# Conference on the Occasion of Richard Varga's 80th Birthday

October 17-18, 2008

Department of Mathematical Sciences, Kent State University

**COMPLETE LISTING OF ABSTRACTS:**

**Title:** Reorthogonalization for accurate singular values in Lanczos bidiagonal reduction
**Speaker:** Jesse L. Barlow, The Pennsylvania State University
**Abstract:** Lanczos bidiagonal reduction generates a factorization of a matrix $X \in \boldsymbol{R}^{m \times n}, m \geq n$, such that

$$X = UBV^T$$

where $U \in \boldsymbol{R}^{m \times n}$ is left orthogonal, $V \in \boldsymbol{R}^{n \times n}$ is orthogonal, and $B \in \boldsymbol{R}^{n \times n}$ is bidiagonal. Since, in the Lanczos recurrance, the columns of $U$ and $V$ tend to lose orthogonality, a reorthogonalization strategy is necessary to preserve convergence of the singular values of the leading $k \times k$ submatrix $B_k = B(1\colon k, 1\colon k)$ to those of $B$. Moreover, in the solution of ill-posed least squares problems and in the computation of matrix functions, it is essential that this convergence occur properly.

It is shown that if

$$\text{orth}(V) = \|I - V^T V\|_2,$$

then singular values of $B$ correspond to those of $X$ according to

$$\left( \sum_{j=1}^{n} (\sigma_j(X) - \sigma_j(B))^2 \right)^{1/2} \leq O(\varepsilon_M + \text{orth}(V)) \|X\|_F$$

where $\varepsilon_M$ is machine precision. Moreover, if

$$\Theta_1 = \text{diag}(\theta_1, \ldots, \theta_j)$$

are the leading $j$ singular values of $B_k$, then the corresponding approximate left singular vectors of $X$ in the matrix $P_j$ satisfy

$$\|I - P_j^T P_j\|_F \leq O(\varepsilon_M + \text{orth}(V)) \|X\|_2 / \theta_j.$$

Thus regulation of the orthogonality of the columns of $V$ serves to preserve accuracy in the singular values and orthogonality in the leading approximate left singular vectors even if there is no attempt to reorthogonalize the columns of $U$.

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**Title:** New extensions of some results of Szego
**Speaker:** Amos Carpenter
**Abstract:** In this talk we will give new extensions of some results of Szego on the interrelationship between the zeros of the partial sums of $e^z$ and those of the partial sums of $\cos(z)$ and $\sin(z)$. Numerical results and graphs will be included.

**Title:** Explicit time stepping algorithms providing stable decoupling of heat equations on two subdomains
**Speaker:** Jeffrey M. Connors of University of Pittsburgh, Jason S. Howell of Carnegie Mellon University, and William J. Layton of University of Pittsburgh
**Abstract:** A variety of physical models feature equations on two domains coupled through an interface condition. There is a need for efficiently solvable algorithms to estimate solutions to these coupled systems. Herein is considered the case of two heat equations posed in domains $\Omega_1, \Omega_2 \subset \mathbb{R}^2$ adjoined by an interface $I = \Omega_1 \cap \Omega_2 \subset \mathbb{R}$. The heat equations are coupled by a condition that conserves energy dissipation across $I$. To compute approximate solutions to the above problem, first order in time, fully discretized numerical methods are presented. The methods consist of a partitioned time stepping approach and an implicit-explicit (IMEX) approach, in which the action across $I$ is lagged. Stability and convergence results are derived for finite element spatial discretizations, and the methods is shown to be optimal in a discrete $H^1$-type norm. Numerical experiments that support the theoretical results are presented, with results using a fully implicit algorithm for comparison.

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**Title:** Slit maps, Green's functions, and Schwarz-Christoffel maps for multiply connected domains
**Speaker:** Tom DeLillo, Wichita State University
**Abstract:** We review recent derivations of formulas for conformal maps from finitely connected domains with circular holes to canonical radially or circularly slit domains. The formulas are infinite products based on simple reflection arguments. Green's functions for the circle domains for the Dirichlet, Neumann, and mixed (Robin) problems can be given explicitly in terms of these formulas. An earlier derivation of the Schwarz-Christoffel formula for multiply connected case using similar arguments will also be reviewed. We will also briefly discuss progress on the numerical implementation of these formulas and the relation of our approach to that of D. Crowdy and J. Marshall. This is joint work with T. Driscoll, A. Elcrat, and J. Pfaltzgraff.

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**Title:** Krylov subspace reduction of large scale evolutionary problems
**Speaker:** Vladimir Druskin, Schlumberger
**Abstract:** We solve a semidiscrete parabolic problem

$$Au + u_t = 0, \ u|_{t=0} = b, \tag{0.1}$$

where $u(t), b \in \boldsymbol{R}^N$ and $0 < A = A^* \in \boldsymbol{R}^{N\times N}$. Our application is the diffusive Maxwell equations arising in geophysical oil exploration. This requires the solution for large time intervals and large, sparse, ill-conditioned $A$.

Traditionally problem (0.1) was solved via the time-stepping until Varga in 1971 suggested to treat it as a rational approximation problem for the matrix exponential.

First we review merits and limitations of the solution (0.1) using the Krylov Subspace reduction, that can be viewed as an adaptive polynomial approximation of $\exp(-tA)b$.

Then we consider the computation of $e^{-tA}b$ for semiinfinite time intervals using Rational Krylov Subspaces (RKS). The key in the latter approach is the choice of the poles (shifts). We consider

this problem in the frequency domain and reduce it to a classical Zolotarev problem. This yields an asymtotically optimal solution with real shifts. We also construct an infinite sequence of shifts yielding a nested sequence of the RKSs with the same (optimal) Cauchy-Hadamard convergence rate.

Finally, time permiting, we consider an extension of this approach to a more general and practically important problem of Maxwell's system in dispersive media (a.k.a. media with memory or with induced polarization), when elements of $A$ in (0.1) are time-convolution operators, such that the Laplace transform $\int_0^\infty e^{-st} A\, dt$ is real symmetric positive-definite matrix valued function of $s$.

This is a joint work with Leonid Knizhnerman and Mikhail Zaslavsky.

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**Title:** Do we need Krylov subspace methods for the evaluation of matrix functions?
**Speaker:** Michael Eiermann, Institut fuer Numerische Mathematik und Optimierung
**Abstract:** The evaluation of $f(A)\boldsymbol{b}$, where $A$ is a matrix, $\boldsymbol{b}$ is a vector and $f$ is a complex valued function, is a common computational task. The most prominent example is the time evolution of a system under a linear operator, in which case $f(\lambda) = \exp(t\lambda)$ and time acts as a parameter $t$. Here, the matrix $A$ is often large and sparse, typically resulting from discretization of an infinite-dimensional operator. In this case evaluating $f(A)\boldsymbol{b}$ by first computing $f(A)$ is usually unfeasible. The standard approach for approximating $f(A)\boldsymbol{b}$ is based on a Krylov subspace of $A$ with initial vector $\boldsymbol{b}$. The advantage of this approach is that it requires $A$ only for computing matrix-vector products and that, for smooth functions such as the exponential, it converges superlinearly. Instead of $f(A)\boldsymbol{b}$, only the "small" vector $f(H)\boldsymbol{e}$ has to be computed, where $H$ and $\boldsymbol{e}$ are projections of $A$ and $\boldsymbol{b}$, respectively. This is usually accomplished by a rational approximation $r$ to $f$, given in partial fraction form $r(\lambda) = \sum_{j=1}^{d} \alpha_j/(\lambda - \pi_j)$. The evaluation of $r(H)\boldsymbol{e}$ is therefore equivalent to the solution of $d$ shifted linear systems $(H - \pi_j I)\boldsymbol{y}_j = \boldsymbol{e}$.

The rational approximation to $f$ can also be applied directly to the original problem $f(A)\boldsymbol{b} \approx r(A)\boldsymbol{b} = \sum_{j=1}^{d} \alpha_j \boldsymbol{x}_j$, where $\boldsymbol{x}_j$ solves the linear system $(A - \pi_j I)\boldsymbol{x} = \boldsymbol{b}$. We investigate the question under which conditions this direct approach is preferable to conventional Krylov subspace methods.

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**Title:** On Pade-type model order reduction of J-Hermitian linear dynamical systems
**Speaker:** Roland W. Freund, University of California, Davis
**Abstract:** A simple, yet powerful approach to model order reduction of large-scale linear dynamical systems is to employ projection onto block Krylov subspaces. The transfer functions of the resulting reduced-order models of such projection methods can be characterized as Pade-type approximants of the transfer function of the original large-scale system. If the original system exhibits certain symmetries, then the reduced-order models are considerably more accurate than the theory for general systems predicts. In this talk, we discuss the use of the framework of J-Hermitian linear dynamical systems to establish a general result about this higher accuracy. In particular, we show that in the case of J-Hermitian linear dynamical systems, the reduced-order transfer functions match twice as many Taylor coefficients of the original transfer function as in the general case. An application to the SPRIM algorithm for order reduction of general RCL electrical networks is discussed.

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**Title:** How sharp is Bernstein's inequality for Jacobi polynomials?

**Speaker:** Walter Gautschi, Purdue University

**Abstract:** Bernstein's inequality for Legendre polynomials $P_n$, as generalized by Baratella, Chow, Gatteschi, and Wong to Jacobi polynomials $P_n^{\alpha,\beta}$, $(\alpha,\beta) \in calR_{1/2} = \{|\alpha| \leq 1/2, |\beta| \leq 1/2\}$, is analyzed analytically and computationally with regard to validity and sharpness in larger domains $\mathcal{R}_s = \{-1/2 \leq \alpha \leq s, -1/2 \leq \beta \leq s\}, s > 1/2$.

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**Title:** Bivariate B-splines used as basis functions for data fitting

**Speaker:** Daniel E. Gonsor, The Boeing Company

**Abstract:** We present results summarizing the utility of bivariate B-splines for solving data fitting and related problems.

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**Title:** IDR explained

**Speaker:** Martin H. Gutknecht, ETH Zurich

**Abstract:** Under the section heading "A preconditioned Lanczos type method" the Induced Dimension Reduction (IDR) method was introduced on three and a half pages of a 1980 proceedings paper [5] by Wesseling and Sonneveld. Few people may have noticed it. Soon after IDR, Sonneveld must have found his widely applied Conjugate Gradient Squared (CGS) algorithm, published in SISSC in 1989 [2], but submitted to that journal on April 24, 1984, already. Then, at the Householder Symposium 1990 in Tylosand, van der Vorst suggested with CGSTAB an improvement of both these methods. It was published as the Bi-CGSTAB method in SISSC in 1992 [4].

Bi-CGSTAB has become one of the methods of choice for nonsymmetric linear systems, and it has been generalized in various ways in the hope of further improving its reliability and speed. Among these generalizations there is the ML($k$)BiCGSTAB method of Yeung and Chan, published in SISC in 1999 [6], which in the framework of block Lanczos methods can be understood as a variation of Bi-CGSTAB with right-hand side block size 1 and left-hand side block size $k$. Probably only few readers studied this paper completely, since the algorithm turned out to be rather complicated.

Last year Sonneveld and van Gijzen [3] reconsidered IDR and generalized it to IDR($s$), claiming that IDR is equally fast but preferable to Bi-CGSTAB, and that IDR($s$) may be much faster than IDR = IDR(1). It turned out that IDR($s$) is closely related to ML($s$)BiCGSTAB, but at no step mathematically equivalent. In fact, the recurrences of IDR and IDR($s$) are simpler than those of Bi-CGSTAB and ML($s$)BiCGSTAB, respectively, and they offer some flexibility that can be capitalized upon for increasing the stability. A similar flexibility is also available in the block Lanczos process but has not been made use of in ML($k$)BiCGSTAB.

In this talk we first try to explain the basic, seemingly quite general IDR approach, which differs completely from traditional approaches to Krylov space methods. Then we compare the basic properties of the above mentioned methods and discuss some of their connections. Most of what we say is taken from [3] and [1], but we also provide some further explanations.

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**Title:** Controlled over relaxation method

**Speaker:** Ali Hajjafar, The University of Akron

**Abstract:** For a wide range of splittings of coefficient matrices whose corresponding iterative method diverge, with a geometric and analytic approach, a two parameter COR method is developed. The choices of parameters are calculated so that the first parameter controls the spectral radius of the iteration matrix and guarantees convergence. The second parameter modifies the acceleration.

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**Title:** Algebra and analysis of the generalized Routh-Hurwitz problem

**Speaker:** Olga Holtz, UC Berkeley

**Abstract:**We revisit known connections and establish some new results in several areas related to the Routh-Hurwitz problem:

* various structured matrices (Hankel, Vandermonde, Toeplitz, Hurwitz, and Jacobi)

* decompositions of rational functions into Stieltjes and Jacobi continued fractions

* root localization of univariate polynomials, e.g., Hurwitz stable and real-rooted polynomials and their generalizations

This is joint work with Mikhail Tyaglov.

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**Title:** Sensitivity relation in iterated Tikhonov method for ill-posed problems

**Speaker:** Ross Ingram

**Abstract:** In derive the iterated Tikhonov method, a relationship between the base Tikhonov approximation and first order Taylor expansion is shown. An interesting extension to the kth order Taylor expansion can be proved. A natural connection of the approximation's parameter sensitivity will also be shown.

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**Title:** Szegő-Lobatto quadrature rules

**Speaker:** Carl Jagels, Hanover College

**Abstract:** Gauss-type quadrature rules with one or two prescribed nodes are well known and are commonly referred to as Gauss-Radau and Gauss-Lobatto quadrature rules, respectively. Efficient algorithms are available for their computation. Szegő quadrature rules are analogs of Gauss quadrature rules for the integration of periodic functions; they integrate exactly trigonometric polynomials of as high degree as possible. Szegő quadrature rules have a free parameter, which can be used to prescribe one node. This talk discusses an analog of Gauss-Lobatto rules, i.e., Szegő quadrature rules with two prescribed nodes.

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**Title:** Iterative methods for Leontief Input-output model
**Speaker:** Lala B. Krishna, The University of Akron
**Abstract:** Iterative methods for solving Leontief input-output problems related to regional and multiregional systems will be presented. We assume the associated matrix is large and sparse. The zero entries in the matrix is caused by lack of interaction between industries and/or regions

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**Title:** Spectral gap conjecture for Brownian motion with jump boundary
**Speaker:** Yuk J. Leung and WenBo V. Li, University of Delaware
**Abstract:** Consider a family of probability meaures $\{\nu_y\}$ defined on a smooth and bounded domain $D$ in $R^d$ indexed by $y \in \partial D$ . For any starting point $x$ in the interior, we run a standard $d$-dimensional Brownian motion $B(t)$ in $R^d$ until it first hits $\partial D$ at time $\tau$. At which time, it jumps to a point in the domain $D$ according to the measure $\nu_{B(\tau)}$ at the exit point and starts the Brownian afresh. One of the problems in this direction considered by I. Ben-Ari and R. Pinsky (2007) is the eigenvalue problem on $D = (0, 1)$ :

$$\frac{1}{2}u'' = \lambda u, \quad u(0) = \int_D u\, d\nu_0, \ u(1) = \int_D u\, d\nu_1,$$

with $\nu_0$ and $\nu_1$ being two given probability measures defined on the interval $(0, 1)$.

It was conjectured by Ben-Ari and Pinsky that (a) the eigenvalues $\lambda$ are real and (b) the first negative eigenvalue lies in the interval $[-9\pi 2/2, -\pi 2/2)$. Proof of part (a) has appeared in Leung, Li and Rakesh (2008). We'll discuss a proof of part (b) using ideas from Pólya and Szegö on the zeros of finite Fourier transforms. There is an interesting Markov Chain transition matrix associated with this Dirichlet problem, which is a low rank perturbation of the well-known Jacobi matrix. If time permits, we'll discuss the empirical distribution of the eigenvalues of this matrix.

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**Title:** System analysis and reconstruction algorithm for the strip-based projection model in discrete tomography
**Speaker:** Xiezhang Li
**Abstract:** Discrete tomography deals with image reconstruction of an object with a finitely many gray levels (such as two). The strip-based projection model is more realistic to model the raw detector reading in some applications than the line-based projection models. In this talk we will analyze the linear system generated by the strip-based projection model and establish equivalence between the system matrices generated by the strip-based and line-based projection models. An algebraic algorithm for binary image reconstruction will be presented too. This new algorithm applies the singular value decomposition and the Moore-Penrose inverse of a rank modified matrix. Numerical experiments demonstrate the efficiency of our algorithm. This is a joint work with Dr. Jiehu Zhu at Georgia southern University, Prof. Yangbo Ye at University of Iowa, and Prof. Ge Wang at Virginia Tech.

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**Title:** Lighthill acoustic analogy and its computational implementation

**Speaker:** Alex Lozovskiy, University of Pittsburgh

**Abstract:** The prediction of the noise generated by turbulence has been of great importance in acoustics. In 1951 James Lighthill introduced the analogy for describing the acoustic wave propagation caused by turbulent flows. In this talk, the model problem using Lighthill analogy will be presented with the Finite Element Method scheme for this problem. Error estimates will be given.

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**Title:** Defect correction with Tikhonov

**Speaker:** Nathaniel Mays

**Abstract:** We will take a look at using the Defect Correction Method applied to Tikhonov regularization to come up with an iterated Tikhonov method. This will allow us to choose the Tikhonov parameter for stability and then iterate for accuracy. We'll also look at an academic example as a proof of concept.

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**Title:** Numerical solution of nonlinear eigenvalue problems arising in acoustic field computations

**Speaker:** Volker Mehrmann, Technische Universität Berlin

**Abstract:** We present numerical methods for the solution of large scale linear systems and structured nonlinear eigenvalue problems arising in the context of acoustic field computations in car interiors.

These problems are very ill-conditioned and badly scaled as well. We discuss different numerical solution techniques and their advantages and disadvantages.

We show some real world applications form the project with our industrial partner and present numerical examples.

This is partially joint work with T. Brüll, E. Teidelt, K. Schreiber and C. Schröder.

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**Title:** Localized linear polynomial operators and quadrature formulas on the sphere

**Speaker:** Hrushikesh N. Mhaskar, California State University

**Abstract:** We describe numerical algorithms for construction of quadrature formulas on a Euclidean sphere, exact for spherical polynomials of a high degree. Our formulas are based on scattered sites; i.e., in contrast to such well known formulas as Driscoll-Healy formulas, we need not choose the location of the sites in any particular manner. While the previous attempts to construct such formulas have yielded formulas exact for spherical polynomials of degree at most 18, we are able to construct formulas exact for spherical polynomials of degree 178. The second goal of the paper is to demonstrate the use of these formulas in constructing localized, linear, quasi-interpolatory polynomial operators based on scattered sites. The approximation and localization properties of our operators are studied theoretically in deterministic as well as probabilistic settings. Numerical experiments are presented to demonstrate their superiority over traditional least squares and discrete Fourier projection polynomial approximations. This is joint work with Q. T. Le Gia, University of New South Wales, Sydney, Australia.

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**Title:** Zeros of sections of the binomial expansion
**Speaker:** Timothy S. Norfolk, The University of Akron
**Abstract:** For integers $0 \leq r \leq n$, we consider the sections of the binomial expansion of $(1+z)^n$ truncated at $z^r$, namely

$$P_{n,r}(z) = \sum_{k=0}^{r} \binom{n}{k} z^k \ ,$$

and examine the asymptotic distribution of the zeros.

The problem has analytical solutions for $r = 0, 1, n-1, n$, and generates elegant limit curves for sequences $\dfrac{r}{n} \to \sigma$, $0 \leq \sigma \leq 1$.

Given the classical limit $\lim_{n\to\infty} \left(1 + \frac{z}{n}\right)^n = e^z$, uniformly on compacta, it is not surprising that the results are reminiscent of the work of Szegő and later Saff and Varga, on the exponential function.

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**Title:** Lipschitz stability of Jordan-Weirstrass bases
**Speaker:** Vadim Olshevsky, University of Connecticut
**Abstract:** We study Jordan-structure-preserving perturbations of matrices selfadjoint in the indefinite inner product. The main result is Lipschitz stability of the corresponding so-called similitude matrices. The result can be reformulated as Lipschitz stability, under small perturbations, of canonical Jordan bases (i.e., eigenvectors and generalized eigenvectors enjoying a certain flipped orthonormality relation) of matrices selfadjoint in the indefinite inner product.

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**Title:** On disk-like sets and square coverings in the plane - a geometric problem
**Speaker:** Gerhard Opfer, Universität Hamburg
**Abstract:** Convex sets in the complex field $C$ will be separated into two classes, disk-like sets and non disk-like sets. The disk-like sets have a connection to Approximation Theory. The class of disk-like sets contains the unit norm disks with respect to the $\| \cdot \|_p$–norms and certain regular polygons. The disk-like sets reveal a remarkable property. If one covers them in a certain fashion with squares - apart from a similarity transformation - they will be reproduced.

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**Title:** Iterative methods for inverse problems in computational array imaging
**Speaker:** Bob Plemmons, Wake Forest University
**Abstract:** Iterative methods for solving inverse problems associated with super-resolution computations in image processing are described. Our main application is the development of a compact

array imaging system, dubbed PERIODIC, which is capable of exploiting diversities including subpixel displacement, phase, polarization, neutral density, and wavelength, to produce high definition images. The optical hardware system and mathematical software interface are described, and sample results for bioimaging and object identification applications are shown. This project is joint with researchers at several universities, including Catholic, Duke, Emory, New Mexico and Penn State.

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**Title:** Means of algebraic numbers in the unit disk
**Speaker:** Igor Pritsker, Oklahoma State University
**Abstract:** Issai Schur considered a class of polynomials $P_n(z) = a_n \prod_{k=1}^{n}(z - \alpha_k)$ with integer coefficients and simple zeros in the closed unit disk. He studied the limit behavior of the arithmetic means $s_n = \frac{1}{n}\sum_{k=1}^{n} \alpha_k$ as $n \to \infty$, under the assumption that the leading coefficients $a_n$ are bounded. In particular, Schur proved that $\limsup_{n\to\infty} |s_n| \le 0.1757$. We show that $\lim_{n\to\infty} s_n = 0$ as a consequence of the asymptotic equidistribution of $\{\alpha_k\}_{k=1}^{n}$ near the unit circle. Furthermore, we estimate the rate of convergence of $s_n$ to 0.

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**Title:** An inequality for rational functions
**Speaker:** Q. I. Rahman, The Université de Montréal
**Abstract:** If $f$ is a polynomial of degree at most $n$ such that $|f(z)| \le 1$ on the unit circle, then $|f'(z)| \le n\,|z|^{n-1}$ outside the unit disk. We propose to discuss some extensions of this result to rational functions having all their poles in the open unit disk. We also intend to mention a generalization to meromorphic functions having all their poles in the lower half-plane.

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**Title:** Cascadic multilevel methods for image denoising and deblurring
**Speaker:** Fiorella Sgallari, University of Bologna
**Abstract:** Multilevel methods are popular for the solution of well-posed problems, such as certain boundary value problems for partial differential equations and Fredholm integral equations of the second kind. However, little is known about the behavior of multilevel methods when applied to the solution of linear ill-posed problems, such as Fredholm integral equations of the first kind, with a right-hand side that is contaminated by error. Cascadic multilevel methods are particularly efficient schemes based on truncated iteration that blend linear algebra and Partial Differential Equations techniques. We discuss their properties and the applications to image deblurring and denoising that are large-scale problems, because of the typically large number of pixels that make up an image.

Joint work with Serena Morigi, Lothar Reichel, Andriy Shyshkov.

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**Title:** Multivariate interpolation and commuting matrices

**Speaker:** Boris Shekhtman, University of South Florida

**Abstract:** Every Hermite interpolation projector (or more generally, ideal projector) $P$ onto a subspace $G \subset C(\mathbb{C}^d)$ generates a cyclic family of pairwise commuting operators: $M_j g := P(x_j g)$. Conversely, every cyclic family of pairwise commuting operators on $G$ defines $P$. In the talk I will relate various properties of matrices $M_j$,such as diagonalazability, non derogatory properties etc., to the properties of projector $P$. In particular I will emphasize the distinction between interpolation in two, three and four variables.

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**Title:** Numerical methods for structured quadratic inverse eigenvalue problem

**Speaker:** Vadim Sokolov, Northern Illinois University

**Abstract:** We consider a formulation and analysis of several numerical methods for solving inverse eigenvalue problems for quadratic matrix polynomials with structure coefficient matrices. Two of the considered methods have global convergence property. Another method is locally quadratically convergent. We give a general convergence analysis for the case of distinct eigenvalues. The results are illustrated by numerical experiments.

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**Title:** Polynomial-like function and derivative approximation of Sinc data

**Speaker:** Frank Stenger, University of Utah

**Abstract:** Sinc methods consist of a family of one dimensional approximation procedures for approximating nearly every operation of calculus. These approximation procedures are obtainable via operations on Sinc interpolation formulas. Nearly all of these approximations – except that of differentiation – yield exceptional accuracy. The exception: when differentiating a Sinc interpolation formula that gives an approximation over an interval with a finite end point. In such cases, we obtain poor accuracy in the neighborhood of the finite end point. In this paper we derive novel polynomial–like procedures for differentiating a function that is known at Sinc points, to obtain an approximation of the derivative of the function that is uniformly accurate on the whole interval, finite or infinite, in the case when the function itself has a derivative on the closed interval.

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**Title:** An optimal block iterative method and preconditioner for banded matrices

**Speaker:** Daniel B. Szyld, Temple University

**Abstract:** We present an algebraic optimizable Schwarz method for banded matrices. It can be interpreted as a modification of the block Jacobi iterative method for the solution of linear systems of equations whose coefficient matrix is banded. By changing selected entries of the matrix we produce an iterative method which is guaranteed to converge in two iterations. Similarly, the modified block diagonal matrix can be used as a preconditioner for a Krylov subspace iterative method such as GMRES. With this preconditioner, the iterative method is also guaranteed to converge in two iterations. (joint work with Martin Gander, University of Geneva)

**Title:** Asymptotics and complex singularities of the Lorenz attractor
**Speaker:** D. Viswanath, the University of Michigan
**Abstract:** The Lorenz attractor is a well-known chaotic set composed of periodic orbits. We begin with very accurate ($>$ 500 digits) computations of some of these periodic orbits and use those computations to determine the asymptotics of the Fourier coefficients as well as the locations and some terms in the form of the complex singularities. The complex singularities have a remarkably simple form, which we deduce completely by means of a formal computation. Both computation and analysis support the view that the mathematical analysis of the Lorenz attractor is a problem in analytic function theory. (Joint work with S. Sahutoglu).

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**Title:** On an unsymmetric eigenvalue problem governing free vibrations of fluid-solid structures
**Speaker:** Heinrich Voss, amburg University of Technology, Institute of Numerical Simulation
**Abstract:** In this talk we consider an unsymmetric eigenvalue problem

$$\begin{pmatrix} K_s & C \\ 0 & K_f \end{pmatrix} \begin{pmatrix} x_s \\ x_f \end{pmatrix} = \lambda \begin{pmatrix} M_s & 0 \\ -C^T & M_f \end{pmatrix} \begin{pmatrix} x_s \\ x_f \end{pmatrix} \tag{0.1}$$

which governs free vibrations of a fluid–solid structure. Here $K_s \in \mathbb{R}^{s\times s}$ and $K_f \in \mathbb{R}^{f\times f}$ are the stiffness matrices, and $M_s \in \mathbb{R}^{s\times s}$ and $M_f \in \mathbb{R}^{f\times f}$ are the mass matrices of the structure and the fluid, respectively, and $C \in \mathbb{R}^{s\times f}$ describes the coupling of structure and fluid. $x_s$ is the structure displacement vector, and $x_f$ the fluid pressure vector.

We introduce a Rayleigh functional $p$ of (0.1) which has similar properties as the Rayleigh quotient of a Hermitian matrix. Right-eigenvectors of (0.1) are stationary points of the Rayleigh functional, and the eigenvalues can be characterized as min-max-values of $p$, the one-sided Rayleigh functional iteration converges cubically, and a Jacobi–Davidson type method improves its local and global convergence properties.

This is joint work with Markus Stammberger

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**Title:** Eigenvalue inclusion regions from inverses of shifted matrices
**Speaker:** Paul Zachlin, Lakeland Community College
**Abstract:** We consider eigenvalue inclusion regions based on the field of values of the inverse of a shifted matrix. A family of these inclusion regions is derived by varying the shift. We study several properties, one of which is that the intersection of a family is exactly the spectrum. We also obtain results by using eigenvalue inclusion regions other than the field of values, such as Gershgorin regions, Brauer regions, and pseudospectra.

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