UNIV.-PROF. DR.
MECHTHILD THALHAMMER

INSTITUT FÜR MATHEMATIK
LEOPOLD–FRANZENS-UNIVERSITÄT INNSBRUCK

TECHNIKERSTRASSE 13/7, 6020 INNSBRUCK, AUSTRIA
EMAIL. MECHTHILD.THALHAMMER@UIBK.AC.AT
PHONE. +43 (0)512 507 53874

Review on the habilitation thesis of Karolina Kropielnicka

The cumulative habilitation thesis of Karolina Kropielnicka entitled *Advanced computational methodologies for evolutionary differential equations* comprises six scientific publications on relevant topics in the field of numerical mathematics. These works were published in high-quality peer-reviewed international journals and confirm the competence of Karolina Kropielnicka to work allone and to collaborate with colleagues.

The habilitation thesis is concerned with the following questions.

(1) K. KROPIELNICKA.
Implicit difference methods for parabolic FDE on cylindrical domains.
Dynamic Systems and Applications 19/3-4 (2010) 557–575.

Functional differential equations that are associated with systems of nonlinear parabolic equations are studied, and a convergence analysis is provided for a class of implicit finite difference schemes.

(2) P. GWIAZDA, K. KROPIELNICKA, A. MARCINIAK-CZOCHRA.
The escalator boxcar train method for a system of age-structured equations.
Networks and Heterogeneous Media 11/1 (2016) 123–143.

The escalator boxcar train algorithm is studied for systems of equations describing structured population models.

(3) M. CONDON, A. DEANO, A. ISERLES, K. KROPIELNICKA.
Efficient computation of delay differential equations with highly oscillatory terms.
ESAIM. Mathematical Modelling and Numerical Analysis 46/6 (2012) 1407–1420.

Systems of linear delay differential equations involving highly oscillatory forcing terms

$$y'(t) = A\,y(t) + B\,y(t-1) + \sum_{m\in\mathbb{Z}} a_m(t)\,\mathrm{e}^{\mathrm{i}m\omega t}$$

are studied, and numerical approximations are obtained through suitable asymptotic expansions.

(4) P. BADER, A. ISERLES, K. KROPIELNICKA, P. SINGH.
Effective approximation for the semiclassical Schrödinger equation.
Foundations of Computational Mathematics 14/4 (2014) 689–720.

The one-dimensional linear Schrödinger equation in the semiclassical regime

$$\mathrm{i}\varepsilon\,\partial_t u(x,t) = -\varepsilon^2\,\partial_{xx} u(x,t) + V(x)\,u(x,t)$$

is studied, and an asymptotic splitting method is proposed.

(5) P. BADER, A. ISERLES, K. KROPIELNICKA, P. SINGH.
Efficient methods for linear Schrödinger equation in the semiclassical regime with time-dependent potential.
Proceedings of the Royal Society A 472/2193 (2016).

The semiclassical one-dimensional linear Schrödinger equation involving a space-time-dependent potential

$$\mathrm{i}\varepsilon\,\partial_t u(x,t) = -\varepsilon^2\,\partial_{xx} u(x,t) + V(x,t)\,u(x,t)$$

is studied, and a numerical method based on the Magnus expansion and Lanczos iterations is proposed.

(6) A. ISERLES, K. KROPIELNICKA, P. SINGH.
Magnus–Lanczos methods with simplified ommutators for the Schrödinger equation with a time-dependent potential.
SIAM Journal of Numerical Analysis (2018) doi 10.1137/17M1149833.

The one-dimensional linear Schrödinger equation involving a space-time-dependent potential

$$\mathrm{i}\partial_t u(x,t) = -\partial_{xx} u(x,t) + V(x,t)\,u(x,t)$$

is studied, and a numerical method based on the Zassenhaus composition and the Magnus expansion is proposed.

A common aspect of the publications (3)–(6) is the highly oscillatory nature of the considered problems. I believe that in particular the series of works (4)–(6) and further recent contributions, e.g.

A. ISERLES, K. KROPIELNICKA, P. SINGH.
Compact schemes for laser-matter interaction in Schrödinger equation based on effective splittings of Magnus expansion.
Computer Physics Communications 234 (2019) 195–201,

have found general approval amongst mathematicians as well as physicists and have significant impact on current and future investigations in the context of efficient numerical methods for Schrödinger equations.

I have met Karolina Kropielnicka on the occasion of international conferences and workshops, and I attended several of her talks. I appreciate her style of presenting mathematical

results and her interest in different areas of mathematics. Her work enthusiasm and communicative competence are important factors for maintaining and establishing scientific contacts. I also appreciate her high commitment to serve the community. In the organisation of the workshops *Modern Numerical Methods for Quantum Mechanics I* (2017, Warsaw) and *Modern Numerical Methods for Quantum Mechanics II* (2018, Gdańsk), Karolina Kropielnicka and her co-organisers succeeded in gathering experts in the field and creating an inspiring and pleasant working atmosphere.

The habilitation thesis of Karolina Kropielnicka comprises methodically solid and novel scientific results. It confirms her competence to represent the field of numerical mathematics and to contribute to future developments. On the basis of the thesis and my personal assessment, I recommend the positive evaluation of the habilitation procedure of Karolina Kropielnicka.

Mechthild Thalhammer

Innsbruck, December 18, 2018 Mechthild Thalhammer