Project Description: Structure-Preserving Computation of Particular Eigenvectors of Skew-Hamiltonian/Hamiltonian Pencils

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During the design process of technical devices, often mathematical models are set up in order to simulate, optimize and control the behavior of the devices. Usually these models are described by differential or differential algebraic equations. In this project we consider the class of linear time-invariant differential-algebraic equations of the form

$$E\dot{x}(t) = Ax(t) + Bu(t), \quad y(t) = Cx(t) + Du(t).$$

Here, $E, A \in \mathbb{R}^{n\times n}$, $B \in \mathbb{R}^{n\times m}$, $C \in \mathbb{R}^{p\times n}$, $D \in \mathbb{R}^{p\times m}$, $x(t) \in \mathbb{R}^n$ describes the state of the system, whereas $u(t) \in \mathbb{R}^m$ is a control input signal and $y(t) \in \mathbb{R}^p$ is an output signal (obtained, e.g., by measurements). Additionally, the matrix E might be singular which means that there are hidden algebraic constraints in the dynamics of the system. Many applications for these systems lead to so-called skew-Hamiltonian/Hamiltonian matrix pencils. Usually we are interested in certain spectral information of these pencils (particular eigenvalues/eigenvectors/deflating subspaces). Recently an algorithm has been developed which computes the eigenvectors associated to the purely imaginary eigenvalues in a structure-exploiting way.

The aim of the project is to implement this algorithm in Fortran 77 in the style of SLICOT[1] routines. A MEX interface for calling the routine from MATLAB should also be developed. Another important part is to test the algorithm with certain test examples and analyze the quality of the results. Certain extreme cases such as pencils which have very close imaginary eigenvalues should also be taken into account.

The internship will take place in the "Computational Methods in Systems and Control Theory" group at the Max Planck Institute for Dynamics of Complex Technical Systems in Magdeburg. Our group has a strong background in systems theory, numerical linear algebra and model reduction with applications in engineering sciences. The working environment is quite international due to the high amount of scientists from abroad. Many other research institutions such as the Otto-von-Guericke University or the Fraunhofer Institute for Factory Operation and Automation are very close to the institute.

Magdeburg is a medium-size city with about 230.000 inhabitants. It is the capital of the federal state of Saxony-Anhalt and therefore offers lots of possibilities to enjoy free-time and cultural life. There are also many opportunities for day-trips, for instance to the Harz Mountains or Berlin which can be reached by train within two hours.

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[1] `www.slicot.org`