Curriculum Vitae - Ferdinand Alexander Bais
(updated October 2007)

Personal data:

Status: Born June 27 , 1945 in Geleen, The Netherlands
Registered partnership with Vera de Vries (2004)
3 children (Polo 1978, Esmee 1980, Melisse 1982)
Work address:
Institute for Theoretical Physics
Valckenierstraat 65
1085 XE Amsterdam
tel: +3120 5255770 (5773 - secretary)
fax: +3120 5255778
Home address:
Floris van Alkemadelaan 21
1181 PW Amstelveen
tel: +3120 6477725
email: bais@phys.uva.nl

Education:

Grotius College (Heerlen): 1964 Eindexamen HBS-B (Sec. school with Math/Sciences + Languages)
(Military service: Reserve Officer Artillery (1965-1967)
Technical University Delft: 1971 Bachelor degree (Physics) ,
1973 Master's (Ir) Degree (Appl. Physics)
University of California (Santa Cruz)/SLAC:
1977, PhD Theoretical Physics
(advisor:Prof. Joel Primack)
Postdoctoral Education: Summer schools at SLAC, CERN, Les Houches, Cargèse, Trieste, Banff etc.

Recent Activities:

September 2007, Invited speaker, Intnl Workshop on Topological Quantum Computation, Trinity College Dublin, Ireland
July 2007, Invited Lecturer, Summer school on Quantum Computation and Topological Order, El Escorial, Spain
February - May 2006, Co-organizer of Workshop " Topological phases and Quantum Computation, KITP, Santa Barbara, California
September – December 2005, Visiting Professor, Yukawa Institute for Theoretical Physics, Kyoto, Japan
July – August 2005, Visiting Scholar, ANU, Canberra, Australia
Febr – April 2005, Visitiong Scientist, Santa Fe Institute, Santa Fe , New Mexico

Employment:

1997-`05 Director of the Institute for Theoretical Physics Amsterdam
1985- Full Professor of Theoretical Physics, University of Amsterdam
1984-'87 Correponding Fellow, CERN
1983-'85 Assoc. Professor, Leiden University
1980 Visiting professor Univ. of Pennsylvania
1980-'83 Research Fellow, Utrecht University
1979-'80 Scientific Associate, CERN, Geneva

1978-'79 Senior Research Fellow,University Leuven, Belgium
1978 (Summer) Scientific Associate, CERN
1977-'78 Postdoctoral research fellow, University of Pennsylvania, Philadelphia
1974-'77 Research Assistant, HEP-Theory, UCSC
1973-'74 Teaching Assistant, UCSC
1971-'73 Research Assistant, Interuniversity Reactor Center, Delft
1970-'71 Teaching Assistant, Theory Group, Delft University
1965-'67 Military service (Res. Officer Artillery)

Organization/management/reputation

2007- External faculty member, Santa Fe Institute, Santa Fe, USA
2006-2007 Member CERN Council Strategy Working Group
2004- Dutch scientific delegate in CERN Council
2002- Elected member of the Royal Holland Society of Sciences and Humanities in Haarlem
2002- Member of the board of the Dutch Platform for Physics
2001- Member of the board of the "K.L. Poll Foundation for Education, Art and Sciences" (Amsterdam)
2000- Member of the Council for Physics and Astronomy of the Royal Dutch Academy of Sciences (Chairman from May 2004)
1997- `05 Director of the Institute for Theoretical Physics (UvA)
1993- `98 Chairman of the executive board of the Dutch Research School for Theoretical Physics (DRSTP).
1991- `99 Member of the governing board of the FOM
1990- Member of the board of the Center for High Energy Astro-physics (CHEAF)
1986- Member of the Section for Theoretical High Energy Physics of the FOM (from 1991-1996 as chairman)
1986- '93 Member of the board of the Institute for Theoretical Physics (UvA) (from 1988-'92 as chairman)

- Active committee work at the UvA for the national educational and research evaluations of the Physics Departments in 1996, 2002 and 2004
- Member of organizing committees of following international conferences and workshops that took place in the Netherlands:
    - Meeting on trends in relativity and astrophysics `Journées Relativistes', May 1992, 180 participants
    - International Symposium on Lattice Field Theory `Lattice 92', September 1992, 300 participants
    - Conference on string theory `Strings '97', June 1997, 300 participants.
    - This also included the symposium `Gravity, Black Holes & Strings' with 600 participants. Speakers were Brian Greene, Hawking, 'tHooft, Susskind and Witten.
    - Symposium "Trends in Theory", Dalfsen, The Netherlands, 1997 and 1999
    - Symposium in honor of H.C. Capel "Demons, Wavelets and Chaos", Amsterdam, The Netherlands, 2001
    - Workshops in Amsterdam on String Theory and Quantum Gravity in 1998, 1999, 2000, 2001 and 2002.

Research Activities Summary

My research activities are well summarized by my list of publications and supervised dissertations, both of which I have included. My work has over the years covered a wide range of topics in field theory and starting in '84, also many aspects of string theory. The program on Theoretical High Energy Physics of the Institute for Theoretical Physics of the University of Amsterdam, scored very high (4.5) in the 1996 comparative quality assessment of Physics Research in the Netherlands, whereas in the related citation analysis our score was the highest among the High Energy Theory Groups in the country as well as highest among althea physics groups of the University of Amsterdam. A strong effort was made to build up a first class research groups in both Condensed Matter Theory and String Theory at the Theoretical Institute of the

University of Amsterdam. On the national level I was one of the initiators of the Dutch Research School for Theoretical Physics.
My own research has in recent years been concerned with developing physical applications of a new symmetry concept denoted as *quantum (double) symmetry*. The structural properties of Hopf algebra's precisely describe what physicists call *topological interactions*. This line of research was started with M. de Wild Propitius quite some years ago, where we discovered novel types quantum statistics. This work combines semi-classical analysis of spontaneously broken gauge theories in various dimensions and *topological field theory* with notions of *duality*; nowadays of interest both in field and in string theory but also in condensed matter physics (topological order, topological phases, Quantum Hall physics, Bose Einstein Condensates, Nematics, Superfluid Helium etc.). Some of these ideas are also at the roots of any physical implementation of *topological quantum computation*. As we showed recently, another interesting aspect of topological interactions in three dimensions is the occurrence of *core instabilities of defects*. At the moment this work is pursued in collaboration with some students (L.Kampmeijer) and with B. Schroers (H-Watts University, Edinburgh), J. Slingerland (Microsoft Research, Seattle) and T. Koornwinder (KdV Institute for Mathematics, Amsterdam). In recent years I have held visiting professorships at the Santa Fe Institute, the Yuakawa Institute in Kyoto, and the Australian National University in Canberra. At the Kavli Institute for Theoretical Physics in Santa Barbara, California, I was coorganizer of an international workshop on topological order and quantum computation in the spring 2006, in collaboration with J. Presskill (Caltech) and C. Nayak (UCSB). I was coorganizer of a similar workshop in Dublin (IAS and University College) which took place in September 2007. This coming Winter I will visit the SFI in Santa Fe, the Perimeter iInstitute , Waterloo, Canada and the ANU, Canberra, Australia.

List of supervised PhD Theses

Bouwknegt, P.G. (Dutch)
An Algebraic Approach towards the Classification of 2-Dimensional Conformal Field Theories (1988) .
Batenburg, P. (Dutch)
Gravity and Gauge Theories in Higher Dimensions (1988) .
Sijs, A.J. van der (Dutch)
Monopoles and confinement (1991),
Copromotor: dr. J. Smit
Driel, P. van (Dutch)
Construction and Application of Extended Conformal Symmetries (1992).
Vos, K. de (Dutch)
Coset algebras, integrable hierarchies and matrix model constraints (1992).
Kalau, W. (German)
On BRST quantisation of constrained systems (1992),
Copromotor: dr. J.W. van Holten
Rietdijk, R. (Dutch)
Applications of supersymmetric quantum mechanics (1992),
Copromotor: dr. J.W. van Holten
Tjin, T. (Dutch)
Finite and Infinite W algebras (1993).
Wild Propitius, M.D.F. de (Dutch)
Topological Interactions in Broken Gauge Theories (1995).
Muller, N.M. (Dutch)
Topological Interactions and Quantum Double Symmetries (1998).
Slingerland, J. (Dutch)
Hopf Symmetry and its Breaking; Braid Statistics and Confinement in Planar Physics (2002).
Striet, J. (Dutch)
Alice Electrodynamics; On the gauging of Charge Conjugation Symmetry (2003).
Kampmeijer, L. (Dutch) (expected completion in 2008)

List of (Postdoctoral) fellows:

Birmingham, D.	1992-1995	(Irish)
Gaite, J.	1993-1994	(Spanish)
Lazzarini, S.	1994-1995	(French)
Miao, Y.G.	1995-1996	(Chinese)
Schroers, B.J.	1995-1999	(German)
Baptista, J	2006-2010	(Portuguese)

Teaching activities

Undergraduate and Master-level Courses:
- Special Relativity
- Electrodynamics (all levels)
- Quantum Mechanics (all levels)
- Quantum Field Theory

Graduate courses:
- Topological defects in Gauge Theories
- Gravity and Big Bang Cosmology
- String Theory
- Conformal Field Theory
- Symmetry as a Language of Nature

The advanced courses were also taught at international summer schools like Cargèse, Banff, Corfu, Durham, Trieste and Scheveningen and at national research schools in Beekbergen (FOMHth), Enschede (FOM Hth and FOM/SMC), Egmond aan Zee (Fantom), and Dalfsen (DRSTP). Some of these have been presented as `capita selecta' lecture series at the universities of Utrecht, Leiden and Amsterdam.

I regularly give lectures popularizing science and physics in particular, for audiences varying from bright kids to curious managers on topics like `The early Universe', `String Theory', `Feynman', `Turning points in Physics', `Reflections on Physics and Religion', `Particle Physics', `Gravity and Big Bang Cosmology'. These include so-called Master Classes at the University of Amsterdam for gifted high school students and Master Courses for physics teachers. In association with University of Groningen I have for many years been involved in teaching and organizing a module on the Natural Sciences at Cambridge University with Peter Goddard, John Barrow, Simon Conway Morris and Richard Bentley (Sanger Institute) and others. In 2003/2004 I have – in collaboration with some astrophysics, biochemistry and biology colleagues -- set up a transdisciplinary science courses at the University of Amsterdam for the Beta-gamma bachelor program and as an open UvA lecture series. Both initiatives have been very successful and reach an ever increasing number of students. I have appeared in numerous Radio and TV programs related to science in general (AVRO, VPRO, ATV, BRT).

Popular Writings on Science and Society

I have already fior many years been writing on science in papers and magazines. In 2005 I wrote a little book called "*The equations; icons of knowledge*" in which the basic equations of physics which marked turning points in our thinking about nature were exposed and briefly described. The book was quite successful, it appeared in Dutch English and German while translations will appear in Portuguese, French, Japanese and Italian.
I am now involved in writing another little book *"Very special relativity, a pictorial lecture",* which I again expect to be published with Harvard University Press in 2007.

- *The equations; icons of knowledge,* Harvard University press, 2005 (to appear)
- *Nooit meer rechtdoor,* Etty Hillesum lecture 2004, Thieme, Deventer, 2004
- *It ain't necessarily so..,*Theologie in het licht van de natuurwetenschappen., Rapport KNAW bijeenkomst over de wetenschappelijkheid van de Theologie (2004)
- *Sneller dan licht?*, Natuur & Techniek, November (2002).
- *De biologisering van de wetenschap*, Hypothese, Tijdschrift NWO,May 2001.
- *Braanwerelden in een metakosmos*, Natuur & Techniek, March 2001.
- *Vernieuwingsimpuls voor baanbrekend onderzoek*, column in FOM expres, 7, 4(2000).
- *Tijd stroomt ook terug*, De Ingenieur, 8, 6-10 (2000)
- *10 recepten voor een nobelprijs*, article in De verdieping, Trouw, September 19, (2000).
- *No pressure like peer pressure*, Tijdschrift voor wetenschap, technologie & samenleving, jaargang 8 nr.2, 52-53 (2000).
- *Ultieme theorie in wording*, Natuur & Techniek 1, 36-37 (2000).
- *Over het slachten van een kip met gouden eieren*, Tijdschrift voor wetenschap, technologie & samenleving, Jaargang 6 nr 1, 18-22 (1998).
- Interview*:Triomf van het snelle nut*, Wetenschappelijke bijlage Volkskrant, 28 March 1998.
- *Kan de wetenschap de grote onbekenden elimineren*, Bijdrage VU Symposium "Why this World?" (Amsterdam, 1997), In de Marge, Jaargang 7, nr 1, 17-28 (1998).
- *De wetenschap het graf in geprezen*, Hypothese 15, 8-9 (1997).
- Interview: *De ijzeren greep van de natuurwetenschappen*, Ned. Tijdschr. v. Nat. 63, 154-156 (1997).
- Contribution to the article "*Retourtje zwart gat*" by Van Delft in the newspaper NRC of June 14, 1997.
- Contribution to the article "*De wereld is een snarenspel*" by Van Maanen in Het Parool of February 8, 1997.
- *Kennisconfrontaties,* in de `Trots van Alfa en Beta', De Bezige Bij, Amsterdam, 1996
- *Door de bomen het bos blijven zien, een theoretisch perspectief*, Ned.Tijdschr.v.Nat. 62/6 (1996) 116-121
- *Wet en Wanorde, over Chaos in de Fysica*, in ``Orde en chaos in de stadsontwikkeling", N. de Vreeze ed. (Uitgeverij 010, Rotterdam, 1994) 19-42
- *Het nieuwe denken heeft domweg niets met wetenschap van doen,* De Volkskrant, 17 september 1994.
- *Towards a Theory of Nothing – Hypothetical particles and Empty Space*, in ``Stories and Statistics, (University of Amsterdam Press, Amsterdam, 1994) 88-94.
- *Een illusie armer een ervaring rijker*, Stroom, 7 (1994) 2-6.
- D. van Delft, `*Brede bèta, Smalle gamma'*, Wetenschaps bijlage, NRC Handelsblad, 9 juni 1994
- *Uitbreiding studieduur TU forse klap voor de beta-drs*, De Volkskrant, 11 mei 1994.
- (met F.A. Muller), *Supersnare*n, Natuur en Techniek, 59(1991)672-696
- *Supersnaren*, Ned.Tijdschr.v.Nat. 8(1991)107-114

Some key publications

1. F.A. Bais, B J. Schroers and J.K. Slingerland,
``Broken quantum symmetry and confinement phases in planar physics,''
Phys.Rev.Lett. 89, 181601 (2002) [arXiv:hep-th/0205117].

2. F.A. Bais and J. Striet,
``On a core instability of 't Hooft Polyakov monopoles,''
Phys. Lett. B 540, 319 (2002) [arXiv:hep-th/0205152].

3. J.K. Slingerland and F.A. Bais,
``Quantum groups and non-abelian braiding in quantum Hall systems,''
Nucl. Phys. B 612, 229 (2001) [arXiv:cond-mat/0104035].

4. B.J. Overbosch and F.A. Bais,
``Inequivalent classes of interference experiments with non-abelian anyons,''
Phys. Rev. A 64, 062107 (2001) [arXiv:quant-ph/0105015].

5. F.A. Bais and N. M. Muller,
``Topological field theory and the quantum double of SU(2),''
Nucl. Phys. B 530, 349 (1998) [arXiv:hep-th/9804130].

6. F.A. Bais, P. van Driel and M. de Wild Propitius,
``Anyons in discrete gauge theories with Chern-Simons terms,
'' Nucl. Phys. B 393, 547 (1993) [arXiv:hep-th/9203047].

7. F.A. Bais, P. van Driel and M. de Wild Propitius,
``Quantum symmetries in discrete gauge theories,''
Phys. Lett. B 280, 63 (1992) [arXiv:hep-th/9203046].

8. F.A. Bais, T. Tjin and P. van Driel,
``Covariantly Coupled Chiral Algebras,''
Nucl. Phys. B 357, 632 (1991).

9. F.A. Bais, P. Bouwknegt, M. Surridge and K. Schoutens,
``Coset Construction for Extended Virasoro Algebras,''
Nucl. Phys. B 304, 371 (1988).

10. F.A. Bais, P. Bouwknegt, M. Surridge and K. Schoutens,
``Extensions of the Virasoro Algebra Constructed from Kac-Moody Algebras using Higher Order Casimir Invariants,''
Nucl. Phys. B 304, 348 (1988).

11. F.A. Bais,
``The Topology of Defects Crossing a Phase Boundary,''
Phys. Lett. B 98, 437 (1981).

12. F.A. Bais,
``Flux Metamorphosis,''
Nucl. Phys. B 170, 32 (1980).

13. F.A. Bais and D. Wilkinson,
``Exact Monopole Solutions In SU(N) Gauge Theory,''
Phys. Rev. Lett. 41, 601 (1978).

Research Interests:

Topology, quantum symmetries and (quantum) information theory.

Topological properties play an important role in physics on all length and energy scales and therefore manifest themselves in condensed matter systems as well as in the gauge theories of particle physics and in string theory. My research group at the Institute for Theoretical Physics of the University of Amsterdam has been pursuing general questions related to topological defects*,* topological phases *and* topological interactions*, without a specific physical system in mind. It has been a challenge to try and carry over novel ideas that surfaced in string theory to certain low energy situations in field theory and condensed matter systems. The group had a rather constant composition over the years consisting of two graduate students, master students and usually a postdoc. The work has all along consistently been funded through the program ``Fundamental Interactions`` of the FOM (Foundation for the fundamental research of matter), NWO (the Dutch Organisation for Scientific research) and the University of Amsterdam. The group has active exchanges with groups in the United Kingdom (Edinburgh) and the U.S. (MIT) and Santa Barbara (Microsoft Research). In the following pages a perspective is sketched and some of the results are reviewed.*

Topological defects

Topological properties are of generic importance in almost all field theoretic settings. In nonlinear settings where analytic tools usually fail a topological analysis often yields insights in certain robust features of the system. For example in phases with broken symmetries the appearance of topological defects is generic. These come in many guises, varying from domain walls between different phases (called kinks) or magnetic flux-tubes or vortices (which are line defects), to such peculiar configurations as magnetic monopoles, textures and instantons. The field theoretic description of such objects is non-perturbative in nature, and though a lot has been learned, many features of these defects remain elusive. The research in my group has for the past decade focused on some of the poorly understood features of topological defects, and revealed surprising aspects of their excitation spectra and the unusual interactions they can exhibit.

Moduli space and defect structure

Defects appear as classical solutions to the field equations carrying (magnetic type) quantum numbers which are conserved because of topological reasons. The classical solution space in a given topological sector contains much information about the additional (electric type) quantum numbers that can be carried by the defect. In this context the interplay of topological and non-topological charges on fluxes and monopoles was studied, also trying to establish non-abelian forms of *duality* (here, duality refers to a hidden symmetry that interchanges magnetic and electric properties of a theory). In this context a lot was learned from the study of *topological field theory*, in particular non-abelian *discrete gauge theories.* These feature topological (magnetic flux) sectors which are characterized by certain non-abelian magnetic charges (conjugacy classes to be specific), whereas the allowed dyonic sectors carry electric charges falling into representations of the stabilizer group of the conjugacy class. This yields an intricate interdependence of admissible electric and magnetic quantum numbers in the semi-classical excitation spectrum of the theory. Important was the discovery that this interplay is a manifestation of a new type of hidden symmetry, denoted as a *quantum group*, whose representations exactly account for the structure just mentioned. It should be added that also for the monopoles in phases with residual non-abelian continuous symmetries, interesting results were obtained which show that a similar picture emerges, but the precise mathematical structure has not yet been fully determined. In other words the algebraic and physical structure reflecting the rather well studied geometry of the moduli (solution) space is still much of a mystery. The important motivation is the fact that the features mentioned are quite generic and do lead to unusual physical phenomena.

Topological Interactions

In a field theoretic setting, interactions are normally taken care of by introducing local interaction terms in the energy function describing the interactions between the various degrees of freedom; these allow the possible exchanges of energy-momentum and possible internal quantum numbers such as spin and charge, respecting the overall conservation laws one wants to impose. In this framework forces are described by the exchange of force-carrying particles such as photons, W-bosons, gluons or phonons. In physical systems one may however encounter another type of interactions, the so-called *topological interactions*, which do not involve the exchange of particles mediating a force, but derive from the nontrivial connectedness of the underlying multi-particle configuration space representing the system. For example, defects in phases with non-abelian residual symmetries, often exhibit nontrivial topological interactions with the other (fundamental and/or topological) degrees of freedom in the theory. These interactions are a consequence of the nontrivial topological properties of the solution space of defects. Physically speaking topological interactions manifest themselves through the possibility of nontrivial *entanglements*, which on the quantum level lead to various scattering phenomena that can be described as non-abelian generalizations of the Ahoronov-Bohm effect. Another exciting consequence is the possibility of exotic, non-abelian quantum statistics for collective excitations in certain phases of the system, as occurring for example in the fractional quantum Hall effect. These peculiar excitations are generically referred to as *(non-abelian) anyons*. These are also envisaged to play a crucial role if it comes to topological realizations of quantum computers. Generically one refers to situations in which the physical excitations carry exotic and fractional quantum numbers as ``*topological phases*'' and these get increasing attention. A beautiful instance of the situation sketched above arises in the theory of general relativity in (2+1) dimensions - which as was shown by Witten, is a topological field theory. This theory was studied from this perspective and the quantum symmetry underlying its structure was constructed. The Hopf algebra in question turned out to be the quantum double of the group SU(2). Recently we showed how gravitational scattering of particles, with and without spin, can be treated consistently within this framework.

Bose condensates and the breaking of quantum symmetries

We mentioned the appearance of quantum symmetries - generally speaking Hopf-algebra's - which have the important feature that they allow one to treat topological (say magnetic) and ordinary (say electric) quantum-numbers equal footing. Having states labeled in this universal way it is interesting to study the question of duality and conceivable condensation phenomena. The group recently presented a phase classification of the non-abelian (topological) field theories and the many distinct but allowed types of confinement one may have. These phases are precisely characterized by the breaking of the Hopf symmetry through the condensation of certain well-defined bosonic order-parameter fields (electric, magnetic or dyonic) in the theory. These findings may be linked to certain duality properties of the Hopf symmetries that were found. This phenomenon of the breaking of quantum-symmetries appears to be important and generic in two-dimensional physics. My group therefore plans to further explore this topic and its applications in the near future.

Core instabilities of monopoles

Of particular interest in the present context are phases of theories where different types of topological excitations can coexist, in such a case the topological interactions between these different types may lead to rather exotic physical phenomena. It was shown quite some time ago that in these theories the core of a defect may deform which might lead to *core instabilities*. A simple but interesting theory that exhibits this behavior is a theory denoted as *Alice electrodynamics*, a theory of electromagnetism with the slight modification that the charge conjugation symmetry is realized in a local fashion i.e. as a gauge symmetry. This implies for example that it is not possible to globally (i.e. uniquely) fix the sign of a given charge! One of the exotic properties of the theory is the emergence of the topological concept of *Cheshire charge*, a non-localizable manifestation of electric and/or magnetic charge. It was shown that this elusive concept for certain parameter ranges in the theory manifests itself through a core instability of magnetic monopoles, where the point defect decays into a ring-shaped object carrying non-localizable magnetic charge. My group intends to pursue this line of research, as there may have been phases in the early universe featuring these phenomena (SO(10) breaking to SU(5) for example) but a very similar instability may also occur in certain Bose-Einstein condensates. As analytic calculations of these models are not possible, lattice simulations were performed to determine the quantum properties of these models, such as the phase diagram and its unusual screening properties in certain phases. This in turn led to the study of a fundamental instability of electric charge that may occur on the quantum level in 2+1 dimensions due to the creation of a pair of Alice strings.

Topological Quantum Computing

Quantum computers should be capable of performing tasks that would be inconceivable with conventional digital computers, but enormous scientific and engineering challenges must be overcome for scalable quantum computers to be realized. Topological quantum computation is a particularly appealing proposal for implementing quantum information processing, in which quantum states are encoded in the nonlocal degrees of freedom of a suitable topologically ordered physical system. Because of the nonlocal encoding, these quantum states are intrinsically resistant to the debilitating effects of local noise i.e. decoherence.

I have addressed fundamental theoretical issues concerning the physical realization of topological quantum computers in condensed matter systems (typically fractional quantum hall systems) and thereby galvanized experimental efforts in this direction. This field goes through rapid changes and brings together researchers in topology, solid state physics, ultra-cold atoms, and computer science, many of whom have not collaborated before. The goal is to assess the feasibility of topological quantum computing and map out a strategy for discovering or engineering a quantum medium conducive to universal quantum computation.

Information Theory

In collaboration with James D. Farmer (Santa Fe Institute) I have made a promising start exploring novel applications of the classical notion of information and information entropy. We have written a review on the Physics of Information, which will be published as a chapter in a book on the History of the Philosophy of Information edited by J. van Benthem and P. Adriaanse to be published by Elsevier

Plans for the near future

With my collaborators I envisage to continue these investigations into 2- and 3-dimensional situations where the interplay between topological and non-topological features leads to unusual physics. As these features are only beginning to be uncovered but appear to be generic, it is important to continue research efforts along these lines. A promising application horizon is topological quantum computation. There are many new areas to be explored. One might think of lifting the discussion of quantum symmetries and confinement to (3+1) dimensions. Also applications of the breaking idea to (2+1)-dimensional gravity may lead to surprising new insights in the nature of space-time. One wants to fully understand the algebraic structure of monopoles in phases with a non-abelian residual symmetry. The exploration of these ideas towards a realistic realization of topological quantum computing is promising and deserves more effort. A systematic analysis of nematic type materials, i.e., their defect structure and their phase structure can be made on the basis of the topological symmetry breaking using Hopf algebra techniques.
The notions of (quantum) symmetry and its breaking, and of topological analysis presumable have many potential uses outside physics in any research field involved with nonlinear systems and their mathematical description. I hope one of these days to be in a position to vigorously pursue such possibilities.