

# Doppler Institute: Activities in 2003

Some of our advisors had recently an opportunity to visit the institute; for them as well as for the others we compile this traditional report.

## 1 Basic information

### 1.1 Members to date

Č. Burdík, *Dept of Mathematics, FNSPE, Czech Technical Univ, Prague*  
G. Chadzitaskos, *Dept of Physics, FNSPE, Czech Technical Univ, Prague*  
J. Dittrich, *Nuclear Physics Institute, AS, Prague/Řež*  
P. Exner, *Nuclear Physics Institute, AS, Prague/Řež*  
M. Havlíček, *Dept of Mathematics, FNSPE, Czech Technical Univ, Prague*  
L. Hlavatý, *Dept of Physics, FNSPE, Czech Technical University, Prague*  
P. Šeba, *Institute of Physics, AS, Prague*  
P. Štovíček, *Dept of Mathematics, FNSPE, Czech Technical Univ, Prague*  
J. Tolar, *Director, Dept of Phys, FNSPE, Czech Technical Univ, Prague*  
M. Znojil, *Nuclear Physics Institute, AS, Prague/Řež*

### 1.2 Advisory board

S.A. Alberverio, *Universität Bonn, Germany*  
J.E. Avron, *Technion, Haifa, Israel*  
M.S. Birman, *St. Petersburg University, Russia*  
J.-M. Combes, *Université de Toulon et du Var, France*  
H.D. Doebner, *Technische Universität Clausthal, Germany*  
J.R. Klauder, *University of Florida, Gainesville, USA*  
S.T. Kuroda, *Gakushuin University, Tokyo, Japan*  
E.H. Lieb, *Princeton University, USA*  
L.A. Pastur, *Centre de Physique Théorique, Marseille, France*  
J. Patera *Université de Montréal, Canada*

### 1.3 Current grant support

According to the statutes, DI members receive their salaries from the academic institutions to which they belong. The research performed in DI has been supported by the following research grants:

1. AS CR Grant No. 1048101 **Graph-type quantum systems**. J. Dittrich, P. Exner (responsible), M. Havlíček, H. Kovařík, M. Krbálek, D. Krejčířík, J. Kríž, K. Němcová, K. Pičugin, S. Pošta, P. Šeba, M. Tater (expires at the year end)
2. The project ME482 **Quantum dynamics, integrable and chaotic systems** of the Ministry of Education of the Czech Republic supporting a collaboration with Japan. J. Dittrich, P. Exner (responsible), H. Kovařík, D. Krejčířík, J. Kríž, K. Němcová, P. Šeba, M. Tater
3. AS CR Grant No. 1048302 **Quantum theory and pseudo-Hermitian Hamiltonians**. M. Znojil (responsible)
4. GA CR Grant No. 201/01/0130 **Some aspects of quantum groups and self-similar structures**. M. Andrlé, Č. Burdík (responsible), M. Havlíček, Z. Masáková, O. Navrátil, P. Šťovíček
5. Votruba–Blokhintsev Grant **Zeta function technique and heat kernel expansion**. J. Dittrich, V.V. Nesterenko
6. Votruba–Blokhintsev Grant **Ordering of levels of the Heisenberg-van Vleck Hamiltonian**. J. Dittrich, V.I. Inozemtsev
7. Votruba–Blokhintsev Grant **Quantum symmetries and discrete dynamical models**. Č. Burdík, A.S. Isaev

## 2 Survey of activities

### 2.1 Publications in journals

1. M. Horowski, G. Chadzitaskos, A. Odziejewicz, A. Tereszkievicz: *The exact solution of the eigenproblem for the parametric down conversion process in the Kerr medium*, Czech. J. Phys. **53** (2003), 1015–1020.
2. V.V. Nesterenko, I.G. Pirozhenko, J. Dittrich: *Non-smoothness of the boundary and the relevant heat kernel coefficients*, Class. Quantum Grav. **20** (2003), 431–455.
3. P. Exner, S. Kondej: *Bound states due to a strong  $\delta$  interaction supported by a curved surface*, J. Phys. **A36** (2003), 443–457.
4. J. Brüning, P. Exner, V.A. Geyler: *Large gaps in point-coupled periodic systems of manifolds*, J. Phys. **A36** (2003), 4875–4890.
5. P. Exner, K. Němcová: *Magnetic layers with periodic point perturbations*, Rep. Math. Phys. **52** (2003), 255–280.
6. G. Carron, P. Exner, D. Krejčířík: *Topologically non-trivial quantum layers*, J. Math. Phys. **45** (2004), to appear
7. P. Exner, M. Tater: *Spectra of soft ring graphs*, Waves in Random Media **14** (2004), S47–60.
8. P. Exner, S. Kondej: *Strong-coupling asymptotic expansion for Schrödinger operators with a singular interaction supported by a curve in  $\mathbb{R}^3$* , Rev. Math. Phys. (2004), to appear
9. P. Exner, K. Yoshitomi: *Eigenvalue asymptotics for the Schrödinger operator with a  $\delta$ -interaction on a punctured surface*, Lett. Math. Phys. **65** (2003), 19–26.
10. P. Exner, K. Němcová: *Leaky quantum graphs: approximations by point interaction Hamiltonians*, J. Phys. **A36** (2003), 10173–10193.
11. F. Bentosela, P. Duclos, P. Exner: *Absolute continuity in periodic thin tubes and strongly coupled leaky wires*, Lett. Math. Phys. **65** (2003), 75–82.
12. M. Havlíček, J. Patera, E. Pelantov, J. Tolar: *On Pauli graded contractions of  $sl(3, \mathbb{C})$* , J. Nonlin. Math. Phys., to appear
13. P. Šeba: *Random matrix analysis of human EEG data*, Phys. Rev. Lett. **91** (2003), 198104
14. P. Středa, P. Šeba: *Antisymmetric spin filtering in one-dimensional electron systems with uniform spin-orbit coupling*, Phys. Rev. Lett. **90** (2003), 256601

15. J.A. Mendez-Bermudez, G.A. Luna-Acosta, P. Šeba: *Chaotic waveguide-based resonators for microlasers*, Phys. Rev. **B67** (2003), 161104
16. M. Krbálek, P. Šeba: *Headway statistics of public transport in Mexican cities*, J. Phys. **A36** (2003), L7–11.
17. V.A. Geyler, P. Štoviček: *On the Pauli operator for the Aharonov-Bohm effect with two solenoids*, J. Math. Phys. **45** (2004), 51–75.
18. M. Znojil: *Low-lying spectra in anharmonic three-body oscillators with a strong short-range repulsion*, J. Phys. **A36** (2003), 9929–9941.
19. M. Znojil:  *$\mathcal{PT}$  symmetric models in more dimensions and solvable square-well versions of their angular Schrödinger equations*, J. Phys. **A36** (2003), 7825–7838.
20. M. Znojil: *Solvable simulation of a double-well problem in  $\mathcal{PT}$  symmetric quantum mechanics*, J. Phys. **A36** (2003), 7639–7648.
21. M. Znojil, D. Yanovich, V.P. Gerdt: *New exact solutions for polynomial oscillators in large dimensions*, J. Phys. **A36** (2003), 6531–6549.
22. M. Znojil: *Comment on “Supersymmetry and Singular Potentials” by Das and Pernice [Nucl. Phys. B561 (1999) 357]*, Nucl. Phys. **B561** (2003), 554–562.

## 2.2 Proceedings, submitted papers, etc.

1. Č. Burdík, O. Navrátil: *The  $q$  boson-fermion realizations of the quantum superalgebra  $U_q(gl(2|1))$* , in proceedings of the int’l workshop “Supersymmetries and Quantum Symmetries” (Dubna, July 2003)
2. Č. Burdík, O. Navrátil: *The  $q$  boson-fermion realizations of the quantum superalgebra  $U_q(gl(m|n))$* , in proceedings of the 5th int’l workshop “Lie Theory and Its Applications in Physics” (Varna, June 2003)
3. Č. Burdík, O. Navrátil: *The  $q$  boson-fermion realizations of the quantum superalgebra  $U_q(osp(m|n))$* , in proceedings of the Xth international conference “Symmetry Methods in Physics” (Yerevan, August 2003)
4. Č. Burdík, O. Navrátil: *Solution of  $2 \times 2$  matrix three-body Calogero model*, submitted to J. Phys. **A**
5. M. Horowski, G. Chadzitaskos, A. Odziejewicz, A. Tereszkievicz: *Systems with intensity dependent conversion integrable by finite orthogonal polynomials*, submitted to Optics Communication; math-ph/0310058
6. G. Chadzitaskos, J. Tolar: *Quantization on compact groups*, in “GROUP24 Physical and mathematical aspects of symmetries” (eds. J.-P. Gazeau et al.), IOP Conference Series, Bristol 2003; vol. 173, pp. 379–383.

7. P. Exner, P. Freitas, D. Krejčířík: *A lower bound to the spectral threshold in curved tubes*, submitted to Proc. Roy. Soc.
8. D. Borisov, P. Exner: *Exponential splitting of bound states in a waveguide with a pair of distant windows*, submitted to J. Phys. A; mp-arc 03-525; math-ph/0312013
9. P. Exner, O. Post: *Convergence of spectra of graph-like thin manifolds*, submitted to J. Geom. Phys.; mp-arc 03-533; math-ph/0312028
- 10 P. Exner: *Spectral properties of Schrödinger operators with a strongly attractive  $\delta$  interaction supported by a surface*, Proceedings of the NSF Summer Research Conference (Mt. Holyoke 2002, ed. P. Kuchment); AMS “Contemporary Mathematics” Series, vol. 309, Providence, R.I., 2004; mp-arc 03-17; math-ph/0301021
- 11 P. Exner, S. Kondej: *Leaky quantum wire and dots: a resonance model*, submitted to Proceedings of the XIV International Congress on Mathematical Physics (Lisbon 2003); mp-arc 03-329; math-ph/0307030
12. P. Exner, T. Ichinose: *Product formula for quantum Zeno dynamics*, submitted to Proceedings of the XIV International Congress on Mathematical Physics (Lisbon 2003)
13. P. Exner, S. Kondej: *Schrödinger operators with singular interactions: a model of tunneling resonances*, submitted to J. Math. Phys.
14. P. Duclos, O. Lev, P. Šťovíček, M. Vittot: *Progressive diagonalization and applications*, in “Operator Algebras and Mathematical Physics” (eds. J.-M. Combes et al), The Theta Foundation, Bucharest, 2003; pp. 75–88.
15. H.-D. Doebner, J. Tolar: *Borel quantisation and nonlinear quantum mechanics. A review of developments*, in “Symmetries in Science XIV” (eds. B. Gruber , G. Marmo), Kluwer, Dordrecht 2004; 17 p.
16. J. Tolar, P. Hájíček: *Can differently prepared mixed states be distinguished?*, submitted to Phys. Lett. A; quant-ph/0309158
17. M. Znojil: *Experiments in  $\mathcal{PT}$ -symmetric quantum mechanics*, Czech. J. Phys. **54** (2004), to appear
18. V. Gerdt, D. Yanovich, M. Znojil: *On exact solvability of anharmonic oscillators in large dimensions*, in “Computer Algebra in Scientific Computing” (CASC 2003, Passau; eds. V.G. Ganzha et al.), TU Munich, Garching 2003; pp. 143–162.
19. M. Znojil: *Conservation of pseudo-norm in  $\mathcal{PT}$ -symmetric quantum mechanics*, Rendiconti del Circ. Mat. di Palermo, to appear

20. M. Znojil: *Re-establishing supersymmetry between harmonic oscillators in  $D \neq 1$  dimensions*, Rendiconti del Circ. Mat. di Palermo, to appear; [math-ph/0104012](#)
21. M. Znojil:  *$\mathcal{PT}$ -symmetry and supersymmetry*, in “GROUP24 Physical and mathematical aspects of symmetries” (eds. J.-P. Gazeau et al.), IOP Conference Series, Bristol 2003; vol. 173; [hep-th/0209062](#)
22. M. Znojil: *Imaginary cubic oscillator and its square-well approximations in  $x$ - and  $p$ -representation*, in “Advances in Numerical Analysis” (ed. F. Columbus), Nova Science Publ.

## 2.3 Seminars

### 2.3.1 Regular seminar

*February 11*

A. Sergeev (Opava): Constructing compatible Poisson structures and establishing integrability: an analog of master symmetry in the Hamiltonian context

*February 18*

A. Stolin (Göteborg): Dynamical Yang-Baxter equations and homogeneous spaces

*February 18*

V.V. Sokolov (Moscow): Compatible Poisson brackets, classical Yang-Baxter equations and integrable systems of the sigma-model type

*February 25*

G. Alber (Darmstadt): Stabilizing quantum dynamics against decoherence – problems, current developments, perspectives

*March 4*

V. Kariš (FNSPE): Physics of  $D_0$  branes

*March 11*

M. Znojil: Polynomial oscillators in large dimensions

*March 18*

F. Gemperle (FNSPE): Wave operators, effective Hamiltonians, and an iterative scheme for their search

*March 25*

M. Noga (Bratislava): The oldest problem of the quantum many-body theory

*April 8*

M. Krbálek (FNSPE): Local balance in non-equilibrium transport systems

*April 22*

P. Hellinger (API AS): Shock waves in collisionless plasma

*April 29*

J. Kvasil (Charles U.): Compressional and toroidal dipole modes in nuclei

*May 6*

I. Jex (FNSPE): Universal processes for two qudits

*May 13*

A. Horzela (Krakow): Alternative Hamiltonians and Wigner quantization

*May 20*

Z. Fiala (Institute of Mechanics, AS): Large deformations - a large unknown. Infinitesimal Riemann manifolds in the mechanics of continuum

*September 23*

Z. Hubáček (FNSPE): Study of multijet final states

*September 23*

J. Smotlacha (FNSPE): Differential dispersion relations and their importance for high-energy hadron scattering

*October 7*

U. Günther (Rossendorf): On the pseudo-Hermiticity of MHD dynamo operators

*October 14*

T. Kiss (Budapest): Waves in singular media: Hawking radiation in the laboratory

*October 21*

V. Bužek (Bratislava): Dynamics of open quantum systems from a perspective of quantum information theory

*November 4*

Č. Burdík, O. Navrátil: Calogero model and its solvability

*November 11*

M. Hnatič (Košice): Some problems concerning developed turbulence in the framework of simple models

*November 18*

A. Frydryszak (Wroclaw): Supersymmetric mechanics and aspects of super-Hilbert space quantization

*December 2*

Z. Skalák (FCE CTU): Suitable weak solutions of the Navier-Stokes equation

*December 9*

A. Sergeev (Ben Gurion Univ.): (Non)locality of symmetries, Poisson structures, and proof of the Novikov-Maltsev conjecture

*December 16*

G. Chadzitaskos: Parametric down conversion in the Kerr medium: exact solution

### **2.3.2 The “Quantum Circle” seminar**

*February 25*

Kenji Yajima (Tokyo and Munich): Dispersive properties of Schrödinger equations with potentials periodic in time

*March 4*

Pavel Exner: Semiclassical properties of the discrete spectrum for Schroedinger operators with the interaction supported by curves and surfaces

*March 18*

Robert Olkiewicz (Wroclaw): Long time asymptotic properties of quantum dynamical semigroups

*March 25*

Jaroslav Dittrich: Heat kernel of a cylinder over the wedge

*April 15*

Hynek Kovařík (Stuttgart): Resonances width in crossed electric and magnetic fields

*April 22*

Isabelle Catto (Paris-Dauphine): Self-energy of one electron and enhanced binding in non-relativistic QED

*April 29*

Kateřina Němcová: Spectrum of a magnetic Schroedinger operator with periodic point interactions in a layer

*May 13*

Saverio Pascazio (Bari): Quantum Zeno subspaces

*May 27*

Jochen Brüning (Berlin): Dirac systems

*June 17*

Petr Šeba: Anti-symmetric spin filtering in one-dimensional electron systems with uniform spin-orbit coupling



*August 26*

Denis Borisov (Pedagogical University, Ufa): Geometric coupling thresholds in a two-dimensional strip

*September 2*

Valery Grikurov (Sankt Petersburg University): Computation of augmented scattering matrix and detection of trapped modes

*September 9*

Kazushi Yoshitomi (Tokyo Metropolitan University): Coexistence problems for the Hill equations with 3-step potentials

*September 30*

Ondřej Lev: Asymptotic behaviour of the perturbation matrix in an oscillator basis by WKB

*October 7*

Jiří Tolar: Can differently prepared mixed states be distinguished?

*November 6*

Taksu Cheon (Kochi University of Technology): Game-theoretic dynamics of dominance and hierarchy in ecosystems

*December 9*

Jaromir Fiurášek (Olomouc and Brussels): Programmable quantum multimeters

*December 16*

Jan Kříž (Hradec Kralové): Statistical analysis of hemodynamics and processes maintaining human stability using force plate

## 2.4 Meetings

**The 12th Student Winter School** (Horní Polubný, January 26–February 1) organized by G. Chadzitaskos

**The 11th Colloquium “Quantum Groups and Integrable Systems”**

(Prague, June 12-14), organized by Č. Burdík with the participation of R. Ablamowitz, A. Agostini, D. Arnaudon, D. Baleanu, D. Basu-Mallick, Y. Brihaye, E. Caliceti, M.V. Chabanov, A. Chakrabarti, A. Cobstandache, V.K. Dobrev, R. Fauser, S.-M. Fei, M. Horowski, A. Horzela, N. Kamyia, E. Kapuscik, K.A. Milton, A.I. Molev, A. Mostafazadeh, M. Nagy, S. Oblezin, A. Odziejewicz, V. Onysko, E. Paal, K. Podlaski, J. Rembielinowski, V.G. Ritter, R. Sasaki, T. Skrypnik, M. Takahashi, K. Takemura, V.M. Tkachuk, A.V. Turbiner, E. Wagner, A. Zotov, and others

**The workshop “Pseudo-Hermitian Hamiltonians in Quantum Physics ”** (Prague, June 16-17), organized by M. Znojil with the participation of B. Basu-Mallick, C.M. Bender, E. Caliceti, C. Dunning, S-M Fei, H. Geyer, C. Handy, R. Kretschmer, K. Milton, A. Mostafazadeh, A. Nayakkara, V.M. Savage, A. Schulze-Halberg, G. Sclarici, A. Sinha, L. Skála, I. Snyman, A. Turbiner, Q. Wang, S. Weigert, T. Wolf, members of DI and their students.

**The workshop “Problems with Moving Boundaries”** (Prague, October 15-18), organized by J. Dittrich with the participation of A. Caloggeracos, V.V. Dodonov, P. Duclos, F. Saif, R. Schrader, M. Vittot, M. Janowicz, members of DI and their students.

**The miniconference “Doppler 200”** on mathematics, physics, and history (Prague, November 28-29), organized by P. Exner, J. Dittrich and J. Tolar with the participation of our advisors, members of DI, their students and others.

## 2.5 Teaching activities

### 2.5.1 Courses and student seminars

In addition to the regular curriculum duties (for the DI members coming from CTU), the following teaching activities have been organized:

1. *Mathematical methods of the quantum theory* (Charles Univ., Exner)
2. *Quantum chaos* (University of Hradec Králové, Šeba)

### 2.5.2 Students

#### Defended PhD theses in 2003:

- M. Krbálek (UHK, supervised by P. Šeba); “Traffic system – particle gases in thermal equilibrium”
- J. Kříž (Charles U., supervised by J. Dittrich); “Spectral properties of planar quantum waveguides with combined boundary conditions”
- O. Mareš (CTU, supervised by Č. Burdík); “Stochastic Models of Glass Transition and Structure”

#### Graduate:

- V. Jakubský (CTU, supervised by M. Znojil); “Models in relativistic quantum mechanics”
- O. Lev (CTU, supervised by P. Šťovíček); “Semiclassical methods of quantum physics”
- P. Vytrás (CTU, supervised by P. Šťovíček); “Magnetic quantum systems”
- K. Němcová (Charles U., supervised by P. Exner); “Solvable models of quantum waveguide systems”

**5th course:**

- H. Bíla (Charles U., supervised by M. Znojil); “Pseudo-Hermitian Hamiltonians in quantum theory”
- M. Fraas (Charles U., supervised by P. Exner); “Time evolution in Winter model”
- J. Hrivnák (CTU, supervised by J. Tolar); “Solution of contraction equations for the Pauli grading of  $sl(3, \mathbb{C})$ ”
- P. Luft (CTU, supervised by G. Chadzitaskos); “Quantization and Coherent States”
- P. Novotný (CTU, supervised by J. Tolar); “Lie algebras obtained by graded contractions of  $sl(3, \mathbb{C})$  in case of Pauli gradations”

**4th course:**

- M. Turek (CTU, supervised by L. Hlavatý); “Dualities in field theories”

**3rd course:**

- A. Černý (CTU, supervised by L. Hlavatý); “Bianchi algebras and their applications to cosmology”
- M. Filan (CTU, supervised by P. Šťovíček); “Representations of classical Lie groups”
- L. Kučerová (CTU, supervised by L. Hlavatý); “Surfaces of constant negative curvature”
- O. Turek (CTU, supervised by P. Exner); “Concentric families of singular interactions”