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## About *IMAGE*

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## FEATURE INTERVIEW

### “Spectral graph theory was somewhere within my soul”

Nair Abreu Interviewed by Vilmar Trevisan<sup>1</sup>

**V.T. - Tell us about your growing up and how you got interested in mathematics.**

**N.A. -** I remember a very sweet, puerile story. My father was a pharmacist and owner of a little drugstore in São Fidélis, a small town in the countryside of the state of Rio de Janeiro, where I was born. I can't remember how old I was but I was so short my head could barely reach the store's counter. I was standing there when a salesman – more of a lab representative – was talking to my dad. I don't know if he wanted to tease me or to please my dad, but he asked, “What do you want to do when you grow up?” To which I replied, “I don't know but it will be something to do with mathematics.”

**V.T. - What was your scientific interest in the beginning of your career?**

**N.A. -** Back in São Fidélis, there was no science course that could prepare me to get into a good university, so when I was 19, I graduated as an elementary school teacher and got a job as a public elementary teacher in the town of Niterói, in order to apply for college there. In 1970, when I was 20, I enrolled in the mathematics undergraduate course at UFF (Universidade Federal Fluminense). I taught during the day to pay my bills and went to college at night. Two years later, I was accepted as a teaching assistant and started assisting algebra professors at UFF.



*Nair Abreu*

As soon as I graduated as a mathematics teacher, I started a master's degree program at IME (Military Engineering Institute). Right after obtaining my master's, I was hired as a teacher there. Thanks to this new job, I had a salary increase which allowed me to drop the work as a school teacher and focus on advanced studies. In 1976, at IME, I started teaching linear algebra to the students of several engineering courses.

During my master's, I was advised by Professor Luiz Oswaldo Teixeira da Silva, at the time one of Rio's greatest specialists in number theory and non-Euclidean geometry. Together, we discovered Harary's book and started our studies in graph theory. My master's thesis was about graphs and continued fractions.

I then started my Ph.D. at COPPE, Universidade Federal do Rio de Janeiro (UFRJ), with an emphasis on graph theory and combinatorial optimization, but kept on teaching at IME. While a student at COPPE, my Graph Theory professor, Paulo O. Boaventura, knowing about my interest in algebra and linear algebra, suggested I read a chapter of Norman Biggs' *Algebraic Graph Theory*, which is about graphs and eigenvalues, so that I could give a seminar on the subject. I loved it. I thought about

developing that in my thesis, but there was nobody who could advise me at that time. So I kept the reference for the future and spent four years working on combinatorial optimization, wrote my Ph.D. dissertation on the Quadratic Allocation Problem, got married, had a daughter, left IME, and went back to UFF, now as an associate professor. I finally had a more flexible schedule which allowed me to be both a teacher and a mother. Nevertheless, serious scientific research was still a dream yet to come true and spectral graph theory was somewhere within my soul.

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**V.T. - In more recent years, your main academic contributions have been in the area of spectral graph theory. When and how did you shift your academic interest to this area of linear algebra?**

**N.A. -** In 1994, I was invited by Roberto Diegues Galvão, a former professor of mine at COPPE, to apply for a CNPq research grant and work as a collaborator in the Production Engineering Graduate Program at COPPE, UFRJ, where I still work to this day. At that time, I met a Ph.D. candidate called Patrícia Erthal de Moraes, who had a teaching degree in mathematics. I suggested we study Biggs' book together, and advised her dissertation on the 5<sup>th</sup> and 6<sup>th</sup> coefficients of the characteristic polynomial of a graph.

Later on, I advised Carla Oliveira on subjects related to spectral graph theory. In 2002, Carla and I attended an event in Scotland where we presented work based on her Ph.D. work. That was where we met Professors Dragoš Cvetković, Peter Rowlinson, and Pierre Hansen. All of them were invited to Rio de Janeiro in order to help us create a research group. On that same occasion, I ran into the book by Godsil and Royle, and soon we also invited Godsil to come help us establish a research group in the field. And then other well-known researchers came to Rio, such as Oscar Rojo from Chile and Domingos Cardoso from Portugal. In order to get ready for visits from such renowned researchers, we found more students, such as Leonardo Lima and Maria Aguiéiras, and invited Renata del Vecchio and Cybele Vinagre from UFF to join us. In turn, they introduced us to Vilmar Trevisan, a professor with expertise in matrices and symbolic computation. Note that Vilmar Trevisan is currently one of the main researchers in spectral graph theory in Brazil and Latin America. He has created a strong spectral graph theory group at Rio Grande do Sul, in the south of Brazil.

In Portugal, at another event we attended with a group of about eight young Brazilian researchers, we met Professor Steve Kirkland in person and immediately invited him to visit us. In 2008, with the help of Claudia Justel, another researcher we brought to our group, we held an event at IME called SGT in Rio, where we had the crème de la crème of spectral graph theory: Richard Brualdi, Vlado Nikiforov, Sebastian Cioabă, Ivan Gutman, Steve Kirkland, Bojan Mohar, Peter Rowlinson, Dragoš Cvetković, Dragan Stevanović, Domingos Cardoso and Miroslav Fiedler, just to mention a few names. Speaking of the latter, Fiedler found out about the meeting by himself and managed to come to our Brazilian shores to meet us. That was the moment when spectral graph theory research definitely and permanently set foot in Brazil.

**V.T. - You are responsible for creating and leading an active research group in Rio de Janeiro and have influenced the growth of linear algebra research in Brazil. How do you perceive these achievements?**

**N.A. -** Once, Professor Dragoš Cvetković told me I was a missionary of spectral graph theory in Brazil. Such a remark brought my attention to the role I was performing which I had not realized until then. In fact, I am more of an encourager of scientific research rather than a proper researcher myself. The fact is that this realization has brought me comfort: I have a role and have to perform it well. Forming research efforts in this huge country which is in great need of education makes me proud.

**V.T. - In the recent past, the gender imbalance in science, and particularly in mathematics, has been given attention. Tell us any story you may have experienced about difficulties, harassment or prejudice as a woman in science.**

**N.A. -** That's a very good question, as it gives me an opportunity to tell this story. My daughter studied at Colégio Santo Agostinho, a very traditional school in Rio. When she was in the 7<sup>th</sup> grade, I attended a parent-teacher meeting where the coordinator, in his speech, made an announcement: "The male students with the best performance in math will, if they so wish, receive extra math tutoring after school." I then asked, "What about the girls? Why can't they join them?" The coordinator then replied, "The girls will visit hospitals and day care centers." The other moms seemed to find it normal but I was horrified. I set up an appointment with the school headmaster to inquire about it. I learned that there was a project called Atlantis in which those selected male students would get to be supervised by undergraduate students from the Scientific Initiation Program of PUC-RJ (Catholic University of Rio). It just so happens that this scientific program is funded by CNPq, a government funding institution. So if the purpose of the program was to give opportunity to future researchers, why should there be opportunities only for boys? At that time, I remember that IMPA, the greatest institute of mathematics in Latin America, also located in Rio, had only one female researcher, if I'm not mistaken, in the area of statistics.

**V.T. - Do you think working in a developing country like Brazil has advantages or disadvantages for a woman in science? What is your advice for increasing the gender diversity in mathematics?**

**N.A. -** I think the work of inserting women in mathematics is being done step by step. Women will be the majority in mathematics as well as in all areas of science – simply because they are imposing themselves and also because the number of independent women has grown relatively fast. In my group, TEG-Rio, for instance, we are mostly women. I believe male-only groups, like the Atlantis project (almost like masonries) will have to steadily and democratically open their doors. The problem is that, at the present time, the world seems to wish to bring the 21<sup>st</sup> century back to the 15<sup>th</sup>. It is easy to identify many archaic and medieval practices from leaders from all over the world.

**V.T. - In your opinion, which topics of linear algebra do you like the most? What areas of linear algebra do you think are going to receive attention in the near future? In this respect, what advice would you give to young mathematicians interested in linear algebra?**

**N.A. -** In Brazil, it is unfortunate to see linear algebra treated mainly as a basic subject for engineering courses. There is no relevant research group in the area. IMPA has shown to be particularly strong in several areas of mathematics and has performance of international standing in dynamical systems, but it has so far never formed a strong research group in linear algebra. It is now hiring researchers in graph theory, number theory and discrete and computational mathematics, but still no linear algebra research is visible. All of this is to say that matrix theory, which is a beautiful area, is not seriously studied here in Brazil. I notice that spectral graph theory, which I perceive as a topic that is both ludic and intuitive, is attracting many young students to linear algebra. At the latest ILAS events, the sessions and mini-symposia on graph spectra have been very popular. The possibility of modeling real and computational problems with the use of graphs, and consequently matrices, has been attracting many young researchers to these areas.

**V.T. - Brazilian mathematics has experienced a tremendous transformation in the past 50 years. In particular, it was promoted to the status of a Group 5 nation by the IMU (International Mathematical Union) in 2018. How do you see these changes in the way science is made and communicated in Brazil over the last decades?**

**N.A. -** In some ways, I have made one or two critical remarks about IMPA in my previous answers. Now I am going to make an absolutely positive one: IMPA is responsible for the transformation of mathematics in Brazil. It has excellent mathematicians among its researchers, has graduated excellent mathematicians, and has developed serious mathematics in our country. The danger we live at this political moment is that “suddenly, no more than suddenly, laughter becomes weeping,” which is a free translation of an excerpt from a lovely poem by one of Brazil’s greatest writers, Vinicius de Moraes. And why do I recite such verses? Because I fear the current Brazilian government. It has openly attacked science, culture and education. I believe IMPA and the scientific societies are concerned and are making efforts to defend these fields.

**V.T. - If you could have a conversation with a mathematician (alive or not), whom would you choose? And what you would like to talk about?**

**N.A. -** I would like to thank Miroslav Fiedler for introducing us to the vector which now carries his name (which he did not enjoy, by the way), the Fiedler Vector. This vector, associated to its eigenvalue (the algebraic connectivity) led us to a huge network which binds us virtually and makes us more connected than before. I would also like to tell Richard Brualdi that he is the true traveling salesperson of linear algebra around the world.

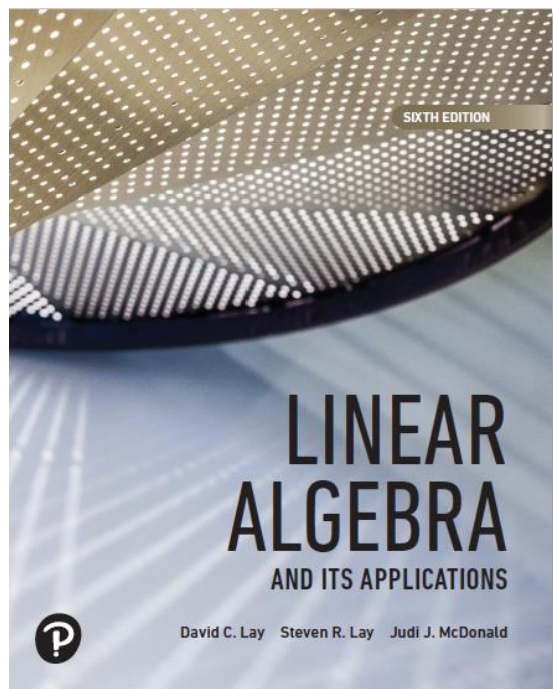
**V.T. - This year, from September 23–25<sup>th</sup>, there will be a workshop celebrating your 70<sup>th</sup> birthday.<sup>2</sup> What, in your own point of view, is the most important contribution of your career so far?**

**N.A. -** Plagiarizing Martin Luther King’s “I have a dream,” I would like to transform kids – boys and girls! – from public schools and favelas (slums of Rio) into good students, attracting them by playing games using matrices and graphs.

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<sup>2</sup>Editor’s note: This meeting, the Workshop on Spectral Graph Theory at Niterói, Rio de Janeiro, has since been postponed due to the COVID-19 global health emergency.

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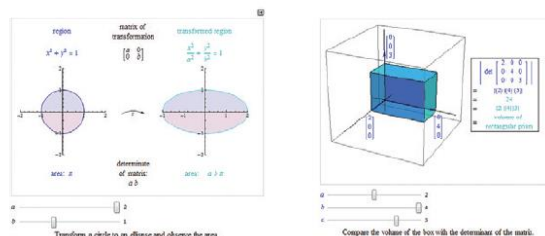
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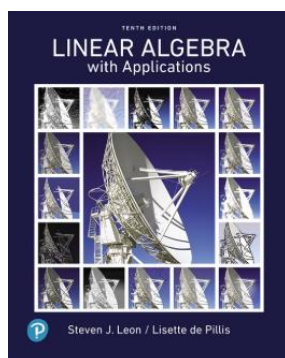
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## LINEAR ALGEBRA EDUCATION

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### Your observations about teaching online?

These past several weeks have been unusual, to say the least. Most of us have had to make the abrupt transition to teaching our classes online. This experience has likely been tumultuous, and yet perhaps an educational and revealing experience for many of us.

For this fall's issue of *IMAGE*, we will have a special section devoted to observations from anyone of you our readers who would like to reflect on how this experience has affected your teaching, perhaps permanently.

Your thoughts might address (1) what you have found most difficult or detrimental about teaching online; (2) techniques and strategies you found particularly effective; (3) any benefits to teaching online that surprised you; and (4) anything you learned from teaching online that might change the way you teach even when we are able to return to teaching in person in the classroom.

Please submit your thoughts to [David.Strong@pepperdine.edu](mailto:David.Strong@pepperdine.edu) by October 15th, 2020. The e-mail itself suffices: no need to send a Word or L<sup>A</sup>T<sub>E</sub>X document.

David Strong  
*IMAGE* Education Editor  
 Chair, ILAS Education Committee

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### Send News for *IMAGE* Issue 65

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*IMAGE* seeks to publish all news of interest to the linear algebra community. Issue 65 of *IMAGE* is due to appear online on December 1, 2020. Send your news for this issue to the appropriate editor by October 15, 2020. Photos are always welcome, as well as suggestions for improving the newsletter. Please send contributions directly to the appropriate editor:

- feature articles to Sebastian Cioabă ([cioaba@udel.edu](mailto:cioaba@udel.edu))
- interviews of senior linear algebraists to Carlos Fonseca ([cmdafonseca@hotmail.com](mailto:cmdafonseca@hotmail.com))
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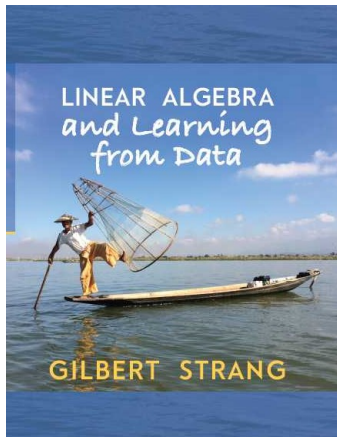
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## BOOK REVIEW

### *Linear Algebra and Learning from Data* by Gilbert Strang

Wellesley-Cambridge Press, 2019, ISBN 978-0-692-19638-0, xiv+432 pages.

Reviewed by Keivan Hassani Monfared, Data Scientist, Ingrooves Music Group, k1monfared@gmail.com



I start by saying that this book is suitable for the following broad groups of readers:

1. mathematicians, scientists, and engineers who have a good understanding of linear algebra, maybe even are experts, and want to learn how their expertise can be used in data science and machine learning, or want to understand the shortcomings of current mathematical methods on the frontiers of data science and design research projects to push those boundaries;
2. practitioners of data science who need to give structure to their mathematical understanding or want to add more advanced tools to their mathematical toolset; and
3. instructors/students who are tired of only saying/hearing that linear algebra has applications without ever getting into those applications.

This book is *not* aimed at readers who wish to learn or examine various packages, libraries, and programming languages, or to get experience with hands-on data science projects. Nor is it aimed at first- or even second-course linear algebra students. However, the topics can be used to motivate material in those courses.

The main objective of the book is to fill part of the gap between mathematical ideas on the one hand and data science problems on the other. The preface of the book mentions three main reasons the book was written: “to organize central methods and ideas of data science,” “to see how the language of linear algebra gives expression to those ideas,” and “to show how to explain and teach those ideas.” The book goes through classical and modern topics in (theoretical and numerical) linear algebra and in real time connects them to how they are currently used in solving real problems involving neural networks, etc. It does not start with a classical introduction to linear algebra, with made-up examples to provide applications. It also does not start with a clean and structured data set and a machine learning problem and then give mathematical tools that solve it in a magical way.

As expected from Gilbert Strang, the book’s approach to a topic in the early chapters usually starts with general intuition about abstract topics using examples, then provides the theory itself in a concise manner, ideas of the proof, and, often, very hands-on practical examples to cement the key points. In order to really make the connection between the abstract theory and its real applications, the book does not shy away from generalizing (for example to tensors whenever possible) or from discussion of special edge cases that need separate treatment. In fact, the main topics of some of the later chapters are these very edge cases that have led to the development of more theory or numerical methods in linear algebra. One of the many strengths of the book is showing vividly why certain abstract topics matter for applications. For example, it concisely explains why computations with orthogonal matrices will not overflow, and it also dedicates many sections of the book to solving particular applications.

The book has a conversational tone, something those who are familiar with Gilbert Strang’s lectures will quickly identify. Even before the preface, the reader is very briefly introduced to the idea of deep learning and neural nets and how linear algebra enters the picture. This sets the tone for the rest of the book. In the preface, it is made clear that the reader is assumed to have a good understanding of undergraduate linear algebra and calculus. In fact, despite the friendly titles of the sections of Part I, such as “Multiplication  $Ax$  Using columns of  $A$ ”, “Elimination and  $A = LU$ ,” etc., the book does not attempt to teach any basic linear algebra topics. Rather, Part I of the book mostly serves as a quick review of the main topics in a first course on linear algebra, as well as some topics from a second course, such as Rayleigh quotients, tensors, and the SVD. It is very effective at briefly motivating various basic topics and connecting them to their applications in data science, and at unifying the language and nomenclature used in the rest of the book. At the

same time, for readers who are less comfortable with these topics, it inspires enough curiosity for them to explore these on their own.

Part II goes into computation with large matrices, which is often required in data science, and brings out the tools from numerical linear algebra. A student in a first-year linear algebra course usually feels that linear algebra is a series of abstract theorems and tools that are presented solely out of curiosity and for the sake of their beauty (some appreciate this and others hate it). Part II should be enough to convince a reader that in fact this is not the case, and the examples here can be used to motivate various topics in those courses. For example, one notable section is an introduction to randomized methods.

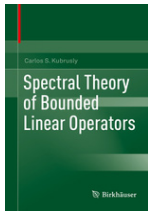
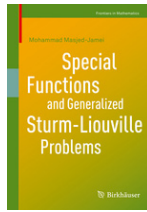
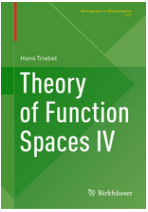
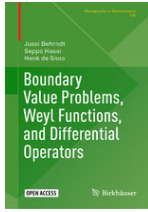
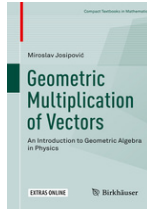
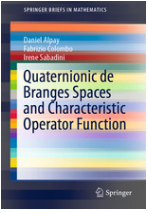
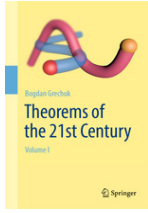
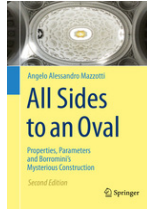
Rather than reproducing the table of contents here, I encourage you to check out the website (<http://math.mit.edu/~gs/learningfromdata>) for the book, which includes the table of contents and also several other useful resources, including multiple solution sets for some of the exercises. It is important to mention that, as with any other textbook by Gilbert Strang, plenty of topics are introduced and discussed within those exercises. Furthermore, despite the book being titled “Linear Algebra and Learning from Data,” you can find chapters on statistics and optimization, as well as sections on game theory and graphs in the book. In fact, some graph clustering methods are discussed in depth. Finally, in the last part of the book, a deep neural network is built and the weights are optimized; the ideas of backpropagation, underfitting, and overfitting are discussed; convolution, ResNet, and wavelets are added to the picture; and even hyperparameter tuning is briefly introduced. If you are more of a data scientist, you could even start from this chapter of the book and then work your way backwards to the earlier chapters as you see fit.

One of the most exciting aspects of the book is its references to numerous books and websites, including blog posts by various people, from students of the course to Terry Tao, news articles, arXiv links, and even recent research publications on the topics being discussed. However, I could not find a list of all of these compiled anywhere.

Overall, the book is written with a great style, it is very dense in information, and it makes all the connections needed between the discussed topics in linear algebra and their applications in data science.

## New Books



|                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>A Course on Topological Vector Spaces</b><br/>(2020)<br/>Jürgen Voigt<br/>ISBN 978-3-030-32944-0</p>                                                    |  <p><b>Spectral Theory of Bounded Linear Operators</b><br/>(2020)<br/>Carlos S. Kubrusly<br/>ISBN 978-3-030-33148-1</p>                                       |  <p><b>Special Functions and Generalized Sturm-Liouville Problems</b><br/>(2020)<br/>Mohammad Masjed-Jamei<br/>ISBN 978-3-030-32819-1</p> |
|  <p><b>Theory of Function Spaces IV</b><br/>(2020)<br/>Hans Triebel<br/>ISBN 978-3-030-35890-7</p>                                                             |  <p><b>Boundary Value Problems, Weyl Functions, and Differential Operators</b><br/>(2020)<br/>J. Behrndt, S. Hassi, H. de Snoo<br/>ISBN 978-3-030-36713-8</p> |  <p><b>Geometric Multiplication of Vectors</b><br/>(2019)<br/>Miroslav Josipović<br/>ISBN 978-3-030-01755-2</p>                           |
|  <p><b>Quaternionic de Branges Spaces and Characteristic Operator Function</b><br/>(2020)<br/>D. Alpay, F. Colombo, I. Sabadini<br/>ISBN 978-3-030-38311-4</p> |  <p><b>Theorems of the 21st Century</b><br/>(2019)<br/>Bogdan Grechuk<br/>ISBN 978-3-030-19095-8</p>                                                          |  <p><b>All Sides to an Oval</b><br/>Second Edition<br/>(2019)<br/>Angelo A. Mazzotti<br/>ISBN 978-3-030-28809-9</p>                       |

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# Linear Algebra: Core Topics for the First Course

By

*Dragu Atanasiu*

*(University of Borås, Sweden)*

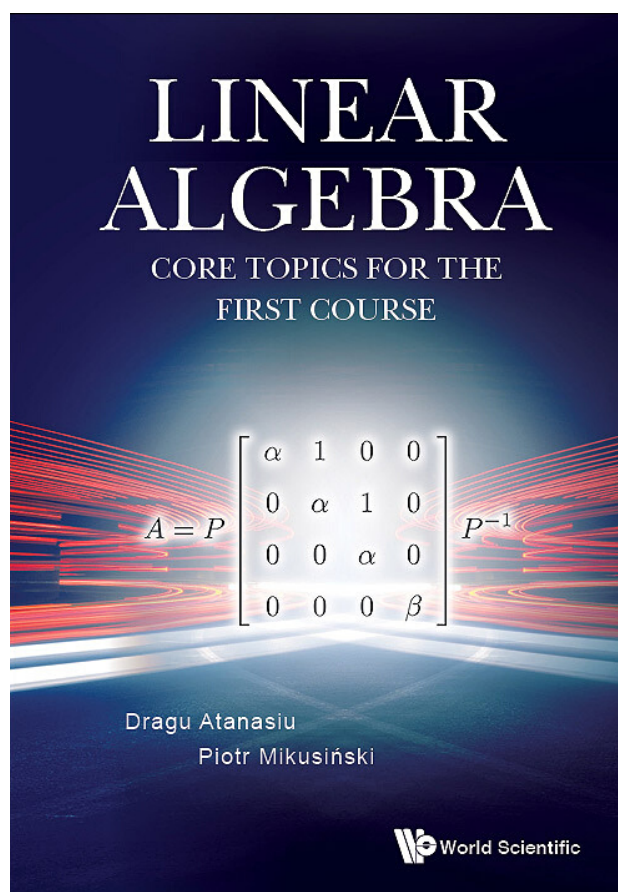
*Piotr Mikusiński*

*(University of Central Florida, USA)*

More details at

<https://doi.org/10.1142/11685>

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The book is an introduction to linear algebra intended as a textbook for the first course in linear algebra. In the first six chapters we present the core topics: matrices, the vector space  $\mathbb{R}^n$ , orthogonality in  $\mathbb{R}^n$ , determinants, eigenvalues and eigenvectors, and linear transformations. The book gives students an opportunity to better understand linear algebra in the next three chapters: Jordan forms by examples, singular value decomposition, and quadratic forms and positive definite matrices.

In the first nine chapters everything is formulated in terms of  $\mathbb{R}^n$ . This makes the ideas of linear algebra easier to understand. The general vector spaces are introduced in Chapter 10. The last chapter presents problems solved with a computer algebra system. At the end of the book we have results or solutions for odd numbered exercises.

Readership: Undergraduate students taking a first course in linear algebra.

450pp | May 2020 | 978-981-121-596-4(pbk) | US\$68    £60

**Request for an inspection copy:**

Visit <http://bit.ly/ws-inspectioncopy> or email [sales@wspc.com.sg](mailto:sales@wspc.com.sg)

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## JOURNAL ANNOUNCEMENTS

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### *ELA*, the Research Journal of ILAS

#### Contributed announcement from Daniel Szyld, ILAS President

ILAS is without a doubt the premier society focused on all aspects of linear algebra. Our research journal, the *Electronic Journal of Linear Algebra (ELA)*, can become the premier journal publishing work on all aspects of linear algebra, a journal presenting the best science that ILAS members and others produce. Such a renowned journal would also contribute to the prestige of our society.

Let me also remind you that *ELA* is a top-tier open-access journal, making it free to publish, and free to read and download papers. This puts us in a unique position these days when governments are starting to insist that the researchers they fund publish only in open-access journals. Therefore, I would like to strongly encourage you to submit your high quality papers to *ELA*.

As you know, Froilán Dopico joined Michael Tsatsomeros as co-Editor-in-Chief on August 1st, 2019. The EICs have recently appointed several new Associate Editors, namely Francesco Belardo, Steve Butler, Heike Fassbender, Fuad Kittaneh, Ren-Cang Li, Valeria Simoncini, and K.C. Sivakumar. In addition, several editors became Advisory Editors: Dario Bini, Sebastian Cioabă, Leslie Hogben, Raphael Loewy, and Bryan Shader. You can find the complete editorial board at <https://journals.uwyo.edu/index.php/ela/about/editorialTeam>.

---

### New URL and management system for the *Electronic Journal of Linear Algebra (ELA)*

#### Contributed announcement from Bryan Shader

As of January 10, 2020, the *Electronic Journal of Linear Algebra (ELA)* has moved to a new location and a new management system.

Previously, *ELA* had been hosted by BePress through an arrangement with the University of Wyoming. BePress was a nonprofit based out of UC Berkeley and one of the first champions of open journals. Recently, BePress was acquired by Elsevier. The University of Wyoming was faced with a decision on whether or not to stay with BePress but under a new financial arrangement. They elected to join a consortium of universities in the Rocky Mountains and select Open Journal Systems (OJS) as the platform for online journals. OJS is part of the Public Knowledge Project (<https://pkp.sfu.ca/ojs>) which is “an initiative developing (free) open source software and conducting research to improve the quality and reach of scholarly publishing.” PKP was started in 1998 at the University of British Columbia. Over 10,000 journals use the OJS system.

The new website for *ELA* is located at <https://journals.uwyo.edu/index.php/ela>. Please take a look at it. If you see anything that needs to be changed, please email [elamath@uwyo.edu](mailto:elamath@uwyo.edu) with the subject “ELA website suggestion.”

For more information about how to access reviews and resubmit edits on the new platform, please follow this link: <https://docs.pkp.sfu.ca/learning-ojs/en/authoring>. The move will necessitate some changes in how you interface with *ELA*:

- If you don't have a paper in the review process, the next time you submit a paper, you need to create an account on the management system. You will have the option of providing your ORCID; we strongly encourage this.
- All submissions and revisions will be done through the portal at <https://journals.uwyo.edu/index.php/ela>. Acknowledgments and updates on submissions will be sent from [noreply@journals.uwyo.edu](mailto:noreply@journals.uwyo.edu).
- You will be able to track the status of your papers by logging into the management system; referee reports and decision letters will be posted there. Whenever an action is taken on a paper, an e-mail will also be sent.
- After acceptance of a paper, you will be asked to provide source files of the paper. This, as well as the final approval of page proofs, will be done through the portal.

For more information about how to access reviews and resubmit on the new platform, please follow this link:

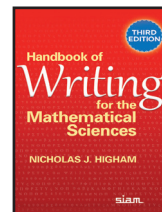
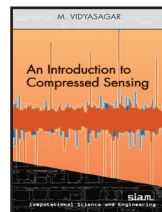
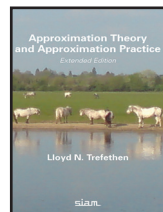
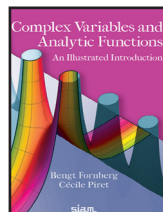
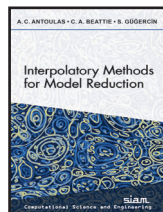
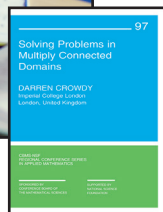
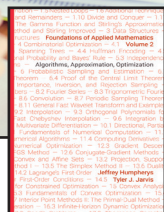
<https://docs.pkp.sfu.ca/learning-ojs/en/authoring>

If you have any questions about the new platform or your account, please contact:

Froilán Dopico ([dopico@math.uc3m.es](mailto:dopico@math.uc3m.es))  
 Michael Tsatsomeros ([tsat@wsu.edu](mailto:tsat@wsu.edu))  
 Bryan Shader ([elamath@uwyo.edu](mailto:elamath@uwyo.edu))



# SIAM Books



## Foundations of Applied Mathematics Volume 2: Algorithms, Approximation, Optimization

Jeffrey Humpherys and Tyler J. Jarvis

Geared toward advanced undergraduate and beginning graduate students in mathematics, data science, and machine learning, this textbook presents the foundations of algorithms, approximation, and optimization—essential topics in modern applied and computational mathematics. The authors provide a unified treatment of several topics that do not usually appear together, and when used in concert with the free supplemental lab materials, this book teaches not only the theory but also the computational practice of modern mathematical methods.

2020 • xviii + 788 pages • Hardcover • 978-1-611976-05-2  
List \$94.00 • SIAM Member \$65.80 • OT166

## Solving Problems in Multiply Connected Domains

Darren Crowdy

This one-of-a-kind book describes a novel mathematical framework for solving problems in two-dimensional, multiply connected regions. The framework is built on a central theoretical concept: the prime function, whose significance for the applied sciences, especially for solving problems in multiply connected domains, has been missed until recent work by the author. It is the first monograph to focus on solving applied problems in multiply connected domains.

April 2020 • xxii + 434 pages • Softcover • 978-1-611976-14-4  
List \$89.00 • SIAM Member \$62.30 • CB97

## Interpolatory Methods for Model Reduction

Athanasios C. Antoulas, Christopher Beattie, and Serkan Güğercin

Interpolatory methods are among the most widely used model reduction techniques, used to replace large systems of coupled differential and algebraic equations that constitute high fidelity system models with substantially fewer equations that are crafted to control the loss of fidelity that order reduction may induce in the system response. This textbook is the first comprehensive analysis of this approach available in a single, extensive resource. It introduces state-of-the-art methods and covers both classical projection frameworks for model reduction and data-driven, noninvasive frameworks.

2020 • xii + 232 pages • Softcover • 978-1-611976-07-6  
List \$79.00 • SIAM Member \$55.30 • CS21

## Complex Variables and Analytic Functions An Illustrated Introduction

Bengt Fornberg and Cécile Piret

This is the first primary introductory textbook on complex variables and analytic functions to make extensive use of functional illustrations. Aiming to reach undergraduate students entering the world of complex variables and analytic functions, the authors utilize graphics to visually build on familiar cases and illustrate how these same functions extend beyond the real axis. The book covers several important topics that are omitted in nearly all recent texts, including techniques for analytic continuation and discussions of elliptic functions and of Wiener-Hopf methods. It presents current advances in research, highlighting the subject's active and fascinating frontier.

2019 • x + 361 pages • Softcover • 978-1-611975-97-0  
List \$84.00 • SIAM Member \$58.80 • OT165

## Approximation Theory and Approximation Practice Extended Edition

Lloyd N. Trefethen

This is a textbook on classical polynomial and rational approximation theory for the twenty-first century. Aimed at advanced undergraduates and graduate students across all of applied mathematics, it uses MATLAB to teach the field's most important ideas and results. It differs fundamentally from other works on the topic in that its emphasis is on topics close to numerical algorithms; concepts are illustrated with Chebfun; and each chapter is a PUBLISHable MATLAB M-file, available online.

2019 • xii + 363 pages • Hardcover • 978-1-611975-93-2  
List \$64.00 • SIAM Member \$44.80 • OT164

## An Introduction to Compressed Sensing

M. Vidyasagar

Compressed sensing is a relatively recent area of research that has applications to signal/image processing and computer algorithms, and it draws from a variety of mathematical techniques such as graph theory, probability theory, linear algebra, and optimization. The author presents significant concepts never before discussed as well as new advances in the theory, providing an in-depth initiation to the field of compressed sensing. The text contains substantial material on graph theory and the design of binary measurement matrices, is the only book to thoroughly study the problem of matrix recovery, and supplies relevant results alongside their proofs in a compact and streamlined presentation that is easy to navigate.

2019 • xii + 341 pages • Softcover • 978-1-611976-11-3  
List \$89.00 • SIAM Member \$62.30 • CS22

## Handbook of Writing for the Mathematical Sciences Third Edition

Nicholas J. Higham

Handbook of Writing for the Mathematical Sciences provides advice on all aspects of scientific writing, with a particular focus on writing mathematics. Its readable style and handy format, coupled with an extensive bibliography and comprehensive index, make it useful for everyone from undergraduates to seasoned professionals. This third edition revises, updates, and expands the best-selling second edition to reflect modern writing and publishing practices and builds on the author's extensive experience in writing and speaking about mathematics.

2019 • xxii + 353 pages • Softcover • 978-1-611976-09-0  
List \$69.00 • SIAM Member \$48.30 • Student \$34.50 • OT167

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## ILAS NEWS

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### ILAS Election Results

Daniel Szyld has been elected to the position of President for a three-year term, beginning on March 1, 2020. Sebastian Cioabă and Dragana Cvetković-Ilić have been elected to three-year terms as members of the ILAS Board, beginning on March 1, 2020.

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#### Message from the Outgoing ILAS President

##### Contributed announcement from Peter Šemrl

It has been a great honour to serve our society. The best realisation I've had over these past six years was that there are so many members willing to dedicate their time and energy to ILAS. It is people like this that make the society successful. At the end of my term I would like to thank all of them for their hard work. It was a pleasure to be a part of this group of dedicated people.

Our discipline, linear algebra, is doing very well, at least in part due to the activities of ILAS. Now the society will have a new President, Daniel Szyld. I am confident that both linear algebra and our society will continue to flourish under his leadership.

---

#### Message from the New President of ILAS

##### Contributed announcement from Daniel Szyld

I want to thank the ILAS membership for the trust you have put in me to usher the Society through the next three years. I have very big shoes to fill, following the tenure of Peter Šemrl, and earlier Steve Kirkland, Danni Heshkowitz, Richard Brualdi, and Hans Schneider. The Society is in good health thanks to them and all the officers who work hard to promote and advance linear algebra.

Since March 1st (and even before then), I have been working with Peter Šemrl towards a smooth transition, and with the other members of the Executive Board (Hugo Woerdeman, Leslie Hogben, Steve Kirkland). I am setting up the appointed committees, and you will be able to read about their constitution in the forthcoming report of the President and the Vice-President.

Please do write to me, or to any of the officers, with ideas, issues, suggestions (or complaints). I want to continue to serve you, the members. Thank you again for this honor, and this opportunity.

---

### Outreach and Membership Committee / Membership Campaign

#### Contributed announcement from Daniel Szyld, ILAS President

David Watkins has been appointed ILAS Outreach Director. He is also chairing the Outreach and Membership Committee, with Minnie Catral, Andrii Dmytryshyn, and Federico Poloni as additional members.

Among the activities of this committee is to launch the "ILAS 2020 Membership Drive."

The goal is to encourage our colleagues who are not currently members of the Society (including many reading this message) to join. In this manner you would support the Society's activities: ILAS-net, *ELA* (the *Electronic Journal of Linear Algebra* – the research journal of ILAS), *IMAGE* (ILAS' newsletter), ILAS conferences, and linear algebra speakers at other venues – and, of course, the sense of belonging to our community.

If you are ready to do so (for \$40 a year; multi-year and lifetime memberships are also available), please go to the ILAS membership page: <https://www.ilasic.org/misc/membersselect.html>. Please also encourage others, including your students and postdocs, to join! Students can request a waiver of their membership fees.

If you have comments or suggestions for the committee, please write to [watkins@wsu.edu](mailto:watkins@wsu.edu).

## ILAS Conference Schedule for the Next Three Years (2021–2023)

### Contributed announcement from Daniel Szyld, ILAS President

The ILAS Board of Directors has approved the following ILAS Conferences:

- 23<sup>rd</sup> Conference of the International Linear Algebra Society (ILAS 2021) embedded in the SIAM Conference on Applied Linear Algebra, May 17–21, 2021, New Orleans, Louisiana, USA (<https://www.siam.org/conferences/cm/conference/la21>)

ILAS is sponsoring four plenary speakers:

- Paola Boito
- Lek-Heng Lim (Hans Schneider Prize Lecture)
- Bryan Shader (the *ELA* 25th Anniversary Lecture)
- Raf Vandebril (Olga Taussky-Todd Lecture)

Please consider submitting mini-symposia proposals and contributed talks (limit one talk per participant). Deadlines will be available in July 2020.

- 24<sup>th</sup> Conference of the International Linear Algebra Society (ILAS 2022) June 20–25, 2022, National University of Ireland, Galway, Ireland
- 25<sup>th</sup> Conference of the International Linear Algebra Society (ILAS 2023) June 5–9, 2023, Madrid, Spain

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## SIAM Conference on Applied Linear Algebra and the Embedded ILAS meeting

### Contributed announcement from Raf Vanderbril

Linear algebra is at the heart of many scientific, engineering, and industrial applications. Research and development in linear algebra include theoretical studies, algorithmic designs and implementations on advanced computer architectures, and applications to various disciplines. The SIAM Conferences on Applied Linear Algebra, organized by SIAM every three years, are the premier international conferences on applied linear algebra. Now, with the embedding of the ILAS conference, we also reach out to more theoretically-oriented linear algebraists. We aspire to a fruitful interaction between theory and application. We will bring together diverse researchers and practitioners from academia, research laboratories, and industries all over the world to present and discuss their latest work and results.

Here are some important deadlines.

- October 19, 2020: Minisymposium Proposal Submissions
- November 2, 2020: SIAM Student Travel and Early Career Travel Award
- November 16, 2020: Contributed Lecture, Poster and Mini-symposium Presentation Abstracts

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## Article About Olga Taussky-Todd

### Contributed announcement from Daniel Szyld, ILAS President

There is a nice piece on the life of Olga Taussky-Todd in the March issue of the AMS *Notices*, which can be found at <https://www.ams.org/journals/notices/202003/rnoti-p345.pdf>.

*Editor's note:* This same issue of the *Notices* features a piece on the life of Fan Chung (<https://www.ams.org/journals/notices/202003/rnoti-p327.pdf>) by ILAS member Steve Butler, who also created the cover image for the issue.

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## ILAS Wikipedia Page Live

### Contributed announcement from Daniel Szyld, ILAS President

ILAS has now a Wikipedia page: [https://en.wikipedia.org/wiki/International\\_Linear\\_Algebra\\_Society](https://en.wikipedia.org/wiki/International_Linear_Algebra_Society)

This is the culmination of several months of work by various ILAS members and officers (under the leadership of Peter Šemrl as ILAS President). I thank in particular Wayne Barrett and Kevin Vander Meulen for their efforts.

## ILAS President/Vice President Annual Report: May 1, 2020

Respectfully submitted by Daniel Szyld, ILAS President, [szyld@temple.edu](mailto:szyld@temple.edu)  
and Hugo Woerdeman, ILAS Vice President, [hugo@math.drexel.edu](mailto:hugo@math.drexel.edu)

### 1. Board-approved actions since the last report include:

- The Board approved the proposal to hold the 25<sup>th</sup> ILAS Conference in Madrid.
- The Board approved a change to the ‘Guidelines for the Hans Schneider Prize,’ allowing for a medal instead of a plaque.
- The Board approved pursuing a Wikipedia page for ILAS. Wayne Barrett has provided initial content for the page, and we thank him for this effort.
- The Board (with Froilán Dopico recused due to the conflict of interest) approved the ILAS Journals Committee’s nomination of Froilán Dopico as co-Editor-in-Chief of *ELA*. His three-year term started on August 1, 2019.
- The Board approved the postponement of the 24<sup>th</sup> ILAS Conference due to the COVID-19 pandemic.
- The Board approved to embed the 23<sup>rd</sup> ILAS conference in the SIAM-LA meeting to be held in New Orleans in May 2021.

### 2. ILAS elections ran from November 15, 2019 – January 15, 2020, and proceeded via electronic voting. The following were elected to offices with three-year terms that began on March 1, 2020:

- President: Daniel Szyld
- Board of Directors: Sebastian Cioabă and Dragana Cvetković-Ilić

The following continue in the ILAS offices which they currently hold:

- Vice President: Hugo Woerdeman (term ends February 28, 2022)
- Secretary/Treasurer: Leslie Hogben (term ends February 28, 2021)
- Assistant Secretary/Treasurer: Minerva Catral (term ends February 28, 2021)
- Second Vice President (for ILAS conferences): Steve Kirkland (term ends June 30, 2020)
- Board of Directors: Maria Isabel Bueno (term ends February 28, 2021), Valeria Simoncini (term ends February 28, 2022), Vilmar Trevisan (term ends February 28, 2021), and Michael Tsatsomeros (term ends February 28, 2022).

On February 29, 2020, Peter Šemrl completed two consecutive terms as ILAS President, for a total of six years on the ILAS Executive Board. Peter Šemrl will now serve a one-year term on the Board of Directors until February 28, 2021. We extend sincere thanks to Peter for his dedicated service to the Society.

James Nagy and Rachel Quinlan completed their terms on the ILAS Board of Directors on February 28, 2019. We thank them for their valuable contributions as Board members; their service to ILAS is most appreciated. We also thank the members of the Nominating Committee – Richard Brualdi (chair), Nair Abreu, Ravi Bapat, Steve Kirkland, Naomi Shaked-Monderer – for their efforts on behalf of ILAS, and all of the nominees for their participation in the elections.

### 3. New appointments and reappointments:

- Advisory Committee (starting March 1, 2020)
  - Misha Kilmer
  - Judi McDonald
  - James Nagy (chair)
  - Tin Yau Tam
- Second Vice President for Conferences (starting July 1, 2020)
  - Raf Vandebril
- Resident Registered Agent in the State of Florida (continuation)
  - Fuzhen Zhang

- Manager of ILAS-NET and ILAS Information Center (ILASIC) (continuation)
  - Sarah Carnochan Naqvi
- ILAS appointees of the Israel Gohberg ILAS-IWOTA Lecture Selection Committee (for ILAS 2022)
  - André Ran
  - Ilya M. Spitkovsky
- *IMAGE* editor (continuation)
  - Louis Deaett
- Journals Committee
  - Chi-Kwong Li
  - Beatrice Meini (chair)
  - Peter Šemrl
  - Louis Deaett (for *IMAGE*)
  - Froilán Dopico (for *ELA*)
- Education Committee
  - David Strong (chair)
- Outreach and Membership Committee
  - Minnie Catral
  - Andrii Dmytryshyn
  - Federico Poloni
  - David Watkins (chair)

4. The following ILAS-endorsed meetings have taken place since our last report:

- International Conference on Matrix Theory and Applications: Combinatorics, Optimization & Data Analysis (2019 ICMTA) AORC-IRCTMT-IDEaS Joint Meeting, Jeju, Korea, May 23–27, 2019. <https://shb.skku.edu/aorc/icmta2019/icmta2019.jsp>
- 27<sup>th</sup> International Workshop on Matrices and Statistics (IWMS2019) Shanghai, China, June 6–9, 2019. <http://www.suibe.edu.cn/ttxy/iwms2019/>
- 8<sup>th</sup> International Conference on Matrix Analysis and Applications (ICMAA 2019) Reno, NV, USA, July 15–18, 2019. <https://wolfweb.unr.edu/homepage/ttam/2019-ICMAA.html>
- International Workshop on Operator Theory and its Applications (IWOTA 2019) Lisbon, Portugal, July 22–26, 2019. Albrecht Böttcher was an ILAS Lecturer. <https://iwota2019.math.tecnico.ulisboa.pt/home>
- International Conference and Ph.D.-Master Summer School on “Groups and Graphs, Designs and Dynamics” (G2D2) Yichang, China, August 12–25, 2019. Michael Boyle was an ILAS Lecturer. <http://math.sjtu.edu.cn/conference/G2D2/>
- International Conference on Matrix Analysis and its Applications (MAT-TRIAD 2019) Liblice, Czech Republic, September 8–13, 2019. Shmuel Friedland was a Hans Schneider ILAS Lecturer. <http://mattriad.math.cas.cz>

5. ILAS has endorsed the following conferences of interest to ILAS members. Please note that due to the ongoing COVID-19 pandemic several meetings are being postponed. Below we reflect the current status.

- Western Canada Linear Algebra Meeting (WCLAM) Brandon, Manitoba, Canada. Postponed. <https://www.brandonu.ca/wclam/>
- A joint meeting of Linear Algebra, Matrix Analysis, and Applications (ALAMA) and “Due giorni di algebra lineare numerica” (ALN2gg) Alcalá de Henares, Spain. Postponed. <http://www.alama2020.com>
- The 16<sup>th</sup> Workshop on Numerical Ranges and Numerical Radii (WONRA) Hotel Termas da Curia, Portugal. Postponed. <http://www.mat.uc.pt/~wonra2020/>
- XXI Householder Symposium, Selva di Fasano, Italy. Postponed. <https://users.ba.cnr.it/iac/irmanm21/HHXXI/index.html>

- The 9<sup>th</sup> International Conference on Matrix Analysis and Applications (ICMAA) Aveiro, Portugal. Postponed. <http://icmaa2020.web.ua.pt>
- 9<sup>th</sup> Linear Algebra Workshop (LAW) Portorož, Slovenia. Helena Šmigoc will be an ILAS Lecturer. Postponed. <http://www.law05.si/law20/>
- International Workshop on Operator Theory and its Applications (IWOTA) Lancaster University, Lancaster, United Kingdom, August 16–20, 2021. Vern Paulsen will be an Israel Gohberg ILAS-IWOTA Lecturer. <https://www.lancaster.ac.uk/math/iwota2020/>
- International Conference on Linear Algebra and its Applications (ICLAA 2020) Manipal, India, December 17–19, 2020. Stephen Kirkland will be a Hans Schneider ILAS Lecturer. <https://carams.in/events/iclaa2020/>
- SIAM Conference on Applied Linear Algebra (SIAM-LA21) New Orleans, May 17–21, 2021. Bryan Shader will be the ILAS-ELA 25<sup>th</sup> Anniversary Lecturer, and Paola Boito will be an ILAS Lecturer. <https://www.siam.org/conferences/cm/conference/la21>

6. The following ILAS conferences are scheduled:

- The 23<sup>rd</sup> ILAS Conference will be embedded in the SIAM Conference on Applied Linear Algebra (SIAM-LA21) scheduled for May 17–21, 2021 in New Orleans.
- The 24<sup>th</sup> ILAS Conference is scheduled to be held at National University of Ireland, Galway. The co-chairs of the organizing committee are Rachel Quinlan and Helena Šmigoc. Due to the COVID-19 pandemic this conference has been postponed and is now scheduled for June 20–24, 2022.
- The 25<sup>th</sup> ILAS Conference is scheduled to be held at Universidad Nacional de Educación a Distancia (UNED), Madrid, Spain, June 5–9, 2023. The chair of the organizing committee is Fernando De Terán.

7. The Electronic Journal of Linear Algebra (ELA) is now in its 36<sup>th</sup> volume. ELA's URL is <https://journals.uwo.edu/index.php/ela>.

Volume 35 was published in 2019 and contains 44 papers.

Froilán M. Dopico (Universidad Carlos III de Madrid) and Michael Tsatsomeros (Washington State University) are the Editors-in-Chief.

8. *IMAGE* is the semi-annual bulletin for ILAS, available online at <http://ilasic.org/IMAGE>. The Editor-in-Chief is Louis Deaett (Quinnipiac University).

9. ILAS-NET is a moderated newsletter for mathematicians worldwide, with a focus on linear algebra; it is managed by Sarah Carnochan Naqvi.

An archive of ILAS-NET messages is available at <http://www.ilasic.org/ilas-net/>. To send a message to ILAS-NET, please send the message (preferably in text format) in an e-mail to [ilasic@uregina.ca](mailto:ilasic@uregina.ca) indicating that you would like it to be posted on ILAS-NET. If the message is approved, it will be posted soon afterwards. To subscribe to ILAS-NET, please complete the form at <http://ilasic.us10.list-manage.com/subscribe?u=6f8674f5d780d2dc591d397c9&id=dbda1af1a5>.

10. ILAS' website, known as the ILAS Information Centre (ILASIC), is located at <http://www.ilasic.org> and provides general information about ILAS (e.g., ILAS officers, bylaws, special lecturers) as well as links to pages of interest to the ILAS community.

Respectfully submitted,

Daniel B. Szyld, ILAS President ([szyld@temple.edu](mailto:szyld@temple.edu)); and

Hugo J. Woerdeman, ILAS Vice President ([hugo@math.drexel.edu](mailto:hugo@math.drexel.edu)).

**ILAS 2019–2020 Treasurer's Report**  
**April 1, 2019 – March 31, 2020**  
**by Leslie Hogben, ILAS Treasurer**

**Net Account Balance on March 31, 2019**

|                                                     |               |                      |
|-----------------------------------------------------|---------------|----------------------|
| Vanguard (ST Fed Bond Fund Admiral 7876.686 Shares) | \$ 88,198.77  |                      |
| Checking Account - Great Western                    | \$ 58,472.25  |                      |
| Certificate of Deposit                              | \$ 46,580.60  |                      |
| Accounts Receivable                                 | \$ 330.00     |                      |
|                                                     |               | <u>\$ 193,581.62</u> |
| General Fund                                        | \$ 107,567.97 |                      |
| Israel Gohberg ILAS-IWOTA Lecture                   | \$ 3,620.00   |                      |
| Conference Fund                                     | \$ 10,014.55  |                      |
| Olga Taussky-Todd/John Todd Fund                    | \$ 11,091.68  |                      |
| Hans Schneider Lecture Fund                         | \$ 12,135.89  |                      |
| Frank Uhlig Education Fund                          | \$ 5,367.31   |                      |
| Hans Schneider Prize Fund                           | \$ 27,600.57  |                      |
| ELA Fund                                            | \$ 592.54     |                      |
| ILAS/LAA Fund                                       | \$ 15,591.11  |                      |
|                                                     |               | <u>\$ 193,581.62</u> |

**INCOME:**

|                                                          |             |                     |
|----------------------------------------------------------|-------------|---------------------|
| Dues                                                     | \$ 6,860.00 |                     |
| Israel Gohberg ILAS-IWOTA Lecture Fund                   | \$ 0.00     |                     |
| Donations                                                | \$ 40.00    |                     |
| General Fund Donations                                   | \$ 3,050.00 |                     |
| Conference Fund Donations                                | \$ 125.00   |                     |
| Taussky-Todd Fund Donations                              | \$ 70.00    |                     |
| Hans Schneider Lecture Fund Donations                    | \$ 20.00    |                     |
| Uhlig Education Fund Donations                           | \$ 0.00     |                     |
| Schneider Prize Fund Donations                           | \$ 110.00   |                     |
| ELA Fund Donations                                       | \$ 40.00    |                     |
| Corporate Dues Income                                    | \$ 0.00     |                     |
| Interest – Great Western                                 | \$ 56.19    |                     |
| Interest on expired Great Western Certificate of Deposit | \$ 494.02   |                     |
| Vanguard – Income                                        | \$ 4,078.07 |                     |
| Elsevier flow-through                                    | \$ 5,000.00 |                     |
| Misc Income                                              | \$ 59.00    |                     |
| Total Income                                             |             | <u>\$ 20,002.28</u> |

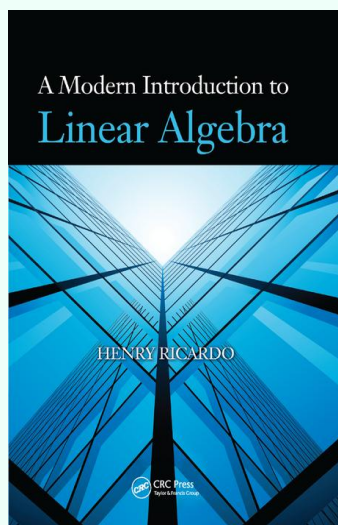
**EXPENSES:**

|                                       |             |                     |
|---------------------------------------|-------------|---------------------|
| ILAS Conference Expenses              | \$ 792.26   |                     |
| ELA                                   | \$ 1,500.00 |                     |
| IMAGE                                 | \$ 0.00     |                     |
| IWOTA                                 | \$ 0.00     |                     |
| Credit Card Processing & Bank Fees    | \$ 777.44   |                     |
| Non-ILAS Conferences                  | \$ 1,583.19 |                     |
| Hans Schneider Lecture                | \$ 1,500.00 |                     |
| Hans Schneider Prize                  | \$ 2,712.20 |                     |
| Taussky-Todd Lecture                  | \$ 0.00     |                     |
| Business License                      | \$ 61.25    |                     |
| Ballot Costs                          | \$ 296.51   |                     |
| Web Hosting & Online Membership Forms | \$ 199.95   |                     |
| Elsevier flow-through                 | \$ 5,000.00 |                     |
| Misc Expenses                         | \$ 0.00     |                     |
| Total Expenses                        |             | <u>\$ 14,422.80</u> |

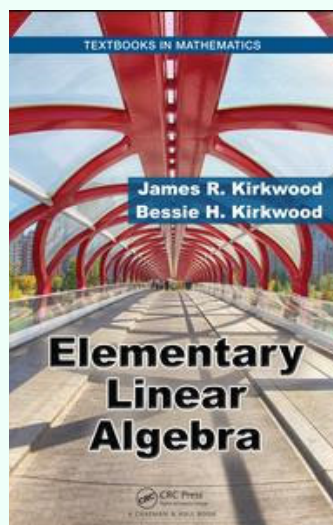
**Net Account Balance on March 31, 2020**

|                                        |               |                      |
|----------------------------------------|---------------|----------------------|
| Checking Account – Great Western       | \$ 130,259.54 |                      |
| Certificate of Deposit (new)           | \$ 60,000.00  |                      |
| Accounts Receivable                    | \$ 8,901.56   |                      |
|                                        |               | <u>\$ 199,161.10</u> |
| General Fund                           | \$ 117,746.91 |                      |
| Israel Gohberg ILAS-IWOTA Lecture Fund | \$ 3,660.00   |                      |
| Conference Fund                        | \$ 9,347.29   |                      |
| Olga Taussky-Todd/John Todd Fund       | \$ 11,161.68  |                      |
| Hans Schneider Lecture Fund            | \$ 10,655.89  |                      |
| Frank Uhlig Education Fund             | \$ 5,367.31   |                      |
| Hans Schneider Prize Fund              | \$ 24,998.37  |                      |
| ELA Fund                               | \$ 632.54     |                      |
| ILAS/LAA Fund                          | \$ 15,591.11  |                      |
|                                        |               | <u>\$ 199,161.10</u> |

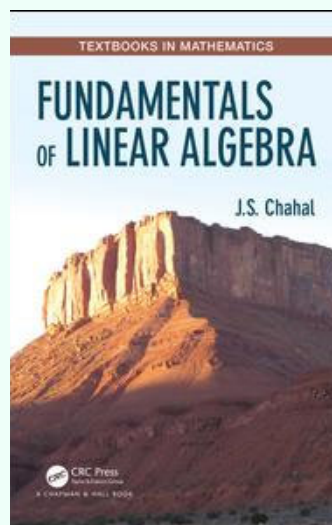
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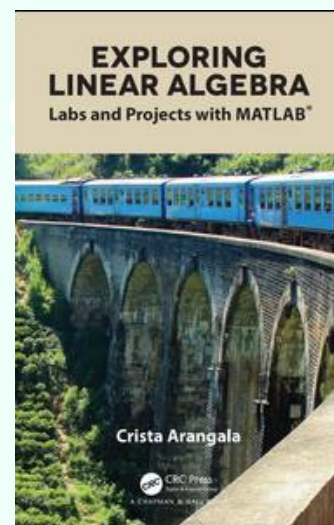
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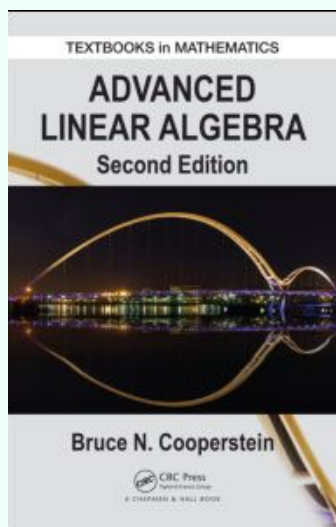
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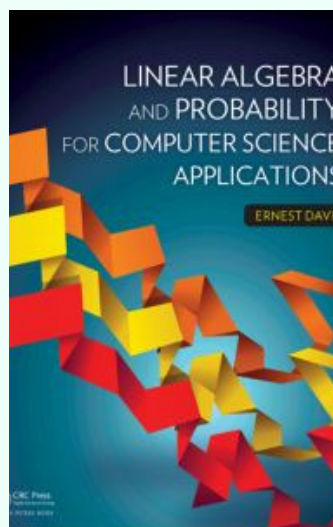
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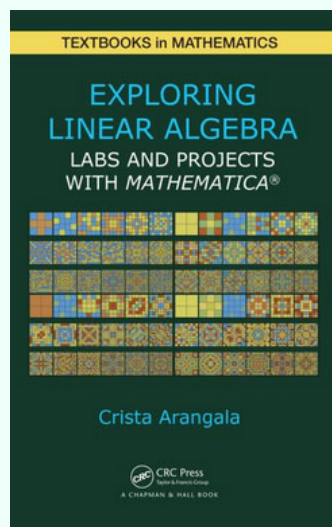
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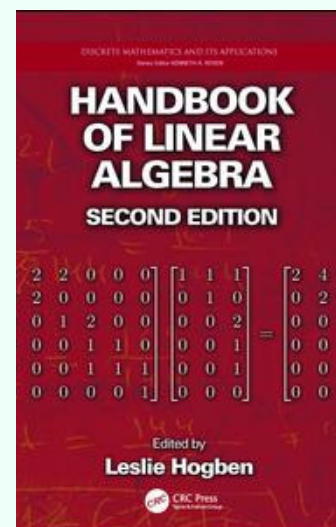
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## CONFERENCE REPORTS

### The 2019 International Conference on Matrix Theory and Applications: Combinatorics, Optimization, Data Analysis Jeju, South Korea, May 23–27, 2019

Report by Gi-Sang Cheon and Qing-Wen Wang

The 2019 ICMTA was held jointly by three institutes, the Applied Algebra and Optimization Research Center (AORC) at Sungkyunkwan University, South Korea (SKKU), the International Research Center for Tensor and Matrix Theory at Shanghai University, China (IRCTMT), and the Institute for Data Engineering and Science (IDEaS) at the Georgia Institute of Technology, USA, over five days in Jeju, a beautiful island in South Korea. The purpose of the conference was to stimulate research and foster the interaction of researchers interested in a variety of aspects of matrix theory and its applications to combinatorics, optimization and data analysis. All of the speakers were invited by the Scientific Organizing Committee:

- Gi-Sang Cheon, Director, AORC, SKKU
- Chi-Kwong Li, College of William and Mary
- Yongdo Lim, Director, National Creative Research Laboratory, SKKU
- Haesun Park, IDEaS, Georgia Institute of Technology
- Qing-Wen Wang, Director, IRCTMT, Shanghai University
- Xuding Zhu, Director, Center for Discrete Mathematics, ZJNU

There were 121 participants from 38 different institutions in 11 countries. There were 6 plenary talks and 34 invited talks in the five-day meeting. The plenary speakers were:

- Richard Brualdi, University of Wisconsin-Madison, USA
- Lajos Molnar, University of Szeged, Hungary
- Michael Ng, Hong Kong Baptist University, Hong Kong
- Haesun Park, Georgia Institute of Technology, USA
- Kim Chuan Toh, University of Singapore, Singapore
- Xuding Zhu, Zhejiang Normal University, China

The talk schedule, with titles and abstracts, is available at <https://shb.skku.edu/aorc/icmta2019/ICMTA2019.jsp>. Conference pictures are available at <https://aorcskku.blogspot.com/2019/05/icmta-2019-in-jeju.html>. In accordance with the research agreement between AORC and IRCTMT, the joint meeting is held alternately every year in China and Korea. The 2019 ICMTA was organized and sponsored by the AORC. This meeting was endorsed by ILAS. The 2020 ICMTA will be at Hainan Normal University, China, December 18–21, 2020.



*Participants of the 2019 ICMTA*

## Advances in Numerical Linear Algebra: Celebrating the Centenary of the Birth of James H. Wilkinson Manchester, United Kindom, May 29–30, 2019

The conference celebrating the centenary of James H. Wilkinson (1919–1986) was hosted at the University of Manchester May 29–30, 2019. The focus of the conference was research in numerical linear algebra. The attendees celebrated the contributions of Wilkinson, and also had the opportunity to celebrate the 80<sup>th</sup> birthday of Cleve Moler. Invited speakers for the conference included: J. Dongarra, S. Güttel, S. Hammarling, N. Higham, I. Ipsen, V. Mehrmann, C. Moler, Y. Nakatsukasa, J. Pestana, F. Tisseur, M. Wright, N. Trefethen, and M Zounon.

More highlights of the conference can be found at

<https://nla-group.org/2019/06/19/highlights-of-advances-in-numerical-linear-algebra-conference/>.

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## The 22<sup>nd</sup> ILAS Conference Rio de Janeiro, Brazil, July 8–12, 2019

Report by Vilmar Trevisan



ILAS 2019: Linear Algebra Without Borders, was held at Fundação Getúlio Vargas (FGV) in Rio de Janeiro, Brazil, July 8–12, 2019. There were over 260 participants from more than 30 countries.

FGV is a well-known Brazilian think tank and higher education institution located in Botafogo, facing the Sugar Loaf, one of the beautiful landmarks of Rio. The main auditorium, where the plenary talks took place, was designed by the famous Brazilian architect Oscar Niemayer.



The conference opened with a talk by Nikhil Srivastava from the University of California, Berkeley, who discussed *Interlacing families*. The first day ended with the LAA Lecturer, Joseph Landsberg from Texas A&M, whose topic was *Efficient matrix multiplication*. The second day started with a talk by Igor Klep from the University of Ljubljana, who spoke on *Convex geometry of completely positive maps*, continued with Gitta Kutyniok from Technische Universität Berlin, on *Compressed sensing: from theory to deep learning*, and ended with LAMA Lecturer Apoorva Khare of the Indian Institute of Science, who taught us about *Entrywise positivity preservers: covariance*. The third day, Wednesday, was a half day where Volker Mehrmann from Technische Universität Berlin was the Hans Schneider Prize Speaker. His talk was titled *Port-Hamiltonian differential-algebraic systems: Stability and passivity through structure*. On the fourth day, we listened to Leslie Hogben of Iowa State University, who spoke on *The inverse eigenvalue problem of a graph and zero forcing*, to Yuan Jin Yun from Universidade Federal do Paraná, on *Relation between direct methods and iterative methods with some applications*, as well as to Federico Poloni from the University of Pisa, whose talk was about *Principal pivot transforms, structured matrices, and matrix equations*. The final day started with a lecture by Christoph Helmberg of Technische Universität Chemnitz, whose talk was on *Intrinsic linear algebra subjects in bundle methods for convex and conic optimization*. The conference closed with SIAG-LA Lecturer David Bindel from Cornell University, who talked about *The structure and interpretation of graph spectral densities*.

Besides the set of 11 outstanding plenary speakers, we had 21 excellent mini-symposia, some invited and some contributed, whose titles and organizers follow.

- MS1 – Algorithms for Rank-Structured Matrices and Low-Rank Approximation, by Paola Boito, Gianna M. Del Corso, Yuli Eidelman & Luca Gemignani
- MS2 – Cocliques and Colourings, by Gabriel Coutinho & Chris Godsil
- MS3 – Combinatorial Matrix Theory, by Bryan Shader, Shaun Fallat, Steve Butler & Kevin Vander Meulen

- MS4 – Evolution Algebras and Non-associative Algebraic Structures, by Yolanda Cabrera Casado, Maria Inez Cardoso Gonçalves, Pablo Martín Rodríguez & Paula Cadavid
- MS5 – Frame Theory and Data Science, by Gitta Kutyniok & Deanna Needell
- MS6 – Linear Algebra Education, by Sepideh Stewart & Rachel Quinlan
- MS7 – Linear Algebra and Quantum Information Science, by Yiu-Tung Poon, Raymond Nung-Sing Sze & Sarah Plosker
- MS8 – Matrices Over Elementary Divisor Domains, by Froilán M. Dopico & Vanni Noferini
- MS9 – Matrix Analysis, by James Pascoe & Miklos Palfia
- MS10 – Matrix Equations and Matrix Inequalities, by Fuzhen Zhang, Qing-Wen Wang & Tin-Yau Tam
- MS11 – Matrix Techniques in Operator Theory and Operator Algebras, by Hugo Woerdeman
- MS12 – M-Matrices and Inverse M-Matrices: Applications and Generalizations, by Minerva Catral & K.C. Sivakumar
- MS13 – Multilinear Algebra and Tensor Spaces, by David Gleich & Yang Qi
- MS14 – Nonnegative Inverse Spectral Problems, by Raphael Loewy & Ricardo L. Soto
- MS15 – Numerical Approaches for Solving Large-Scale Sparse Systems, by Xiao-Chuan Cai, Marcus Sarkis & Daniel Szyld
- MS16 – Perturbations of Matrix Eigenstructures, by Andrii Dmytryshyn, Stefan Johansson, Alexei Mailybaev & Amaury A. Cruz
- MS17 – Solving Large Linear Systems from Oil Reservoir Simulation, by Luiz Mariano Carvalho, Paulo Goldfeld & Michael Souza
- MS18 – Spectral Graph Theory, by Sebastian Cioabă, Jack Koolen & Leonardo de Lima
- MS19 – Spectral Inequalities, by Enide Andrade, Maria Robbiano Bustamante & Geir Dahl
- MS20 – Symbolic-Numeric Methods in Matrix Theory, by Yao Sun, Dingkan Wang & Yang Zhang
- MS21 – Zero Forcing, Propagation, Throttling: Variations and Applications, by Mary Flagg, Jesse Geneson & Leslie Hogben



*Participants of ILAS 2019*

Altogether, the mini-symposia contained 176 talks, and we had also a set of 49 contributed talks, for a total of 225 lectures. These were divided into 66 sessions, with at most 7 parallel sessions. This year, in order to attract students, we had two minicourses as well as a poster session. The minicourses were:

- MC1 – Graph Theory and Quantum Walks, by Gabriel Coutinho & Chris Godsil
- MC2 – Nonlinear Techniques in Matrix Theory, by Carlos Tomei & Tiago Pereira

The total number of student attendees was around 80. We estimate that approximately 10,000 minutes of mathematics were offered to the audience. The proceedings of the conference will be published in *Linear Algebra and its Applications*.

The Scientific Organizing Committee (SOC) was very diligent in selecting the plenary speakers and the mini-symposia, as well as the five *LAA* Early Career Speakers: Ryan Tully-Doyle of the University of New Haven, in mini-symposium Matrix Analysis; Xuemei Chen of New Mexico State University, in mini-symposium Frame Theory and Data Science; Austin Reilley Benson of Cornell University, in mini-symposium Algebra and Tensor Spaces; John Sinkovic of the University of Waterloo, in mini-symposium Combinatorial Matrix Theory; and Pietro Paparella of the University of Washington Bothell, in mini-symposium Nonnegative Inverse Spectral Problems. A warm “thank you” to the SOC: Nair Abreu (UFRJ – Brazil), Ravindra Bapat (ISI Delhi – India), Leslie Hogben (Iowa State U – USA), Alfredo Iusem (IMPA – Brazil), Steve Kirkland (U Manitoba – Canada), Chi-Kwong Li (William & Mary – USA), Volker Mehrmann (TU Berlin – Germany), Beatrice Meini (U Pisa – Italy), Rubens Sampaio (PUC Rio – Brazil), Peter Šemrl (U Ljubljana – Slovenia), Ricardo Soto (U Catolica del Norte – Chile) and Vilmar Trevisan (UFRGS – Brazil).

The theme of the meeting was “Linear Algebra Without Borders,” referring primarily to the fact that linear algebra and its myriad of applications are interwoven in a borderless unit. The idea was to create a program whose plenary talks and symposia would represent the many scientific “countries” of linear algebra, and which invited participants to “visit” them. The theme also referred to the openness and inclusiveness of linear algebra to researchers of different backgrounds. In this direction, beyond having “ambassadors” of different areas in which linear algebra is relevant, the mini-courses aimed at graduate and senior undergraduate students were meant to motivate them to start research careers in this area. Judging by feedback given to the Local Organizing Committee and the nice atmosphere of the conference, these goals were achieved.



*Volker Mehrmann with the Hans Schneider prize*

In fact, the social events were for all attendees to enjoy. There was a cocktail reception on Monday night. Wednesday afternoon was dedicated to the optional excursions provided by a local agency. The conference banquet was at Assador, where a traditional Brazilian barbecue was served. A main point of the banquet was the ceremony where the Hans Schneider Prize was offered to Volker Mehrmann for his contributions to the linear algebra community over the years. We thank Peter Šemrl and Volker Mehrmann for their speeches. The conference ended in the afternoon on Friday, July 12, with a relaxing beer break.





For more information and additional photos, see the conference web site, <http://ilas2019.org>.

## The 8<sup>th</sup> Workshop on Matrix Equations and Tensor Techniques (METT VIII) Magdeburg, Germany, November 6–8, 2019

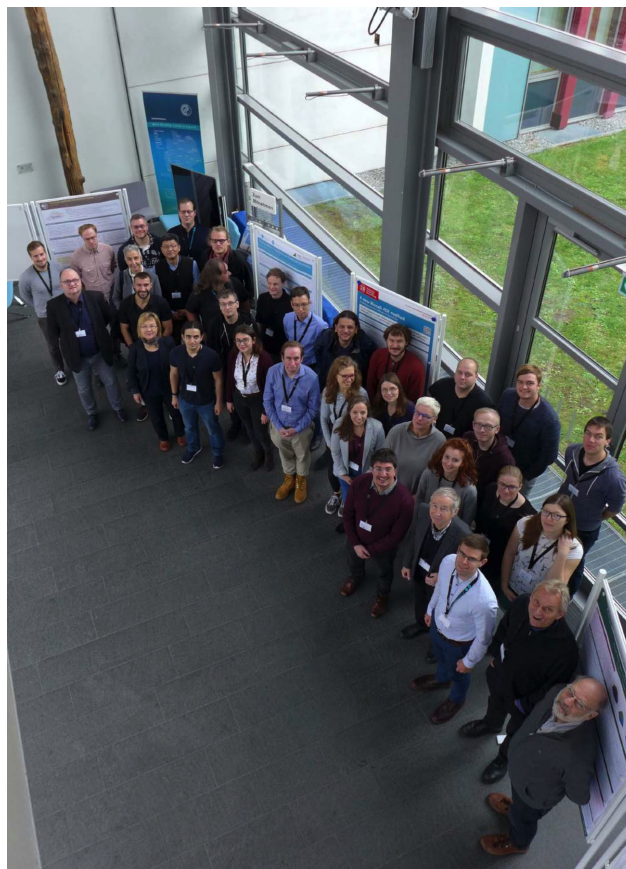
Report by Davide Palitta

In November 2019, the 8<sup>th</sup> Workshop on Matrix Equations and Tensor Techniques (METT VIII) was held at the Max Planck Institute for Dynamics of Complex Technical Systems in Magdeburg, Germany. This three-day workshop was the 8<sup>th</sup> in a series of itinerant workshops on matrix equations and, since its 4<sup>th</sup> edition, also on tensor techniques. The METT takes place every two years in a different location, with previous workshops held in Germany (Leipzig, Chemnitz, Braunschweig and Aachen), Switzerland (Lausanne) and Italy (Bologna, Pisa).

As with the previous meetings, the focus of the workshop was on the latest developments in the theory, computation and applications of linear and nonlinear matrix equations and tensor formulations. The efforts of many outstanding researchers are currently devoted to these topics and the study of matrix equations and tensor techniques is certainly one of the most active research areas in numerical analysis. The scientific program of the workshop included 19 contributed talks and 10 notable poster presentations, whose contents ranged from error bounds for low-rank tensor approximation to the exploitation of the tensor-train format in image classification, and from the efficient solution of large-scale algebraic and differential Riccati equations to the design of novel matrix equation techniques in parametric model order reduction.

Many scientists, from well-known experts in the field to Ph.D. students that had just started working in this area, took part in the METT VIII. In total, 47 researchers from all around Europe (Germany, Italy, UK, Czech Republic, France, Belgium, Switzerland) as well as from the US and Asia attended the METT VIII, and thanks to the generous sponsorship of the MathCoRe Graduate School in Magdeburg, the attendance of three Ph.D. students was fully supported. The informal, friendly atmosphere of the workshop, along with the facilities of our institute (e.g., many rooms for discussions and brainstorming) contributed to a very fruitful and successful meeting.

We are all looking forward to the 9<sup>th</sup> Workshop on Matrix Equations and Tensor Techniques that will be held in Perugia, Italy, September 9–10, 2021.



*Participants of METT VIII*

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## UPCOMING CONFERENCES AND WORKSHOPS

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*Editor's note:* Due to the changing situation with respect to the COVID-19 pandemic, much of the information here is necessarily out of date, or will have changed by the time you read it. In particular, please see the announcement "ILAS Conference Schedule for the Next Three Years (2021–2023)" on page 14 regarding the revised schedule of ILAS meetings. In the following sections, when a conference had been postponed or canceled at press time, this, along with any available dates, is indicated in red.

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### 28<sup>th</sup> International Workshop on Matrices and Statistics (IWMS 2020) Manipal, India, December 15–17, 2020

The 28<sup>th</sup> International Workshop on Matrices and Statistics (IWMS 2020) will be held December 15–17, 2020 at the Center for Advanced Research for Applied Mathematics and Statistics, Manipal Academy of Higher Education (MAHE), Manipal, Karnataka, India.

The purpose of the Workshop is to stimulate research and, in an informal setting, to foster the interaction of researchers in the interface between statistics and matrix theory. The Workshop will provide a forum through which statisticians may be better informed of the latest developments and newest techniques in linear algebra and matrix theory and may exchange ideas with researchers from a wide variety of countries. As well as a range of plenary speakers, the meeting will strengthen the interactions between participants through a range of mini-symposia in various areas of specialization.

Themes of the workshop will include: Matrix Analysis, Projectors in Linear Models & Multivariate Analysis, Growth Curve Models, Linear Regression Models, Linear Statistical Inference, Modelling Covariance Structures, Multivariate and Mixed Linear Models, and Statistics in Big Data Analysis.

The Scientific Committee consists of Ravindra B. Bapat, Manjunatha Prasad Karantha, Steve Kirkland, and Simo Puntanen. The Organizing Committee consists of Narayana Sabhahit (Chairman, Registrar, MAHE) and Manjunatha Prasad Karantha (Organizing Secretary, Coordinator, CARAMS, MAHE).

*CRR Day on December 17, 2020:* The present 28<sup>th</sup> IWMS will be held alongside ICLAA 2020 (December 17–19, 2020) and CRR Day will be held on December 17, the day common to these events, to celebrate 100 years of C. R. Rao, who is among greatest statisticians and matrix theorists India has ever produced.

Please visit <https://carams.in/events/international-workshop-on-matrices-and-statistics> for more details and registration.

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## International Conference on Linear Algebra and its Applications (ICLAA 2020) Manipal, India, December 17–19, 2020

In a sequel to the ICLAA series, the International Conference on Linear Algebra and its Applications will be held December 17–19, 2020 at the Center for Advanced Research for Applied Mathematics and Statistics, Manipal Academy of Higher Education (MAHE), Manipal, Karnataka, India.

The themes of the conference shall focus on classical matrix theory, nonnegative matrices and special matrices, matrices and graphs, combinatorial matrix theory, matrix and graph methods in statistics and biological science, and matrices in error analysis and its applications.

The Scientific Committee consists of Ravindra B. Bapat, Manjunatha Prasad Karantha, Steve Kirkland, and Simo Puntanen. The Organizing Committee consists of Narayana Sabhahit (Chairman, Registrar, MAHE) and Manjunatha Prasad Karantha (Organizing Secretary, Coordinator, CARAMS, MAHE).

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Please visit <https://carams.in/events/iclaa2020> for more details and registration.

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## *Special session on* The Inverse Eigenvalue Problem for Graphs, Zero Forcing, and Related Topics *at the* 2021 Joint Mathematics Meetings Washington, D.C., USA, January 6–9, 2021

A special session on “The Inverse Eigenvalue Problem for Graphs, Zero Forcing, and Related Topics” is being planned for the Joint Mathematics Meetings in Washington, D.C., January 6–9, 2021. The session is organized by Leslie Hogben (Iowa State University and the American Institute of Mathematics) and Bryan Shader (University of Wyoming). An e-mail requesting titles and abstracts for consideration will be sent via ILAS-Net once final approval of the special session has been received.

## 6<sup>th</sup> Workshop on Algebraic Designs, Hadamard Matrices & Quanta Kraków, Poland, **rescheduled to June 28–July 2, 2021**

The 6<sup>th</sup> Workshop on Algebraic Designs, Hadamard Matrices & Quanta will be held at Jagiellonian University, as well as at the Institute of Mathematics, in Kraków, Poland.

The list of confirmed invited speakers includes: Ingemar Bengtsson (Stockholm, Sweden), Robert Craigen (Winnipeg, Canada), Ilias Kotsireas (Waterloo, Canada), Hadi Kharaghani (Lethbridge, Canada), Mate Matolcsi (Budapest, Hungary), and Padraig Ó Catháin (Worcester, USA).

Early conference registration is due by March 1, 2020. Further information can be found at <https://chaos.if.uj.edu.pl/hadamard2020>.

Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.

## 9<sup>th</sup> Linear Algebra Workshop (LAW'20) Portorož, Slovenia, **postponed until 2021**

The 9<sup>th</sup> Linear Algebra Workshop (LAW'20) will continue the tradition of the previous meetings. Its main theme will be the interplay between operator theory and linear algebra on one side and algebra with a variety of algebraic and geometric structures on the other.

The organizers believe in including time to think about the problems, not only to listen to each other's formal talks. So the workshop will be organized in a less formal way. Following tradition, only a few hours of talks will be scheduled for the morning sessions, while afternoons will be reserved for work in smaller groups. Participants are welcome to suggest their own topics of interest for these working groups. All topics from linear algebra within the broad scope outlined above are welcome. Many past working groups have produced multi-author papers.



*Portorož, Slovenia*

The workshop will be held at the Faculty of Maritime Studies and Transport, University of Ljubljana, Portorož. Portorož (Italian: Portorose, literally “Port of roses”) is a Slovenian Adriatic seaside resort and spa town located in the Municipality of Piran in southwestern Slovenia. Piran is an ancient Venetian city built as an exporting port for salt, which is still being produced in the vicinity in the traditional way. The workshop will be held following the 23<sup>rd</sup> Conference of the International Linear Algebra Society in Galway, Ireland, and it is a satellite conference of the 8<sup>th</sup> European Congress of Mathematics to be held July 5–11, 2020 in Portorož, Slovenia. Those interested in attending should register by April 15, 2020 (early bird), or by June 10, 2020 (regular). More information can be found at <http://www.law05.si/law20>.

Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.

## Linear Algebra, Matrix Analysis, and Applications (ALAMA2020) Alcalá de Henares, Spain, **postponed until 2021**

The thematic network ALAMA (Linear Algebra, Matrix Analysis, and Applications) will hold its seventh biennial meeting June 3–5, 2020 in Alcalá de Henares, after the previous editions held in Vitoria-Gasteiz (2008), Valencia (2010), Leganés (2012), Barcelona (2014), León (2016) and Alicante (2018).

This 2020 edition is a celebration in honour of Ion Zaballa, professor at Universidad del País Vasco, and of Dario A. Bini, professor at Università di Pisa, so that this ALAMA meeting is celebrated jointly with the seventeenth edition of ALN2gg (Due giorni di Algebra Lineare Numerica). The meeting ALN2gg periodically gathers the Italian community of numerical linear algebra, this time for three days.

The joint meeting will be celebrated in a singular environment: the historical Colegio de San Ildefonso of the University of Alcalá, in the city of Alcalá de Henares (province of Madrid), whose historical centre was in 1998 declared a UNESCO World Heritage Site.

The scientific committee includes: Ana Marco [President] (Universidad de Alcalá), Raymond Honfu Chan (City University of Hong Kong), Froilán M. Dopico (Universidad Carlos III de Madrid), Christian Mehl (TU Berlin), Juan Manuel Peña (Universidad de Zaragoza), Lothar Reichel (Kent State University), Stefano Serra-Capizzano (Insubria University and Uppsala University), Ana M. Urbano (Universitat Politècnica de València), and Marc Van Barel (KU Leuven).

Abstract submission is due no later than March 1, 2020, and early registration ends April 12, 2020. Further information can be found at: <https://congresosalcala.fgua.es/alama2020>

**Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.**

## Workshop on Numerical Ranges and Numerical Radii (WONRA 2020) Curia, Portugal, **postponed until 2021**

The 16<sup>th</sup> Workshop on Numerical Ranges and Numerical Radii (WONRA 2020) will take place June 13–16, 2020, at the Hotel Termas da Curia, Portugal.

The purpose of the workshop is to stimulate research and foster interaction between researchers interested in the subject. The informal workshop atmosphere will facilitate the exchange of ideas from different scientific areas and, hopefully, the participants will be informed on the latest developments and new ideas. Background on the subject and on previous meetings may be found at the WONRA website (<http://www.mat.uc.pt/~wonra2020/>); also see the Wikipedia page for the history of the workshop and related meetings: [https://en.wikipedia.org/wiki/Workshop\\_on\\_Numerical\\_Ranges\\_and\\_Numerical\\_Radii](https://en.wikipedia.org/wiki/Workshop_on_Numerical_Ranges_and_Numerical_Radii).

The organizing committee consists of Natália Bebian (CMUC, University of Coimbra), Chi-Kwong Li (College of William and Mary, Williamsburg, Virginia, USA), Susana Furtado (CEAFEL, University of Porto), and Ana Nata (CMUC, Polytechnic Institute of Tomar).

The workshop is endorsed and sponsored by the International Linear Algebra Society (ILAS); Compete (Programa operacional factores de competitividade); the Centre for Mathematics, University of Coimbra (CMUC); and the Centre for Functional Analysis, Linear Structures and Applications (CEAFEL).

One may visit <http://www.mat.uc.pt/~wonra2020/> for further information, and send e-mail to [wonra2020@mat.uc.pt](mailto:wonra2020@mat.uc.pt) with any questions.

**Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.**

## 9<sup>th</sup> International Conference on Matrix Analysis and Applications (ICMAA 2020) Aveiro, Portugal, **postponed until 2021**

The 9<sup>th</sup> International Conference on Matrix Analysis and Applications (ICMAA 2020) will be held at the University of Aveiro in Aveiro, Portugal, June 18–20, 2020. This meeting aims to stimulate the research and interaction of mathematicians in all aspects of linear and multilinear algebra, matrix analysis, graph theory, and their applications, and to provide an opportunity for researchers to exchange ideas and discuss developments on these subjects. The previous ICMAA conferences were held in China (Beijing, Hangzhou), the United States (Nova Southeastern University), Turkey (Selçuk University, Konya), Vietnam (Duy Tan University, Da Nang), Japan (Shinshu University, Nagano Prefecture) and the United States (University of Nevada, Reno). Former keynote speakers are Roger Horn, Richard Brualdi, Chi-Kwong Li, Steve Kirkland, Alexander A. Klyachko (ILAS guest speaker), Shmuel Friedland, Man-Duen Choi, Tsuyoshi Ando, Fumio Hiai and Lek-Heng Lim.

The keynote speaker of ICMAA 2020 is Peter Šemrl, University of Ljubljana, Slovenia, and the two invited speakers are Natália Bebiano, University of Coimbra, Portugal and Chi-Kwong Li, College of William and Mary, USA.

The organizers are Enide Andrade (Organizing Committee Chair), University of Aveiro, Aveiro, Portugal; Rute Lemos, University of Aveiro, Aveiro, Portugal; Tin-Yau Tam (Organizing Committee co-Chair), University of Nevada, Reno, USA; Qing-Wen Wang, Shanghai University, Shanghai, China; and Fuzhen Zhang, Nova Southeastern University, Florida, USA. The workshop is endorsed and sponsored by the International Linear Algebra Society (ILAS); the Center for Research and Development in Mathematics and Applications (CIDMA); the Portuguese Foundation for Science and Technology (FCT-Fundação para a Ciência e a Tecnologia) through the Center for Research and Development in Mathematics and Applications (CIDMA) within project UID/MAT/04106/2019; and the Mathematics Department (DMat-UA) of the University of Aveiro, Portugal.

Please visit <http://icmaa2020.web.ua.pt> for detailed information and updates. Contact Rute Lemos ([rute@ua.pt](mailto:rute@ua.pt)) or Enide Andrade ([enide@ua.pt](mailto:enide@ua.pt)) with any questions.

**Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.**

## XXI Householder Symposium on Numerical Linear Algebra Selva di Fasano (Br), Italy, **rescheduled to June 12–17, 2022**

The next Householder Symposium will be held June 14–19, 2020 at the hotel Sierra Silvana, Selva di Fasano (Br), Italy.

This meeting is the twenty-first in a series, previously called the Gatlinburg Symposia, but now named in honor of its founder, Alston S. Householder, a pioneer of numerical linear algebra. As envisioned by Householder, the meeting is informal, emphasizing an intermingling of young and established researchers. Topics include numerical linear and multilinear algebra, matrix theory, including probabilistic algorithms, and related areas such as optimization, differential equations, signal and image processing, network analysis, data analytics, and systems and control.

The seventeenth Householder Prize for the best Ph.D. thesis in numerical linear algebra since January 1, 2017 will be presented.

The Householder Committee includes Zhaojun Bai (University of California, Davis, USA), David Bindel (Cornell University, USA), James Demmel (University of California, Berkeley, USA), Zlatko Drmac (University of Zagreb, Croatia), Heike Faßbender [chair and SIAM representative] (Technical University of Braunschweig, Germany), Sherry Li (Lawrence Berkeley National Laboratory, USA), Volker Mehrmann (Technical University of Berlin, Germany), James Nagy (Emory University, USA), Valeria Simoncini (University of Bologna, Italy), and Andrew Wathen (Oxford University, UK).

This meeting is sponsored by ILAS, MathWorks, and SIAM. Attendance at the meeting is by invitation. Further information can be found at <https://users.ba.cnr.it/iac/irmanm21/HHXXI>.

**Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.**

## ILAS 2020: Classical Connections

### Galway, Ireland, **rescheduled to June 20–24, 2022**

The 23<sup>rd</sup> meeting<sup>1</sup> of the International Linear Algebra Society, ILAS 2020: Classical Connections, will be hosted by the School of Mathematics at the National University of Ireland, Galway, June 22–26, 2020. The venue will be the University’s beautiful riverside campus.

The conference theme is “Classical Connections.” This will be reflected in the plenary programme and mini-symposia, and all participants are encouraged to think about relating their themes to their historical roots. Contributions on all aspects of linear algebra and its applications are welcome.

The conference will feature 10 plenary talks, by the following speakers:

- Shmuel Friedland, University of Illinois at Chicago, USA
- Nicolas Gillis, Université de Mons, France
- Rod Gow, NUI Dublin, Ireland
- Misha Kilmer (SIAG-LA Lecture), Tufts University, USA
- Monique Laurent, Centrum Wiskunde & Informatica, the Netherlands
- Lek-Heng Lim (Hans Schneider Prize Lecture), University of Chicago, USA
- Clément de Seguins Pazzis, Lycée privé Sainte-Geneviève, France
- Christiane Tretter, University in Bern, Switzerland
- Vilmar Trevisan, Instituto de Matemática, UFRGS, Brazil
- Raf Vandebril (Tausky-Todd Lecture), KU Leuven, Belgium

Invited mini-symposia (with organizers): Graph spectra (D. Cardoso, C. Justel, R. del Vecchio), Spectral properties of non-negative matrices (C. Marijuán, P. Paparella), Copositive and completely positive matrices (A. Berman, M. Dür, N. Shaked-Monderer), Mathematics of quantum information (R. Levene, I. Todorov), Combinatorial matrix theory (J. Breen, R. Canogar), The inverse eigenvalue problem for graphs (J. Lin, P. Oblak), General preservers (L. Molnár, G. Geher), Distance matrices of graphs (P.N. Choudhury, A. Khare), Linear algebra education (A. Cronin, S. Stewart), Numerical linear algebra for PDEs (S. MacLachlan, N. Madden), The research and legacy of Richard A. Brualdi (A. Berliner, L. Deaett, S. Meyer), Matrix positivity: theory and applications (A. Belton, D. Guillot).

The Scientific Organising Committee includes: Nair Abreu (Brazil), Peter Cameron (Scotland), Mirjam Dür (Germany), Ernesto Estrada (Scotland), Vyacheslav Futorny (Brazil), Stephen Kirkland (Canada), Yongdo Lim (Korea), Rachel Quinlan (Ireland), Peter Šemrl (Slovenia), Helena Šmigoc (Ireland), Françoise Tisseur (England), Paul Van Dooren (Belgium).

The conference proceedings will be published as a special issue of *Linear Algebra and its Applications*. The editors for this special issue are: Nicolas Gillis, Rachel Quinlan, Clément de Seguins Pazzis, and Helena Šmigoc. Peter Šemrl is the Editor-in-Chief of *LAA* responsible for this special issue.

Ongoing updates and more information about the conference can be found at <http://ilas2020.ie>.

**Due to the global COVID-19 emergency, the schedule of the conference/workshop has been changed. Please refer to the website for the latest news.**



<sup>1</sup> *Editor’s note:* With the addition of the ILAS conference to be embedded in the 2021 SIAM Conference on Applied Linear Algebra, the Galway meeting will become the 24<sup>th</sup> meeting of ILAS.

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## IMAGE PROBLEM CORNER: OLD PROBLEMS WITH SOLUTIONS

We present solutions to Problems 59-5 and 63-2. Solutions are invited to Problems 60-2, 61-3, 63-1, 63-3 and for all of the problems of issue 64.

### Problem 59-5: Domination in the Derangement Graph

Proposed by Rajesh PEREIRA, *University of Guelph, Guelph, Canada*, [pereirar@uoguelph.ca](mailto:pereirar@uoguelph.ca)

In graph theory, a subset  $D$  of the vertex set of a graph  $G$  is called a *dominating set* if every vertex of  $G$  not in  $D$  is adjacent to a vertex in  $D$ . The derangement graph of order  $n$ , denoted  $\Gamma_n$ , is the graph whose vertices are the  $n$  by  $n$  permutation matrices with an edge between  $P$  and  $Q$  if and only if  $\text{Tr}(P^T Q) = 0$ . Let  $C$  be the  $n$  by  $n$  permutation matrix with ones in the  $(i, i+1)$  place for all  $i$  with addition modulo  $n$  and  $J$  be the  $n$  by  $n$  permutation matrix with ones in the  $(i, n-i)$  place for all  $i$ . Show that  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  is a dominating set for  $\Gamma_n$  if and only if  $n$  is either equal to one, even or divisible by three.

### Solution 59-5 by the proposer

If  $n \leq 3$ , the set  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  contains all permutations in  $S_n$  and clearly is a dominating set, so we only need prove our result for  $n \geq 4$ . Let  $\sigma \in S_n$  be a permutation and let  $P$  be the permutation matrix with ones in the  $(\sigma(j), j)$ -entry for all  $j$  and zeros elsewhere. Let  $\{e_j\}_{j=1}^n$  be the standard basis. Then  $\text{Tr}(P^T C^k) = \sum_{j=1}^n e_j^T P^T C^k e_j = \sum_{j=1}^n e_{\sigma(j)}^T e_{j-k}$  (where the subscript  $j-k$  is taken modulo  $n$ ) and hence is equal to the number of solutions in  $j$  of  $j - \sigma(j) = k \pmod{n}$ . Similarly,  $\text{Tr}(P^T C^k J) = \sum_{j=1}^n e_j^T P^T C^k J e_j = \sum_{j=1}^n e_{\sigma(j)}^T e_{n+1-j-k}$  and hence is equal to the number of solutions in  $j$  of  $j + \sigma(j) = 1 - k \pmod{n}$ . It follows from this that  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  is a dominating set for  $\Gamma_n$  if and only if for all  $\sigma \in S_n$ , either the map  $f_\sigma(j) = j - \sigma(j)$  or  $g_\sigma(j) = j + \sigma(j)$  is not a bijection from  $\mathbb{Z}/n\mathbb{Z}$  to itself.

Note that if  $f_\sigma$  is a bijection then  $\frac{n(n-1)}{2} \equiv \sum_{j=0}^{n-1} f_\sigma(j) \equiv \sum_{j=0}^{n-1} j - \sum_{j=0}^{n-1} \sigma(j) \equiv 0 \pmod{n}$  which is impossible if  $n$  is even. Therefore if  $n$  is even, then  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  is a dominating set for  $\Gamma_n$ . Similarly, if  $f_\sigma$  and  $g_\sigma$  are both bijections, then  $\frac{(n-1)n(2n-1)}{3} \equiv \sum_{j=0}^{n-1} f_\sigma(j)^2 + \sum_{j=0}^{n-1} g_\sigma(j)^2 \equiv 2(\sum_{j=0}^{n-1} j^2 + \sum_{j=0}^{n-1} \sigma(j)^2) \equiv 2 \frac{(n-1)n(2n-1)}{3} \pmod{n}$  or equivalently  $\frac{(n-1)n(2n-1)}{3} \equiv 0 \pmod{n}$ . Since this equation is false if  $n$  is divisible by three, it follows that in this case also  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  is a dominating set for  $\Gamma_n$ . Finally, suppose  $n > 1$  and  $\gcd(n, 6) = 1$ . Let  $\tau(k) = 2k \pmod{n}$ . Note that  $\tau \in S_n$  since  $n$  is odd. Then  $f_\tau(k) = -k$  is always a bijection from  $\mathbb{Z}/n\mathbb{Z}$  to itself and  $g_\tau(k) = 3k$  is a bijection from  $\mathbb{Z}/n\mathbb{Z}$  to itself since  $n$  is not divisible by 3. Therefore  $\tau$  is neither in or nor adjacent to  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$ .

*Editor's note:* A permutation is not adjacent to  $\{C^k\}_{k=0}^{n-1} \cup \{C^k J\}_{k=0}^{n-1}$  if and only if it represents  $n$  non-attacking queens on an  $n$ -by- $n$  toroidal chessboard. It was shown by Pólya that we can have  $n$  non-attacking queens if and only if  $\gcd(n, 6) = 1$ .

### Problem 63-2: Normal Principal Submatrices of a Normal Matrix

Proposed by Achiya DAX, *Hydrological Institute, Jerusalem, Israel*, [dax20@water.gov.il](mailto:dax20@water.gov.il)

Let  $E = \{z \in \mathbb{C} : |z - z_0| > r\}$  be the exterior of a circle of radius  $r$  and centre  $z_0$  in the complex plane, where  $r$  and  $z_0$  are arbitrary fixed positive and complex numbers, respectively. Let  $M$  be a normal matrix and  $N$  be a normal principal submatrix of  $M$  of any order. Show that the number of eigenvalues (counted with multiplicity) of the submatrix  $N$  which lie in  $E$  is always less than or equal to the number of eigenvalues of  $M$  which lie in  $E$ .

### Solution 63-2 by Pan Shun LAU, *University of Nevada, Reno, USA*, [panlau@connect.hku.hk](mailto:panlau@connect.hku.hk)

Let  $z_0 \in \mathbb{C}$ ,  $r > 0$  and  $E = \{z \in \mathbb{C} : |z - z_0| > r\}$ . Assume  $M$  is an  $n \times n$  normal matrix and  $N$  is an  $m \times m$  normal principal submatrix of  $M$ . By replacing  $M$  with  $M - z_0 I$  if necessary, we may assume without loss of generality that  $z_0 = 0$ . Let  $\lambda_1, \lambda_2, \dots, \lambda_n$  be the eigenvalues of  $M$  with  $|\lambda_1| \geq |\lambda_2| \geq \dots \geq |\lambda_n|$  and  $\alpha_1, \alpha_2, \dots, \alpha_m$  be the eigenvalues of  $N$  with  $|\alpha_1| \geq |\alpha_2| \geq \dots \geq |\alpha_m|$ . Observe that  $|\lambda_j|$  ( $j = 1, \dots, n$ ) and  $|\alpha_i|$  ( $i = 1, \dots, m$ ) are singular values of  $M$  and  $N$ , respectively. It suffices to show that for every  $i = 1, \dots, m$ ,  $|\lambda_i| \geq |\alpha_i|$ . This is a consequence of the interlacing property of singular values [1, Theorem 1].

### Reference

- [1] R. C. Thompson. Principal submatrices. IX. Interlacing inequalities for singular values of submatrices. *Linear Algebra Appl.*, 5:1-12, 1972.

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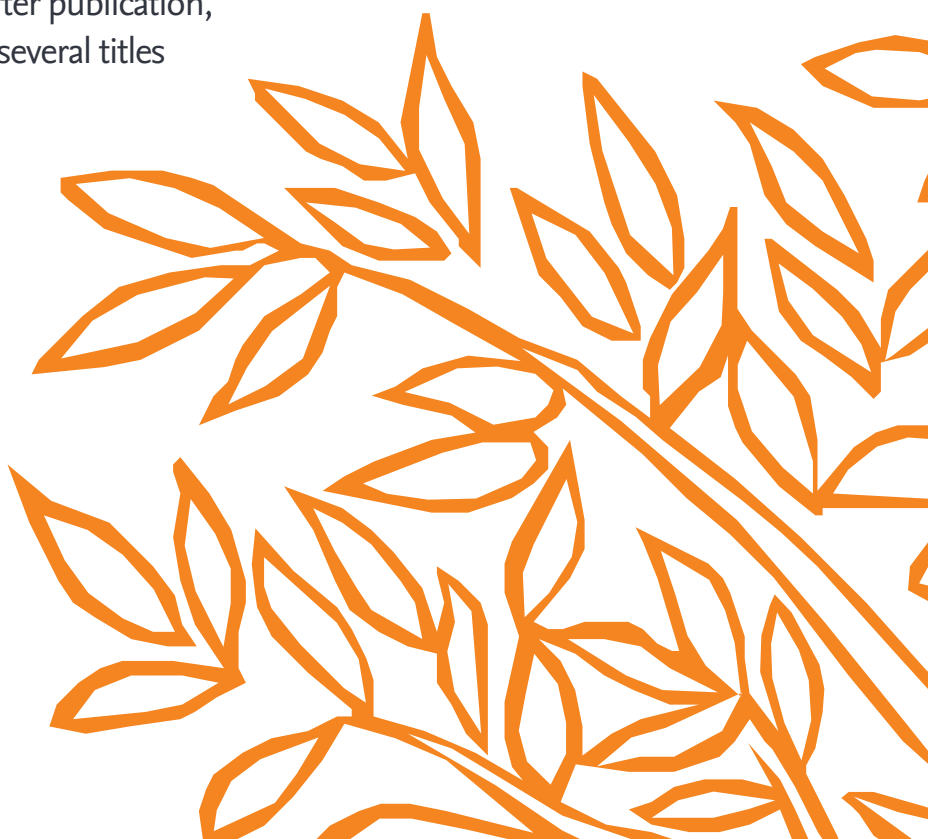
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## IMAGE PROBLEM CORNER: NEW PROBLEMS

**Problems:** We introduce five new problems in this issue and invite readers to submit solutions for publication in *IMAGE*.

**Submissions:** Please submit proposed problems and solutions in macro-free L<sup>A</sup>T<sub>E</sub>X along with the PDF file by e-mail to *IMAGE* Problem Corner editor Rajesh Pereira ([pereirar@uoguelph.ca](mailto:pereirar@uoguelph.ca)).

### NEW PROBLEMS:

#### Problem 64-1: A Matrix Limit

Proposed by Dennis S. BERNSTEIN, *University of Michigan, Ann Arbor, MI, USA*, [dsbaero@umich.edu](mailto:dsbaero@umich.edu)

and Ankit GOEL, *University of Michigan, Ann Arbor, MI, USA*, [ankgoel@umich.edu](mailto:ankgoel@umich.edu)

and Syed Aseem Ul ISLAM, *University of Michigan, Ann Arbor, MI, USA*, [aseemisl@umich.edu](mailto:aseemisl@umich.edu)

and Tam NGUYEN, *University of Michigan, Ann Arbor, MI, USA*, [Tam.Nguyen@ieee.org](mailto:Tam.Nguyen@ieee.org)

Suppose  $P$  is a real  $n \times n$  (symmetric) positive semidefinite matrix and  $M$  is a real  $n \times m$  matrix with the range of  $M$  being equal to the range of  $P$ . Find a closed-form expression for  $\lim_{\lambda \rightarrow 0^+} \frac{1}{\lambda} [P - PM(\lambda I_m + M^T P M)^{-1} M^T P]$ .

#### Problem 64-2: Simple Neo-Pythagorean Means

Proposed by Richard William FAREBROTHER, *Bayston Hill, Shrewsbury, England*, [R.W.Farebrother@hotmail.com](mailto:R.W.Farebrother@hotmail.com)

This question explores when a perfect square is the arithmetic or harmonic mean of two distinct perfect squares.

- (a) Suppose that  $x, y, z \in \mathbb{N}$  with  $x < y < z$ . Show that  $y^2$  is the arithmetic mean of  $x^2$  and  $z^2$  if and only if there exists a right-angle triangle whose hypotenuse has length  $y$  and whose other two sides have lengths  $\frac{z-x}{2}$  and  $\frac{z+x}{2}$ .
- (b) Suppose that  $x, y, z \in \mathbb{N}$  with  $x < y < z$ . Show that  $y^2$  can never be the harmonic mean of  $x^2$  and  $z^2$  (i.e.,  $2/y^2 = 1/x^2 + 1/z^2$  has no integer solutions except when  $x = y = z$ ).

#### Problem 64-3: $2 \times 2$ Matrix Diagonalization

Proposed by Fuzhen ZHANG, *Nova Southeastern University, Fort Lauderdale, Florida, USA*, [zhang@nova.edu](mailto:zhang@nova.edu)

Let  $F$  be a field and let  $M_n(F)$  be the set of all  $n \times n$  matrices with entries in  $F$ . A matrix  $M \in M_n(F)$  is said to be *diagonalizable* over  $F$  if there exist  $D$  a diagonal matrix in  $M_n(F)$  and  $S$  an invertible matrix in  $M_n(F)$  such that  $M = SDS^{-1}$ . Let  $A = (a_{ij})$  be a  $2 \times 2$  symmetric matrix over  $F$  whose off-diagonal entries are nonzero. It is well-known that if  $F = \mathbb{R}$ , then the real symmetric matrix  $A$  will always be diagonalizable. Now let  $\Theta_A = \frac{a_{11} - a_{22}}{a_{12}}$ .

- (a) Show that if  $F = \mathbb{C}$ , then  $A$  is diagonalizable over  $\mathbb{C}$  if and only if  $\Theta_A \neq \pm 2i$ .
- (b) Show that if  $F = \mathbb{Q}$ , then  $A$  is diagonalizable over  $\mathbb{Q}$  if and only if there exist  $m, n \in \mathbb{N}$  such that  $\Theta_A = \frac{m^2 - n^2}{mn}$ .

#### Problem 64-4: A Matrix Equation

Proposed by Rajesh PEREIRA, *University of Guelph, Guelph, Canada*, [pereirar@uoguelph.ca](mailto:pereirar@uoguelph.ca)

Let  $A$  be an  $n \times n$  complex matrix with  $\text{Tr}(A) = 0$  and with all nonzero eigenvalues having multiplicity one. Show that there exist invertible matrices  $P$  and  $Q$  such that  $PAP^{-1} + QAQ^{-1} = A$ .

#### Problem 64-5: Symmetry of a Sum of Permutation Matrices

Proposed by Yue LIU, *Fuzhou University, Fujian, China*, [liuyue@fzu.edu.cn](mailto:liuyue@fzu.edu.cn)

and Fuzhen ZHANG, *Nova Southeastern University, Fort Lauderdale, Florida, USA*, [zhang@nova.edu](mailto:zhang@nova.edu)

Let  $P = (p_{ij})$  be the basic circulant permutation matrix of order  $n$ ; that is,  $p_{i,i+1} = 1$  for  $i = 1, 2, \dots, n-1$ , while  $p_{n1} = 1$ , and all other entries are equal to 0. Let  $i$  and  $j$  be nonnegative integers. Show that  $P^i + P^j$  is a symmetric matrix if and only if either (a)  $n$  divides  $i + j$ , or (b)  $n$  is even and  $\{i, j\} = \{0, \frac{n}{2}\} \pmod{n}$ .

*Solutions to Problems 59-5 and 63-2 are on pages 32-32.*