigour that the B Cyclics are Lorentz covariant. They are therefore CPT conserving in QFT. Standard gauge theory shows that they obey Maxwell s equations for the separate indices (1), (2), and the phaseless (3). The last Maxwell equation shows that $\mathbf{B}^{(3)}$ is irrotational *in vacuo*, *i.e.* that it is a very fundamental, intrinsic field spin. Fourthly Múnera, Guzman and coworkers have demonstrated the existence of a class of longitudinal solutions of the vacuum Maxwell equations. Very clearly, the *choice* of a transverse gauge gives one transverse fields, which is what one used to want in the first place. Fifth, Meszaros and coworkers have rigorously demonstrated that the fundamental validity of radiation thermodynamics (including that of the Planck Law itself) depends on the existence of longitudinal components *in vacuo*. Sixthly, Recami and co-workers have demonstrated $\mathbf{B}^{(3)}$ through the Majorana formulation of the Maxwell equations. A seventh independent corroboration has emerged recently from the interesting work of Esposito, who gives a fully covariant *field* formulation of electrodynamics without the use of potentials. He arrives at an intrinsic boost and spin, which is identified with the $i\mathbf{E}^{(3)}$ and $\mathbf{B}^{(3)}$ fields in the earlier notation of Evans and Vigier. Eighth, Costa de Beauregard has recently given a new derivation of photon mass from an entirely different standpoint, and shows its compatibility with the B Cyclics. Ninth, Israelit has developed a unified Dirac Weyl field theory which is expected to link $\mathbf{B}^{(3)}$, photon mass, and the Dirac monopole. This is exciting progress indeed.
10) It is now known that the *Aharonov-Bohm Effects* must be developed from $\mathbf{B}^{(3)}$ theory following the rules of gauge transformation in non-Abelian gauge theory, with internal indices ((1), (2), (3)). It is the very first example of a physical and observable mag-

netic field that can be understood as the conjugate product of potentials, *i.e.* $\mathbf{A}^{(1)} \times \mathbf{A}^{(2)}$, rather than the curl of a single potential. Evidently, $\mathbf{A}^{(1)} \times \mathbf{A}^{(2)}$ is *gauge invariant*, because $\mathbf{B}^{(3)}$ is physical, and so the gauge transformation rules and possible existence of an optically induced Aharonov Bohm effect follow from this. They *do not* follow from the gauge transform of the curl of a vector potential, and this is an entirely novel feature in physics, only now becoming properly understood.

11) Hardly touched to date is the relation of $\mathbf{B}^{(3)}$ to the other powerful field theories of contemporary physics, such as those of *Higgs* and *Sachs*. The former introduces mass as spontaneous symmetry breaking in the vacuum, the latter is a holistic theory within general relativity which is highly successful in several areas.

In *summary*, the $\mathbf{B}^{(3)}$ theory is a most radical and far reaching development in electrodynamics. If Maxwell were alive today he would surely have examined its implications open-mindedly, and taken note of the exceedingly important fact that it is based on *empirical data* from magneto-optics. It actually makes his own view of electromagnetism that much more powerful, and in no way does it disagree with his findings. Similarly for Planck and de Broglie, it makes their quantum theory that much more powerful, especially de Broglie s view of the massive photon. It lends support to the Einstein / de Broglie / Bohm / Vigier interpretation of the equations of quantum mechanics, and may lead quite quickly now to the abandonment of the Big Bang theory of the Universe. The enemy of all this is the human psyche itself: we have nothing to fear except fear itself in the words of Rooseveldt in the midst of the Great Depression. We have nothing to fear about $\mathbf{B}^{(3)}$, it makes our physics stronger and better understood.

John Milton on Claudius Ptolemy

In Milton s day the Ptolemaic system was still the only one recognized by academic science. Milton caricatures it in a famous passage of *Paradise Lost*:

> *From man or angel the great Architect*
> *Did wisely to conceal, and not divulge,*
> *His secret to be scanned by them who ought*
> *Rather admire; or if they list to try*
> *Conjecture, he his fabric of the Heavens*
> *Hath left to their disputes, perhaps to move*
> *His laughter at their quaint opinions wide*
> *Hereafter, when they come to model Heaven*
> *And calculate the stars, how they will wield*
> *The mighty frame, how build, unbuild, contrive*
> *To save appearances, how gird the sphere,*
> *With centric and eccentric scribbled o er,*
> *Cycle and epicycle, orb in orb.*

Quoted from Arthur Koestler, *The Sleepwalkers* (Hutchison, London, 1968).

M.W. Evans

About the authors

Andrew Chubykalo is a theoretical physicist, educator and researcher. He was born in Polotsk, Bielorussia, USSR on April 30, 1959 and graduated from Kharkov State University, Faculty of Physics (Ukraine, USSR) in 1986. He earned a Ph.D from the Institute of Monocrystals of the Ukraine Academy of Sciences in 1992, and wwas a postdoctoral fellow and research fellow at the Instituto de Ciencia de Materiales, Madrid, Spain from 1993 to 1995. He is currently a Professor in the of School of Physics at the University of Zacatecas, Mexico, and is a member of the New York Academy of Sciences. His research interests include solid state theory and the classical theory of fields.

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V.V. Dvoeglazov was graduated from Saratov State University (ex-U.S.S.R.) in 1983. He defended his first doctorate degree (in Russia there are two doctorate degrees) at the JINR, Dubna (1991) with the thesis Description of the interactions of two relativistic particles with spins in the quantum field theory . The degree was confirmed by the U.S.S.R. State Attestation Committee in April 1992. Since 1993 he has been working in Mexico, and since March 1994 at the Universidad Autonoma de Zacatecas, the university city in the central mountainous part of Mexico, where he is a member of the Mexican Sistema Nacional de Investigadores, Nivel I (Mexican System of National Researchers, Level I). He is the (co)author of approximately fifty (50) scientific publications and has made contributions to several dozen conferences at the national (Mexico), all-Union (ex-U.S.S.R.) and international levels. His main areas of research are the physics of neutral particles and the extended Poincaré group symmetries.

Myron W. Evans first proposed the existence of the $\mathbf{B}^{(3)}$ field in Physica B, in 1992, at Cornell University, and has developed it since then in volumes such as *Modern Nonlinear Optics* (Wiley, 1997, paperback); *The Enigmatic Photon* (Kluwer 1994 to present, first four volumes); *The Photon s Magnetic Field*, and *The Photomagneton in Quantum Field Theory*, both for World Scientific; and in several papers and letters. He is a Meldola and Harrison Medallist of the Royal Society of Chemistry of London; Junior Research Fellow (1975) of Wolfson College, Oxford; and graduate of the University of Wales (D. Sc., 1977).

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Berkeley for a Ph.D. in Nuclear Engineering and was caught by the swirl of the nuclear risk controversy, spending fifteen years doing research on the foundations of decision making. By the late eighties he was convinced that the concept of macroscopic probability has to be causal, and returned to physics, to explore such nonconventional possibilities.

Sisir Roy is presently a Full Professor, Theoretical Physics at the Indian Statisitcal Institute. His main research areas include Stochastic Quantum Mechanics, Unsharp Observables, Wolf Mechanism and Alternate Cosmology, Signal Processing and modelling of the Cerebellum, as well as Extended Electromagnetic Theory. He has published more than 60 papers in various international journals, and is the author of six books.

Jean-Pierre Vigier is among the most eminent of mid-twentieth century theoretical physicists. He has worked with Frederic Joliot-Curie, Louis de Broglie and David Bohm and founded the Vigier School at the Poincaré Institute of the University of Pierre and Marie Curie in Paris. He has worked unceasingly on behalf of science and humanity for over sixty years; and is a distinguished public figure in Europe. His wartime experiences, in which he was a member of the General Staff of the French Resistance, *Légion d Honneur*, and *Médaille de Résistance*, has left him with a deep abhorence of war and an advocate of international peace and understanding. To him, physics is an ever fruitful discussion among schools of thought, as it was to the Okhamites of the University of Paris in the fourteenth century.