

**Center of Basic Research „Doppler Institute for Mathematical
Physics and Applied Mathematics“
2006 – 2008 Activities and Results**

Referee's report

The Center of Basic Research „Doppler Institute for Mathematical Physics and Applied Mathematics“ was established in 2006 as an institute supported by the Ministry of Education, Youth and Sports of the Czech Republic for the period 2006 – 2010 (code No. LC06002). It is based on a close cooperation of three institutions, the Czech Technical University in Prague, the Nuclear Physics Institute of the Academy of Sciences of the Czech Republic in Řež, and the University of Hradec Králové. The project is intended to strengthen top-level research and international collaboration, and to support the postgraduate education and early researcher careers in mathematical physics and applied mathematics in the Czech Republic. The core topic of the project is quantum theory and related mathematical methods, together with wide applications. The Institute should provide an internationally recognised basis in these fields, and to educate young perspective researchers to keep a high-level research for at least the next 1-2 decades.

The project is solved by a stable research team consisting of experienced experts holding permanent positions (18 people) and PhD students and postdoctorals on long-term and short-term temporary positions. In addition, visiting professors for periods up to two months, and a number of other visitors from abroad participate in the project. Typical activities are publications, seminars, organisation of scientific meetings and conferences, lectures at international conferences, and education of undergraduate and postgraduate students.

Activities and research results

In what follows, I will comment on activities of the Institute and research results, as well as on their international impact.

Research

Doppler Institute conducts research in 7 main directions, each of the research groups being headed by an experienced researcher. During the last 3 years members and visitors of the Institute published 1 monograph (Springer) and 1 popular book, almost 130 papers, mostly in journals, 2 proceedings volumes (AMS, and a special issue of *J. Phys. A*), and registered 1 patent. Other more than 40 articles have been submitted for publication.

However, in my opinion, a quantitative analysis is not the most essential issue: I find the quality of the results and their impact much more important. In this respect, it should be pointed out that a high number of the articles was published in recognised journals, such as *Ann. H. Poincaré*, *Arch. Rat. Mech. Anal.*, *Discrete Math. Theor. Comput. Sci.*, *Int. Rev. Phys. Chem.*, *J. Math. Phys.*, *J. Phys. A*, *Lett. Math. Phys.*,

Phys. Lett. A, Phys Lett. B, Phys. Rev. A, Phys. Rev. D, Phys. Rev. Lett., Rev. Math. Phys., Theor. Comput. Sci., and others.

The following are the most significant results obtained by the individual research groups:

(1) Quantum graphs and waveguides (head Exner)

Attention has been concentrated on geometrically induced spectral properties of Laplacians in tubes (Krejčířík, Kovařík) and to quantum graphs Hamiltonians, in particular, their approximations by Schroedinger operators in thin network systems (Exner, Post, Cacciaputi). An outstanding outcome is also the second edition of the monograph by Blank, Exner and Havlíček published by Springer, with two new chapters about quantum waveguides and graphs.

(2) Symmetries and integrable systems (head Burdík)

This group organized a summer school, in addition they published three papers on solvable models with particular symmetries.

(3) Quantum information and communication, quantum optics (head Jex)

A very active group (Jex and students). They analysed properties of quantum walks, especially of the corresponding Polya numbers (a paper in PRL). They also studied quantum search algorithms and properties of quantum chaos in model systems.

(4) Aperiodic structures (head Pelantová)

Another very active group (Pelantová, Masáková, Ambrož and students). The main results concern non-standard numeration systems, from both combinatorial and algebraic point of view, combinatorics on words, and applications in physics, in particular, to description of quasicrystals.

(5) Parametric properties of quantum systems (head Šťovíček)

Papers on spectral properties of periodically driven systems and on solvable models of point interactions on a nontrivial geometric background (Šťovíček and students).

(6) Analytical and algebraical methods in quantum theory (head Znojil)

High productivity of this group is mostly due to its head. He explores systematically various properties of PT-symmetric systems.

(7) Applications of quantum chaos methods (head Šeba)

Another very successful group, the driving force being its head Šeba. The main subject is data analysis in various systems both in quantum physics and in everyday life (parking, economic processes, animal behaviour), which allow explanation by random matrix and other probabilistic methods. It should be pointed out that Šeba's work was mentioned by Percy Deift in his plenary lecture to the International Congress of Mathematicians in Madrid in 2006.

Seminars

Research groups in the Institute regularly meet at four seminars (Doppler Institute Seminar, Quantum Circle Seminar, Seminar on Combinatorial and Algebraic Structures, a microseminar on quantum theory and related topics and methods),

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serving for discussions and dissemination of new ideas and results of the members of the Institute and their students. A very important part of the work of the seminars consists in talks delivered by visitors to the Institute, stimulating further research and collaboration.

International collaboration

The Institute has a wide and fruitful international collaboration. Every year, about 30 visitors come for short and long term visits. Typically, they deliver a seminar talk, however, some of them participate directly in the research. The rich international exchange is also extraordinarily important in education of students and young researchers. The existing collaboration also documents on one hand, and further stimulates on the other hand, the high quality of research. The members of the Institute regularly publish joint papers with their colleagues abroad and deliver lectures at international conferences and workshops. In particular, they are very active in organising various scientific meetings – international schools, microconferences, workshops, international conferences. Among them, I would like to mention at least *Operator Theory in Quantum Physics* (Prague, 2006), *Symmetries in Physics: Modern Trends* (Prague, 2007), *Pseudo-Hermitian Hamiltonians in Quantum Physics* (London, 2007), *Journées Numeration* (Prague, 2008), or *Modern Trends in Quantum Optics and Quantum Information* (Prague, 2008). The most important and prestigious event, however, is the coming *XVI International Congress on Mathematical Physics*, to be held in Prague this August. The International Association of Mathematical Physics choose Prague as the site of its next congress, and the Doppler Institute plays a leading role in the ICMP organisation. This, of course, necessitated some modifications in the Institute's work program and budget. From the 2009 budget, activities of the congress will be supported, some meetings planned for 2009 have to be postponed, some guests to the Institute in 2009 will preferably join their visit with the attendance of the congress, etc.

Last but not least, one should not forget mentioning a high international reputation and authority of the Institute's Scientific Director, prof. Exner, who has been recently elected President of the *International Association of Mathematical Physics*.

Students and early career researchers

In my opinion, education of students and supervising of young postdoctorals is one of the most important parts of the institute's activities. Every year, members of the Institute supervise more than 20 PhD students and a number of undergraduate students. Since 2006, under their supervision, 11 PhD theses were defended. They regularly organise Student Winter Schools on Mathematical Physics, with lectures of the Institute's members and experts from abroad.

It is also to be stressed that the Doppler Institute supports the Václav Votruba Prize, yearly awarded for the best PhD thesis in theoretical physics, sponsored by the Foundation for Support of Theoretical Physics.

Long and short term temporary positions supported by the project serve to the training of young career researchers. Most of them successfully join one of the research groups and contribute to the research outcomes. At this place I also wish to mention a habilitation degree obtained in 2006 by Zuzana Masáková, who belongs to the very active research group of Aperiodic Structures.

Project cost

The project budget is well ballanced and effectively used.

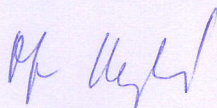
Conclusion

Within the last 3 years, the Doppler Institute members proved a high ability to successfully complete the project. Their activities are internationally recognised and the impact of their research results in the international community is high. The international collaboration is fruitful, and the training of young researchers is successful.

The activities and outcomes correspond (up to naturally induced minor modifications) with the aims and scope of the project.

My evaluation is „excellent“, I strongly suggest the project to continue.

Olomouc, 27 January, 2009



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