Rochester Academy of Science

BULLETIN

"An organization of people in the Natural Sciences"

March 2023; Vol. 77, #3

President's Message

The Rochester Academy of Science Annual Meeting & Spring Lecture is Wednesday, April 26, 7:15 p.m.

This live meeting (with Zoom broadcast) will be at Rochester Institute of Technology's Golisano Hall, room 1400, with directions to be sent with the April Bulletin. After a short introduction, the Board of Directors election will be conducted at the business meeting. A ballot is included on this page and as a PDF with the Bulletin distribution to members. Please show us your support by printing and mailing your completed ballot to **RAS, P.O. Box 92642, Rochester NY 14692-0642**. You will also be able to vote at the meeting through the Zoom Chat function. **Note that you must have renewed your membership by March 31st.** We cannot take email ballots, but we will send proxy directions next month.

The Spring Lecture will begin at 7:30 p.m. following the business portion of the meeting. We are delighted to have Dr. Paul D. Curtis as our guest speaker. He is Professor of Wildlife Science in the Department of Natural Resources and Environment at Cornell University.

Dr. Curtis specializes in human-wildlife conflicts in suburban, forested, and agricultural landscapes, wildlife fertility control, and resolving community-based wildlife issues. He is an author on 135 research papers, including several specifically on black bears. Dr. Curtis is a co-author of the National Wildlife Control Training Program, and a Certified Wildlife Biologist® with The Wildlife Society.

Black bear raiding a backyard bird feeder. (photo credit Dr. Curtis)

Dr. Curtis states that "*management of black bears in New York State is a success story. During the past decade, populations in the southern part of the state have grown, and bears have expanded their range northward. Abundance of bears in the Adirondacks and northern NYS has remained relatively stable. Bears can now be seen in almost any NYS county, and they are becoming more abundant near suburban communities. Consequently, conflicts between bears and people sometimes occur. The most frequent concerns are damage to bird feeders, and bears rummaging through trash.*" In this presentation, Dr. Curtis will discuss bear biology, behavior, and ways to reduce potential human-bear conflicts.

Spring Lecture
Wednesday, April 26, 2023

Living with Black Bears in New York State

Presented by Dr. Paul D. Curtis, Cornell CALS

Dr. Curtis earned his Ph.D. in Zoology from North Carolina State University in 1990. See you there!

ROCHESTER ACADEMY OF SCIENCE
BALLOT FOR JUNE 2023 – MAY 2024 OFFICERS

OFFICE	NAME	√	WRITE-IN CANDIDATE
President:	Michael Grenier		
Vice President:	Jeff Gutterman, P.E.		
Treasurer:	Timothy Tatakis, Ph.D.		
Secretary:	Helen Downs Haller, Ph.D.		
Member, Board of Directors (2023-2026)	Douglas Kostyk		
Member, Board of Directors (2023-2026)	Karen L. Wolf		
Member, Board of Directors (2023-2025)	Theodore Lechman		
Member, Board of Directors (2023-2024)	Daniel Krisher		

Table 1: RAS board of directors ballot

2024 Eclipse Watch

March 1st, 2023 is just **404** days until the total solar eclipse passes through Rochester on Monday, April 8, 2024.

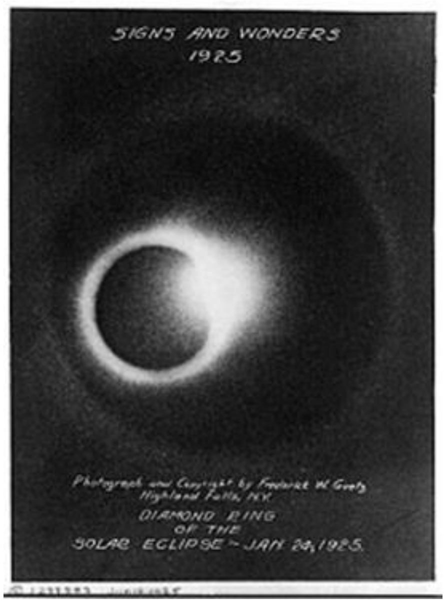
The last total eclipse in Western NY was over 98 years ago, way back on Jan. 24, 1925. The next one will not be until July 23, 2093—over 71 years

(President's Message, Continued on p.2)

(President's Message, Continued from p.1)

from now. The next Annular Solar Eclipse of July 2, 2057 will be only a partial eclipse with 77% coverage in Rochester. That's a dimming, not a darkening.

I hope this gives you a sense of how extraordinarily rare a total eclipse is here. In this 169-year interval, next year has the only one.



We are fortunate to have a photograph of the last one. *(Credit: Library of Congress)*

The Syracuse Herald reported the next day on January 25, 1925 that thousands of people in Syracuse and Central New York viewed the "phenomenon of the century" and pronounced it "impressive, awesome, magnificent and inspiring." Their team of reporters wrote that they saw the "flaming corona - masses of blazing fire shooting from the rim of the black spot in the sky." Viewing conditions were fairly good. Peak totality occurred at 9:11 a.m. and lasted two minutes. It was cold, with temperatures near zero, and with clouds occasionally obscuring parts of the eclipse. Most business was suspended as folks went out-of-doors for "the sight of a lifetime." Viewing in Rochester was also good. They were fortunate, as Buffalo and Niagara Falls were overcast, seeing none of the eclipse, only a darkening.

Michael Grenier, President RAS

***

Events for March 2023

1 Wed: Astronomy Board Meeting
7:00 p.m. Zoom only meeting. ASRAS members are welcome. Contact: Anthony Golumbeck at semp@use.startmail.com

2 Thu: Anthropology Section
Annual Archaeological Institute of America (AIA) Spring Lecture. 7:00 p.m. – 8:00 p.m. Memorial Art Gallery Auditorium. Speaker: Dr. Uzma Z. Rizvi is an Associate Professor of Anthropology and Urban Studies at Pratt Institute, Brooklyn, NY, and also the Principal Investigator for the Mohenjo-Daro project at the LIAVH. Topic: *Community Engagement in the Archaeology and Heritage of Pakistan: New Work at Mohenjo-Daro.*

3 Fri: Astronomy Members Meeting
7:30 p.m. – 10:00 p.m. RIT Carlson Center for Imaging Science, CAR-1125. Parking Lot F. Speaker: Jeremy Couturier, University of Rochester Ph.D. student. Topic: *A journey into Saturn's rotation: Why is it so tilted?* Contact: Anthony Golumbeck at semp@use.startmail.com

5 Sun: Astronomy Open House
Open House: 12:00 p.m. - 3:00 p.m. Observatory tours and work parties. Members may bring guests. Farash Center for Observational Astronomy, 8355 County Road 14, Ionia, NY 14475. For weather related cancellations or changes contact site manager Roger McDonough at rdmcdogz@aol.com or see www.rochesterastronomy.org/calendar-of-events

7 Tue: Fossil Section Meeting
7:30 p.m. Meeting will be held remotely via ZOOM and is open to all RAS Members and guests. Our distinguished guest is Dr. Derek Briggs, Professor of Earth & Planetary Sciences at Yale University and Curator at the Yale Peabody Museum of Natural History. This meeting will feature our 1st Annual Samuel Ciurca Memorial Lecture. Dr. Briggs will speak on *Remarkable fossils from Sam Ciurca's eurypterid collection*. The Yale Peabody Museum is the repository for the major part of Sam's lifelong collection. For meeting details and login info Contact Michael Grenier at paleo@frontier.com.

15 Wed: RAS Board Meeting
7:00 p.m. – 9:00 p.m. at Landmark Society Warner Castle on Mt. Hope Ave. Zoom option available. For details, contact Michael Grenier at mgrenier@frontiernet.net.

18 Sat: Life Sciences - Herbarium Workshop
10:00 a.m. – 2:00 p.m. The Life Sciences section will hold a workshop at the RAS Herbarium, located in the basement of the Rochester Museum and Science Center (RMSC). We ask that those attending be fully vaccinated, due to the close quarters in the herbarium. You may bring a lunch or buy lunch at the Cafe.If you plan to attend, please send RSVP or any inquiries to Elizabeth Pixley, herbarium curator, at eypixley@gmail.com, or call (585) 334-0977.

28 Tue: Mineral Section Meeting
7 p.m. Zoom and in-person meeting (members will receive venue information in March). Speaker: Daniel Robertson, Associate Professor, Geosciences and Chair, Chemistry and Geosciences at Monroe Community College. Topic: *Minerals, Mining, and Alternate Energy*. Guests welcome. Contact: Jutta Dudley juttasd@aol.com).

***

RAS 2022 Fall Paper Session Oral Presentation and Display Table

Paul Jacob, Logan Kusher, Unoma Okoye, Connor Levine, Ahmad Elrakhawi, Ashleigh Hunt, Mark Indovina, and Santosh Kurinec, Ph.D. Electrical & Microelectronic Engineering, Rochester Institute of Technology.

Celebrating 75 Years of the Bipolar Junction Transistor (BJT): Looking Inside the Apollo Guidance Computer BJT Logic Chip.

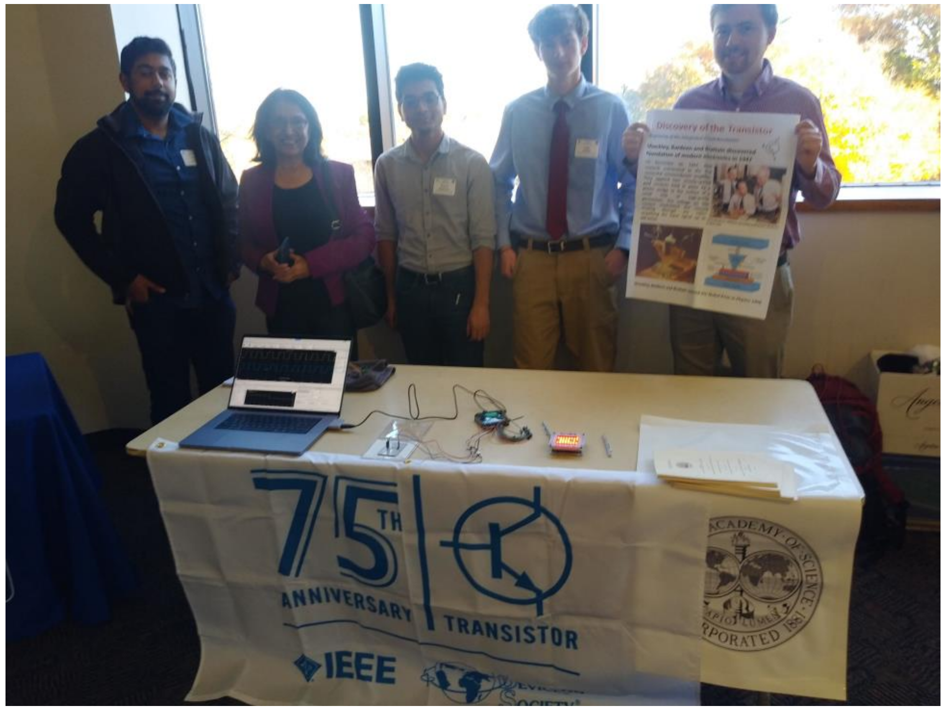


Figure 1: Dr. Santosh Kurinec with her RIT Microelectronics Students at the October 29, 2022, RAS Paper Session at the Rochester Museum and Science Center. (Photo credit: RAS Bulletin Editor)

Abstract

The Electron Devices Society is celebrating the year 2022-2023 as the 75th Anniversary of the Transistor. In 1947, John Bardeen, Walter Brattain and William Shockley developed the solid-state semiconductor switch that replaced the bulky vacuum tube. The Apollo Guidance Computer (AGC) was the first recognizably modern embedded system, used in real-time by astronaut pilots to collect and provide flight information, and to automatically control all the navigational functions of the Apollo spacecraft. It is notable for being one of the first IC based computers. Each chip contained a pair of logic gates, and each gate was a simple electronic switch that monitored three inputs and turned its output to "off" if any of the inputs were "on" — that is, a 3-input NOR gates, using bipolar junction transistors (BJT). Some 5,600 of these, arranged in a sequence, formed the digital cascade that was the computer's brain. We received the original chip of Apollo 11 from Eldon Hall, the leader of hardware design of the AGC, and tested it in our lab at RIT to recreate it as an IEEE sponsored project. This presentation presented our inside look at the chip, its design and test results of the gates and devices within this chip.

Oral Presentation

Elden Hall, June 15, 1923 - May 25, 2022, was the leader of the hardware design effort throughout the development of the AGC, and pioneered the use of integrated circuits (ICs) in the design of the Apollo AGC.

Figure 2: Recent photo of Elden Hall, shared by his daughter Pamela Hall holding a box of his AGC chips.

The AGC chip we received from Elden Hall is physically shown below in figure 3, the logical pinout is shown in the left of figure 4, and the transistor pinout is shown in the right of figure 4. The breadboard of the actual circuit used to test the characteristics of the device is shown in figure 5.

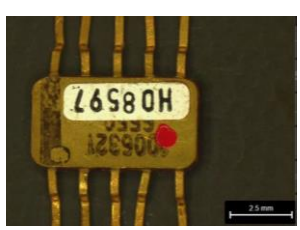


Figure 3: Photo of actual AGC chip received from Elden Hall

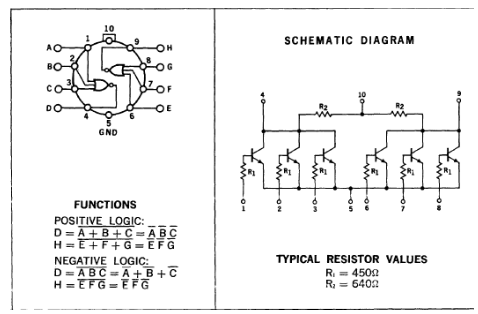


Figure 4. Left: Logical pinout of the AGC Chip, including its Boolean logic. Right: Electronic schematic and pinout of the AGC Chip.

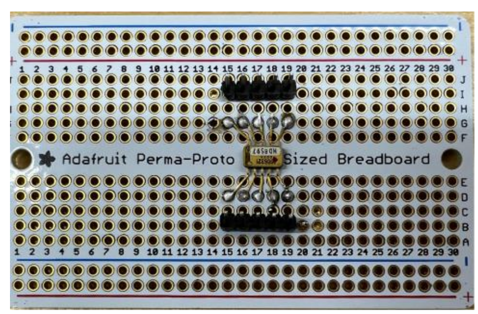


Figure 5: photo of breadboard used to perform device test on the AGC chip.

<u>Junction diode testing</u>

Each AGC chip has 6 npn transistors. The physical structure of each npn transistor is seen in cross section in figure 6 below. Each transistor consists of a base (B) - emitter (E) p-n junction and a base (B)-collector (C) p-n junction. Each p-n junction acts similar to a diode.

(Continued on p.4)

(Continued from p.3)

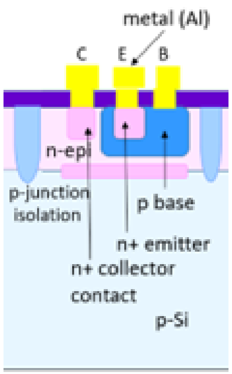


Figure 6: Cross section of a single npn transistor of the AGC Chip.

To test the V-I (voltage -current) characteristics of the B-E p-n junction, a varying voltage is applied across the terminals on the left side of figure 7 and the resulting current measured. The V-I curve of figure 8 was the result. Similarly, the B-C junction at the right side of figure 7 is measured, resulting in figure 9.

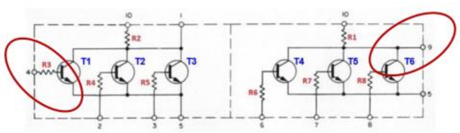


Figure 7: Red circles indicate-E p-n junction terminals on left, and B-C p-n junction terminals on right.

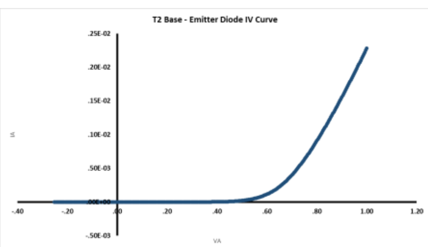


Figure 8: B-E p-n junction V-I characteristic

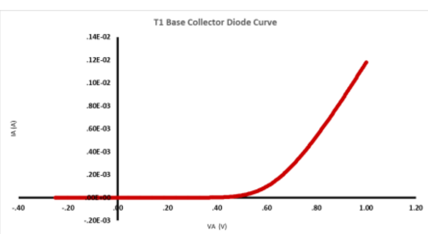


Figure 9: B-C p-n junction V-I characteristic

Transistor Curve Trace

The transistor is a 3-terminal device which acts as a current amplifier. The Current Gain β = Collector Current/Base Current (I_c/I_b) is fairly constant over the linear range of operation.

Figure 10 shows the transistor as a 2-port device as well as the relationships between base, collector, and emitter currents.

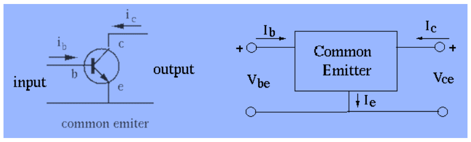


Figure 10. Left: direction of current in an npn junction transistor. Right: The transistor modeled as a two-port network.

Figure 11 shows the relationship between the currents of figure 10 and the internal charge carriers, both negative electrons and positive “holes” of the doped semiconductors constituting the n, p, and n doped semiconductors.

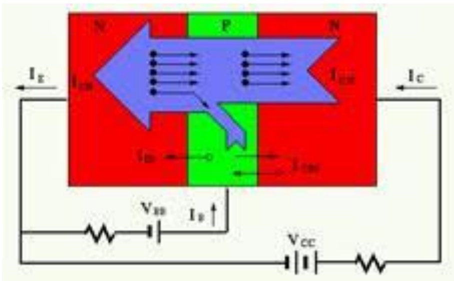


Figure 11: Test circuit and direction of currents and voltages and movement of electrons (black circles) and holes (missing electrons – positive charge carriers).

Figure 12 shows how the Source Measure Unit (SMU) test device is set up to drive the B, C, and E terminals of the transistor while simultaneously measuring them. The result is the family of curves shown in figure 13.

Using the tools described above, the I-V characteristics was measured. TABLE III describes the probe and SMU setting used to obtain the I-V family of curves.

TABLE III. Probe SMU setting for 3-input NOR gate

Pin Number	SMU	SMU type	Measure	Bias
2	SMU2	STEP	IB	0-0.1mA, 6 steps
4	SMU1	COMM	VE	0V
6	SMU4	SWEEP	IC, VC	0-5V, 21 steps

Figure 12: SMU Test equipment settings used to generate transistor gain curve of figure 14.

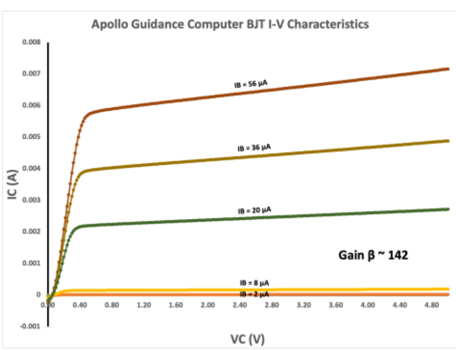


Figure 13: Family of transistor 2-port parameters generated by varying I_B and V_C and measuring I_C.

Dynamic Gate Test

The dynamic response of the NOR gate transistors as a logical device is measured.

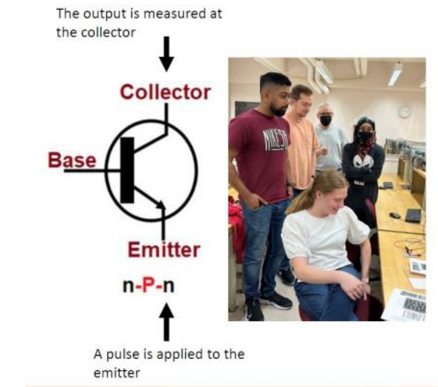


Figure 14: AGC chip team performs dynamic measurements.

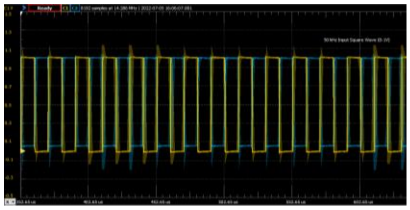


Figure 15: The yellow trace is the input, and the blue trace is the output. Even at high frequencies such as 50 kHz, the output still follows the input, inverting.

AGC Chip Geometries

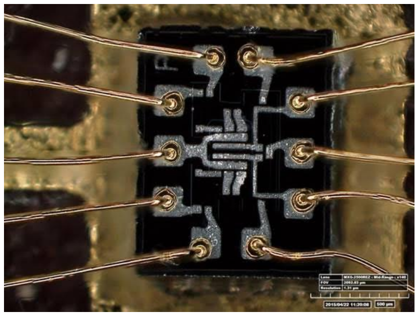


Figure 16: Microscopic view of dual, three-element NOR gate, the inside of a silicon chip, used in Apollo. Photo: Lisa Young, Smithsonian (https://airandspace.si.edu/stories/editorial/apollo-guidance-computer-and-first-silicon-chips)

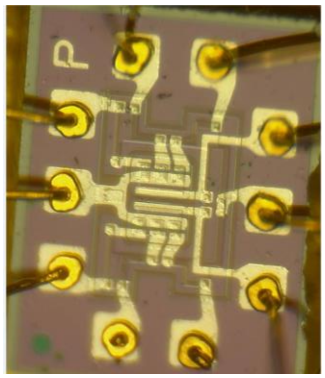


Figure 17: View of the semiconductor structures below the top insulating layer and the gold metal interconnects.

(Continued on p. 5)

(Continued from p.4)

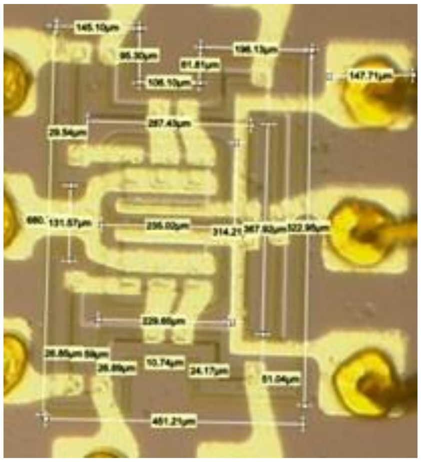


Figure 18: Same as figure 17 but with device measurements

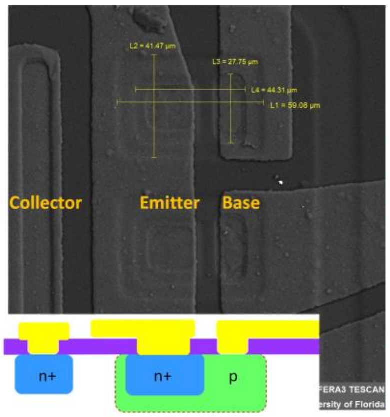


Figure 19: AGC Chip pnp transistor structure viewed under a TESCAN scanning electron microscope, revealing greater detail.

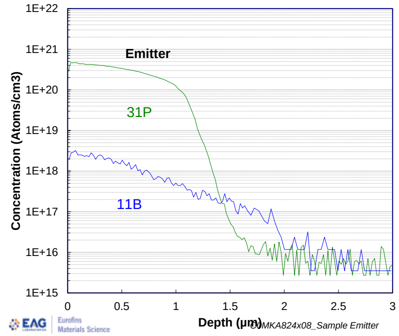


Figure 20: AGC Chip Doping Profiles measured by Secondary Ion Mass Spectrometry (SIMS) in the Emitter and the Base

Ongoing Work for Recreating the AGC Chip

- Design masks,
- Develop the process
- Carry out simulations
- Make masks
- Run the process at the RIT Micro-electronic Engineering cleanroom.

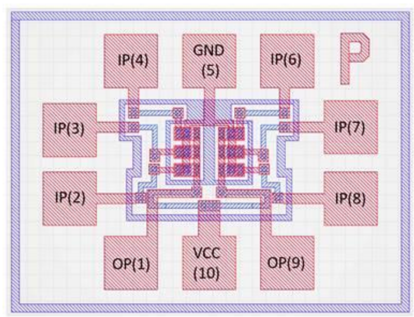


Figure 20: Mask Design layout created at RIT

Conclusions

We have led the creation of a team to rebuild the Apollo Guidance Computer Chip in a student run lab.

The original chip was tested, and the electrical tests show the device functioning just as designed 54 years ago.

Interest from a number of iconic people and institutions has been expressed to get an RIT-made AGC chip!

Acknowledgements

The authors acknowledge the immense support from Jimmie Wayne Loocke, former NASA Technician, and founder of Space Computer Org for his interest and connecting us with Eldon Hall; and Professor Navid Asadi's group from University of Florida for chip inspection. Special thanks to the IEEE Electron Devices Society (EDS) for supporting this work under the Semiconductor STEM Outreach program.

***

RAS 2022 Fall Paper Session Oral Presentation

Sophia Sosa Fiscella and Michael T. Lam, Ph.D., Rochester Institute of Technology.

Dispersion Measure Misestimations with Varying Bandwidths.

The detection of long-period gravitational waves involves the utilization of pulsars as celestial precision clocks through the technique known as pulsar timing. However, this implies measuring all possible sources of error in our observations. One of those sources is interstellar dispersion (DM). In this work, we calculate the offsets in the infinite-frequency arrival time of pulsar observations due misestimations in the modeling of interstellar dispersion when using varying-bandwidth backends at the Green Bank Telescope. We use a set of broadband pulsar observations, artificially restricted them to a narrowband frequency range, and then use both datasets to calculate residuals with a simplified timing model that does not include short-scale dispersion variations. By fitting the resulting residuals to a dispersion model, and comparing the ensuing fitted parameters, we quantify the dispersion misestimations when using varying bandwidths. We find that for high-DM pulsars the measurements suffer from a system offset of ~22 pc cm^{-3} due to DM-misestimations when using narrowband receivers, with correlations over a timescale of ~1 month. For lower-DM pulsars, the offset is closer to ~5 pc cm^{-3}. This error quantification can then be used to correct legacy data, thereby increasing the currently available time baseline and, hence, the gravitational wave sensitivity.

Dr. Michael T. Lam, Physics and Astronomy, RIT. (Credit: RIT)

***

RAS 2022 Fall Paper Session Poster Presentation

Michael T. Lam, Ph.D. Rochester Institute of Technology.

Autoregressive Models for Pulsar Dispersion Measure Timeseries.

Abstract

Changes in the line of sight between the Earth and a pulsar result in well-known variations in pulsar dispersion measure (DM) timeseries. These include stochastic variations from the turbulent interstellar medium as well as systematic variations from the changing line of sight. We have developed the statistical framework to describe both aspects of DM timeseries using an extended family of autoregressive moving average (ARMA) models. With our models and simulated data, we show the efficacy of the method in estimating parameters of the data, such as the electron-density wavenumber spectral index. We also apply our method to the observed timeseries of the Crab Pulsar. Modeling of the DM timeseries from multiple pulsars can yield further constraints on global parameters, allowing for the creation of a "pulsar insterstellar medium array" analogous to pulsar timing arrays but for the detection of electron-density variations from common or correlated mechanisms.

Poster

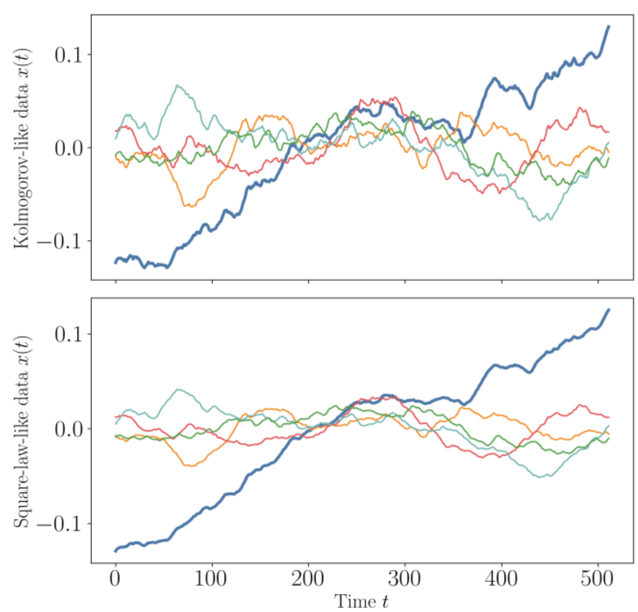
Radio pulsar emission travels through free electrons in the ionized interstellar medium. The light is subject to many different *optical* effects just like visible light traveling through a prism or the atmosphere. The dominant effect for radio waves is *dispersion*, in which the light is *dispersed* so that longer wavelengths (redder light) are delayed and arrive later at the observatory than shorter wavelengths (bluer light). The time delay is inversely proportional to the frequency of light squared (ν^{-2}) and directly proportional to the *Dispersion Measure* (DM), the integrated electron density along the line of sight from the pulsar to the Earth, DM = $\int n_e(l)\, dl$.

Dr. Michael T. Lam (right) and Sophia Sosa Fiscella (second from right) with students at the October 29, 2022, RAS Paper Session at the Rochester Museum and Science Center.
(Photo credit: RAS Bulletin Editor)

Time-variations of DM are well known in the literature and there have been many methods of modeling them, including with piecewise constants (DMX), trend analyses, and Gaussian process regression. Physical mechanisms include the line of sight passing through the turbulent medium, solar wind, filaments, compact plasma lenses, and more. *We are working to separate the **signature of turbulence** in the **interstellar medium** as observed in pulsar timeseries from other time-varying effects.*

Shown below are different realizations for two types of turbulent mechanisms (top: Kolmogorov, bottom: square-law). One of the realizations has a small linear trend added to it, which might result from the Earth and pulsar moving towards or away from each other.

***



Different Realizations for Two Types of Turbulent Mechanisms — Top: Kolmogorov, Bottom: Square-Law.

ROCHESTER AREA COLLOQUIA

University of Rochester

Department of Physics and Astronomy
https://www.pas.rochester.edu/news-events/events/index.html

Department of Biology
https://www.sas.rochester.edu/bio/news-events/seminars.html

Department of Earth and Environmental Sciences
https://www.sas.rochester.edu/ees/news-events/seminars.html

Department of Biochemistry and Biophysics
https://www.urmc.rochester.edu/biochemistry-biophysics/events.aspx

Department of Mathematics
https://www.sas.rochester.edu/mth/news-events/events/index.html

RIT

Neuroscience – March 1: Dr. Bill Geisler. *Finding Targets in Noise and Natural Backgrounds.*
https://www.rit.edu/events/college-science-distinguished-speaker-bill-geisler

Life Sciences and Genetics – March 3: Adam Rutherford. Author of *How to Argue with a Racist*
https://www.rit.edu/events/inclusive-excellence-seminar-adam-rutherford-author-how-argue-racist

Neuroscience – March 6: Dr. Newton Howard. *From Battlefield to Brain Science*
https://www.rit.edu/events/golisano-college-computing-and-information-sciences-deans-lecture-series-speaker-dr-newton-howard

Chemistry – March 8: Dr. Peidong Yang. *Liquid Sunlight*
https://www.rit.edu/events/cos-john-wiley-jones-distinguished-speaker-peidong-yang

Computational Relativity and Gravitation – March 10: Dr. Luciano Rezzolla. *Binary Neutron Stars*
https://www.rit.edu/events/center-computational-relativity-and-gravitation-colloquium-dr-luciano-rezzolla-binary-neutron-stars

University at Buffalo

Department of Physics
For details see: https://arts-sciences.buffalo.edu/physics/news-events/upcoming-events/colloquium-seminar-series.html

Department of Biological Sciences
https://arts-sciences.buffalo.edu/biological-sciences/news-events/events.html

Center for Cognitive Science
https://arts-sciences.buffalo.edu/cognitive-science/events/colloquia-series.html

Department of Chemistry
https://arts-sciences.buffalo.edu/chemistry/news-events/seminars/foster-colloquium.html

Department of Biochemistry
https://medicine.buffalo.edu/departments/biochemistry/news_and_events/events.html

Department of Biomedical Engineering
https://engineering.buffalo.edu/bme/news-events/upcoming_events.html

Cornell University

Department of Physics
https://physics.cornell.edu/upcoming-colloquia

Department of Psychology
https://psychology.cornell.edu/colloquium-schedule

Department of Astronomy
https://astro.cornell.edu/events

Department of Mathematics
https://pi.math.cornell.edu/m/Colloquia/bulletin.html

Department of Chemistry
https://chemistry.cornell.edu/seminars-and-lectures

Department of Earth and Atmospheric Sciences
https://www.eas.cornell.edu/eas/events

Paleontological Research Institution
https://www.priweb.org/visit/events

Museum of the Earth
https://www.museumoftheearth.org/visit/events

School of Engineering
https://www.engineering.cornell.edu/events

Department of Cognitive Science
https://events.cornell.edu/search/events?search=cogscievents

Department of Anthropology
https://events.cornell.edu/search/events?search=anthro

Department of Archeology
https://events.cornell.edu/search/events?search=ciamscal

Department of Molecular Biology and Genetics
https://cals.cornell.edu/molecular-biology-genetics/colloquia/events-seminars

College of Agriculture and Life Science
https://cals.cornell.edu/about/newsroom/events

Center for Applied Mathematics
https://www.cam.cornell.edu/cam/events

School of Biomedical Engineering
https://www.bme.cornell.edu/bme/events

Rochester Engineering Society

https://www.roceng.org/Calendar

***

ROCHESTER AREA RESEARCH IN REVIEW

Single gene causes sea anemone's stinging cell to lose its sting. February 23, 2023, Cornell University.

Archaeologists uncover early evidence of brain surgery in Ancient Near East. February 22, 2023, University of Albany.

Air pollution speeds bone loss from osteoporosis. February 21, 2023, University at Buffalo.

Better tools needed to determine ancient life on Mars. February 21, 2023, Cornell University.

Gene variations for immune and metabolic conditions have persisted in humans for more than 700,000 years: Genetic study of modern humans, Neanderthals, and Denisovans points to the importance of 'balancing selection' in evolution. February 21, 2023, University at Buffalo.

Perovskites, a 'dirt cheap' alternative to silicon, just got a lot more efficient. February 16, 2023, University of Rochester.

How a record-breaking copper catalyst converts CO2 into liquid fuels. February 16, 2023, Cornell University.

Canine distemper now threatens big cats in Nepal. February 16, 2023, Cornell University.

New models shed light on life's origin. February 10, 2023, University of Rochester.

'Ghostly' neutrinos provide new path to study protons. February 1, 2023, University of Rochester.

How to reduce the temptation to cheat: Empathy. January 30, 2023, University of Rochester.

New method to control electron spin paves the way for efficient quantum computers. January 30, 2023, University of Rochester.

Researchers identify neurons that 'learn' to smell a threat. January 24, 2023, University of Rochester.

New 'whipping jet' sprayer controls how aerosols move. January 20, 2023, University at Buffalo.

A star's unexpected survival. January 13, 2023, Syracuse University.

AI improves detail, estimate of urban air pollution. January 13, 2023, Cornell University.

How did the Butterfly Nebula get its wings? It's complicated. January 12, 2023, University of Rochester, RIT.

Wide diversity of galaxies in the early universe: Scientists use CEERS Survey to examine the structure and morphology of 850 high-redshift galaxies. January 9, 2023, RIT.

Air quality improvements lead to more sulfur fertilizer use. January 9, 2023, Syracuse University.

Newly discovered anatomy shields and monitors brain. January 5, 2023, University of Rochester.

Meaningful but unused products hinder sustainability. January 5, 2023, Cornell University.

ABOUT THE ACADEMY

The Rochester Academy of Science, Inc. is an organization that has been promoting interest in the natural sciences since 1881, with special focus on the western New York state region. Membership is open to anyone with an interest in science. Dues are minimal for the Academy and are listed in the membership application online. Each Section also sets dues to cover Section-related publications and mailings. We are recognized as a 501(c) 3 organization.

For information, contact President Michael Grenier at (585) 671-8738 or by email paleo@frontier.com.
The Academy Internet website is http://www.rasny.org or see us on Facebook at https://www.facebook.com/Rochester-Academy-of-Science-792700687474549.

This "**BULLETIN**" is produced monthly, except July and September, by the Rochester Academy of Science. Submissions are due by the 10th of the month and may be emailed to the editor, Theodore W. Lechman, at Theodore.W.Lechman@gmail.com.

The Academy postal address is P.O. Box 92642, Rochester NY 14692-0642.

ROCHESTER ACADEMY OF SCIENCE CONTACTS

		(585) home // work
Michael Grenier	President	671-8738
Dan Krisher	VP & Fossil	698-3147 (c)
Jutta Dudley	Past President	385-2368
Helen D. Haller	Secretary	387-9570
William Hallahan	Treasurer	624-1628
Alex Smith	Anthropology	750-3329 (c)
David Bishop	Astronomy	329-8831
Lawrence Hirsch	Life Sciences	429-6199
Stephen Busschaert	Mineral	351-7633 (c)
Michael Richmond	Director '24	586-7432
Tim Tatakis	Director '24	292-2332 (w)
Tony Golumbeck	Director '25	(315) 789-4374
Jeff Gutterman	Director '25	392-8299// 748-2272 (c)
Douglas Kostyk	Director '23	943-3419
Karen Wolf	Director '23	670-9709
Elizabeth Pixley	Herbarium	334-0977
Jutta Dudley	Publications	385-2368
Ted Lechman	Bulletin Editor	490-1132
William Hallahan	Student Grants	624-1628