MAX-PLANCK-INSTITUT
FÜR DYNAMIK KOMPLEXER
TECHNISCHER SYSTEME
MAGDEBURG

CSC
NUMERISCHE METHODEN IN DER
SYSTEM- UND REGELUNGSTHEORIE

Prof. Dr. Alexander Zuyev
MAX-PLANCK-INSTITUT
FÜR DYNAMIK KOMPLEXER TECHNISCHER SYSTEME MAGDEBURG
NUMERISCHE METHODEN IN DER SYSTEM- UND REGELUNGSTHEORIE
Sandtorstraße 1 I 39106 Magdeburg I Germany

Institute of Mathematics,
University of Szczecin
ul. Wielkopolska 15
70-451 Szczecin, Poland

Prof.
Alexander Zuyev
Senior Scientist

Sandtorstraße 1
39106 Magdeburg
T +49 391 6110-478
F +49 391 6110-526
zuyev@mpi-magdeburg.mpg.de
www.mpi-magdeburg.mpg.de

Secretary
T +49 391 6110-450
F +49 391 6110-526
sek-csc@mpi-magdeburg.mpg.de

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Report on the PhD thesis of Mateusz Firkowski
"Selected Problems of Stability and Observability of Timoshenko Beams"

The thesis of Mr. Mateusz Firkowski is devoted to the development of operator methods for stabilization and observability problems of Timoshenko beam models in infinite-dimensional spaces. This research field has rich background in continuum mechanics and distributed parameter control theory, as well as potential engineering applications in robotics.

The manuscript under review is composed of 4 Chapters, and its main part (Chapters 3–4) is based on the following papers by M. Firkowski, co-authored with J. Woźniak: "Note on the stability of a slowly rotating Timoshenko beam with damping" (Adv. Appl. Math. Mech.), "Optimal damping coefficient of a slowly rotating Timoshenko beam" (Proc. SIAM Conf. Cont. Appl.), "Stability of slowly rotating Timoshenko beam with two viscoelastic damping coefficients" (Proc. 23rd MED Conf. Cont. Autom.), "Optimal decay ratio of damped slowly rotating Timoshenko beams" (Z. Angew. Math. Mech), and "Existence of optimal stability margin for weakly damped beams" (In: Stabilization of Distributed Parameter Systems: Design Methods and Applications, SEMA SIMAI Springer Series).

The introduction to the theory of C_0-semigroups and spectral methods is presented in Chapter 1. Here basic results on the Riesz-spectral operators are summarized as well.

Chapter 2 contains the derivation of mathematical models of slowly rotating Timoshenko beams. The equations of motions are presented in the operator form for the subsequent analysis. The model of a cantilever flexible beam is explicitly addressed as a particular case.

Stability issues of the above introduced infinite-dimensional mathematical models are studied in Chapter 3. The asymptotic stability result is obtained for the system with damping. It is shown that the corresponding semigroup satisfies the spectrum determined growth condition according to the Zwart theorem.

In Chapter 4, Mr. Firkowski considers the observability problem for the linear control system in a Hilbert space. It is shown that the considered system is not exactly observable in the natural state space. Then the exact observability problem is treated in the space with a stronger topology. Exact observability conditions are obtained in Theorem 4.7, provided that the observability time is large enough. The main observability result is summarized in Theorem 4.14.

The thesis is globally well-written with clear theoretical results. I have however the following comments:

1. In section 2.4 and some subsequent theorems, the author assumes that the mechanical parameter γ is chosen to be 1. It would be reasonable to justify the physical origin of this assumption in view of the existing publications, e.g., Jensen J. J. (1983): *On the shear coefficient in Timoshenko's beam theory*, Journal of Sound and Vibration, Vol. 87(4), pp. 621–635; Hutchinson J. R. (2001): *Shear coefficients for Timoshenko beam theory*, Journal of Applied Mechanics, Vol. 68(1), pp. 87–92; Chan K. T., Lai K. F., Stephen N. G., and Young K. (2011): *A new method to determine the shear coefficient of Timoshenko beam theory*, Journal of Sound and Vibration, Vol. 330(14), pp. 3488–3497.

2. There is a typo in Definition 1.38 on page 21: $\sigma(A) = \sigma_p(A) \cup \sigma_p(A) \cup \sigma_r(A)$.

The above comments do not diminish the excellent value of Mr. Firkowski's work.

This thesis provides a novel contribution to stability and control theory for Timoshenko beam model, based on spectral methods and perturbation theory of linear operators. The author has carried out an in-depth stability analysis of the resulting closed-loop systems in abstract spaces, including the cases of polynomial stability.

To sum up, I recommend the dissertation work of Mr. Mateusz Firkowski for the defense procedure and evaluate his thesis with the highest grade.

Yours respectfully,

Alexander Zuyev