Stepan Douplii (Steven Duplij) Homepage

Scientific results and innovative ideas

with direct links to articles

- A new direction in **supersymmetric models** of elementary particles, based on the inclusion of semigroups is proposed (book, thesis). The concept of *semisupermanifold* having noninvertible transition functions (satisfying higher von Neumann regularity) is introduced, and its deviation from being an ordinary manifold is given by a newly defined variable, *obstructedness*. Based on this idea, the novel notions of *category regularization, regular topos, regular functor, higher regular braiding, regular Yang-Baxter equation and regular module, regular algebra and coalgebra, regular graded algebras* are presented, and their role in topological quantum field theory is outlined.

  Even- and odd-reduced supermatrices are introduced and considered on a par, being complementary in terms of the newely obtained *Berezinian addition formula*, and are unified into a kind of *"sandwich" semigroup*. A special subset of odd-reduced supermatrices represent *higher order rectangular bands* for which new generalized *"fine" Green's relations and egg-box diagrams* are constructed. *One-parameter semigroups of idempotent odd-reduced supermatrices* and corresponding superoperator semigroups are introduced and studied by the new *semigroup × semigroup method*. The linear idempotent superoperators and exponential superoperators are mutually dual in some sense, and the first gives rise to an additional noninvertible *non-exponential solutions to the initial Cauchy problem*. A novel *permanent-determinant symmetry* is found for even complex superplane. It is shown that the corresponding counterparts (*per analogs*) of the cross ratio, distance and harmonic set are invariant under the introduced *per mapping*, a special noninvertible subset of the fractional linear transformation. The per analogs of the *Laguerre formula for distance and Schwarzian derivative* are presented.

  An *additional superextension of complex structure* is uncovered, which is noninvertible and can correspond to another (odd) superanalog of Riemann surfaces and to the counterpart of *superconformal-like transformations which twist the parity of tangent space* and their *nonlinear realization*, which together with the ordinary ones form the *superconformal semigroup* having special unusual properties. A unique formula connecting *berezinian, permanent and determinant* is obtained. From a physical viewpoint, the above conceptions can lead to *semistatistics*, being *von Neumann regular analog* of the ordinary statistics.

- **Quantum groups**: a generalization of the Hopf algebra is introduced by relaxing the requirement for inverses of the generators of the Cartan subalgebra, which leads to a *regular quasi-R-matrix* structure. The classification of 6-vertex *constant solutions to Yang-Baxter equation over Grassmann algebra* is presented, including noninvertible ones which correspond to *von Neumann regular R-matrix*. The *actions of universal enveloping quantum algebras* on quantum planes (also of *arbitrary dimension*) are found. A novel *double-graded quantum superplane* and

corresponding *double-graded Hopf algebra* are presented.

- **Singular theories** with degenerate Lagrangians are formulated *without involving constraints* using Clairaut equation theory and the corresponding generalized *Clairaut duality*. A new *antisymmetric bracket* (an analogue of the Poisson bracket) describing the time evolution of singular systems is built. A novel *partial Hamiltonian formalism* is constructed. It is shown that a *singular theory can be interpreted as the multi-time dynamics*.

- **Nonlinear gauge theories**: a generalized approach to nonlinear classical electrodynamics and supersymmetric electrodynamics is suggested, which takes into account all possible types of media and nonlocal effects, and is described in both Lagrangian and *non-Lagrangian* theories. First steps in the formulation of a general *nonlinear conformal-invariant electrodynamics* based on *nonlinear constitutive equations and conformal compactification* were made.

- **Gravity**: constitutive equations for *nonlinear gravito-electromagnetism* and an exact form of the Maxwell gravitational field equations are obtained. A general approach to describing the *interaction of multi-gravity models* in space-times of arbitrary dimension is formulated. The gauge gravity vacuum is investigated in the *constraintless Clairaut-type formalism* (as in QCD). A special *fermionic lineal gravity* model which differs from standard supersymmetry is presented.

- **Quantum computing** (book IOP, FrontMatter): a new conception of quantum computing which incorporates an additional kind of uncertainty, vagueness/fuzziness, by introducing a new *"obscure" class of qudits/qubits*, is announced. A superqubit theory in super-Hilbert space is reconsidered, and a new kind of *superqubit carrying odd parity* is introduced. A new kind of quantum gates, namely *higher braiding gates*, is suggested, which lead to a special type of multiqubit entanglement that can speed up key distribution and accelerate various algorithms. A novel visualization of quantum walks in terms of newly defined objects, *polyanders*, is also proposed.

- **Polyadic structures** (book IOP, FrontMatter): *polyadization*, i.e. exchanging binary operations with higher arity ones, is proposed as a general new approach to the algebraic structures used in physics. A new form of the Hosszu-Gluskin theorem (giving the general shape of *n*-ary multiplication by the chain formula) in terms of polyadic powers is given, and its *"q-deformed" generalization* is found using the newly introduced *quasi-endomorphism*. A polyadic analog of homomorphism, or *heteromorphism*, a mapping between algebraic structures of different arities, is introduced, which leads to the definition of a new kind of *n*-ary group representation, *multiplace representations, as well as multiactions* and a *polyadic direct product*.

  The *arity invariance principle*, a manifest expression of algebraic structure in terms of operations independent of their arities, is claimed. The relations of the von Neumann regular semigroups and the Artin braid group were found, and a

higher arity generalization gave the *polyadic-binary correspondence*, which allowed the definition of the following new structures: *higher braid groups*, *higher degree analogs of Coxeter group and Artin braid group*. The following were also uncovered: unusual *polyadic rings and fields (which can, remarkably, be zeroless and nonunital)* having addition and multiplication of different arities, *polyadic integer numbers* and *p-adic integers*, *polyadic convolution products* having multiplication and comultiplication of different arities and their corresponding *polyadic Hopf algebra* and *n-ary R-matrix*, *polyadic multistar adjoints* and *polyadic operator C*-algebras and Cuntz algebras*. The *polyadic analogs of the Lander–Parkin–Selfridge conjecture and Fermat's Last Theorem* were formulated.

It is proposed that mediality as a principle is more natural, unique and universal than commutativity in generalizing the latter to *n*-ary algebras (in the binary case commutativity directly follows from mediality). This is called the *commutativity-to-mediality ansatz*, which is applied to obtain *almost medial n-ary graded algebras*, a new kind of tensor categories, *polyadic nonunital "groupal" categories* with *"quertors"* (analogs of querelements in *n*-ary groups), *"medialed" tensor categories and querfunctors*. A principally new mechanism of additional *"continuous noncommutativity"*, governed by a special *"membership deformation" of commutativity* for algebras with the underlying set as obscure/fuzzy set, is introduced. Using the membership deformation factor together with the ordinary graded commutation factor, the almost commutative graded (*n*-ary) algebras and Lie algebras with *double commutativity* are obtained, and their projective representations are studied.

As a first step towards a the *polyadic algebraic K-theory*, the *Grothendieck construction* of the completion group for a monoid is generalized to the case, where both are of different, higher arities. As opposed to the binary case, an identity is not necessary for the initial *m*-ary semigroup to obtain a class *n*-ary group, which in turn need not contain an identity.

A new (infinite) class of division algebras, the *hyperpolyadic algebras*, which correspond to the (only 4) binary division algebras R, C, H, O (reals, complex numbers, quaternions, octonions) are defined. A *polyadic analog of the Cayley-Dickson construction* is proposed, and a novel iterative process gives *"half-quaternions"* and *"half-octonions"*. *New polyadic algebras with higher brackets* which have (as opposed to *n*-ary Lie algebras) different arity from the initial *n*-ary algebra multiplication, are introduced. The *sigma matrices and the Pauli group* are generalized to *higher arities*. Using them, a toy model of one-dimensional supersymmetric quantum mechanics was constructed, as a first example of *polyadic supersymmetry*, which is specially extended in a way different from the *new multigraded SQM* previously proposed.

- **DNA theory**: a new characteristic of nucleotides, the *determinative degree*, which is proportional to the dipole moment and the weight of hydration site, is unveiled. The physical characteristics of nucleotides such as *dipole moment, heat of formation and energy of the most stable formation* are newly computed by advanced methods. The concept of a *triander* is set up, which leads to a new method of visual sequence analysis and identification using *DNA walk diagrams*.

Scientific publications

PDF (1985-2024) mathematical physics, quantum computing and DNA structure (161 items)
PDF (1980-1985) radiophysics and nuclear physics, particle physics and quantum chromodynamics (31 items)
HTML (1985-2008) with links to articles (105 items)

In total: **192** publications, among them 9 books and 183 articles.
In addition: 130 entries (table in PDF) in Concise Encyclopedia of Supersymmetry.

Listed in Universität Münster Highly Cited Researchers (n.23 from 37).

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