Rochester Academy of Science

BULLETIN

"An organization of people in the Natural Sciences" *June-July 2022; Vol. 76, #6*

President's Message

Our Annual Meeting was held on April 14 and I thank all of you who gave a vote of confidence in your Board of Directors and Academy Officers. I look forward to continuing to work with your Board and Officers to deliver on the important programs of the Academy.

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The 23rd Annual **ADK Outdoor Expo** is featured on our calendar within for Saturday, June 11 in Mendon Ponds Park, Pittsford - Mendon. They will have over 60 workshops and demos — and three of them are from the Academy. Our Astronomy, Fossil, and Mineral Sections will have tables and equipment set up and will give away educational materials and specimens. I would love to see you there helping with this—it is good fun—but I would be just as happy to see you there as a visitor. Besides seeing us, there are lots of other interesting activities. Try out a kayak on 100-Acre Pond, go for a short hike, visit the Wild Wings birds of prey facility and the Mendon Ponds Park Nature Center, explore hiking, canoeing, kayaking, backpacking, camping, bicycling and bike repair, the petting zoo, music by the Golden Link Folk Singing Society, and many other events and displays.

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This Fall, on Saturday, October 29th, we will host the **48th Annual RAS Fall Scientific Paper Session**. We now call for RAS Member Abstracts.

As a member of the Academy with scientific interests, you are invited to present a poster or short talk. Are you working on projects, made any discoveries or been active in a citizen science activity? Let us hear about it!

The paper session will be held at the *Rochester Museum & Science Center*. This means there will be more interesting things to see and do than at most past sessions. We will be featuring our Life Sciences Section Herbarium collection of over 30,000 specimens, among other museum resources. This will be the first time since 1984 that RMSC has been host.

More information about the paper session and how you can sign up to present will be forthcoming on the RAS website and in the August Bulletin. In the meantime, think about what you might present! Otherwise, plan to come to hear about the latest local research in fields of interest to you and hear our annual Larry King Memorial Lecture.

Save The Date!
Saturday, October 29, 2022
RAS Scientific Paper Session
Rochester Museum & Science Center

2024 Eclipse Watch

On May 31, it will be just 678 days until the total solar eclipse that may be visible from Rochester (if not too cloudy) on Monday, April 8, 2024. It is not too soon to start making plans, especially contingency plans for a fast trip to elsewhere if it is forecast 7-10 days out to be too overcast or rainy to be visible from here. Many members from Rochester traveled to other parts of the country for the August 21, 2017 total eclipse. Being able to see the diamond ring effect and Baily's beads just before totality and the Sun's corona at maximum is worth the trip, if necessary.

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With the coming of fine weather, get out and enjoy the natural world around you. Take advantage of our field trips, our observatory, and collecting opportunities.

Michael Grenier, President RAS

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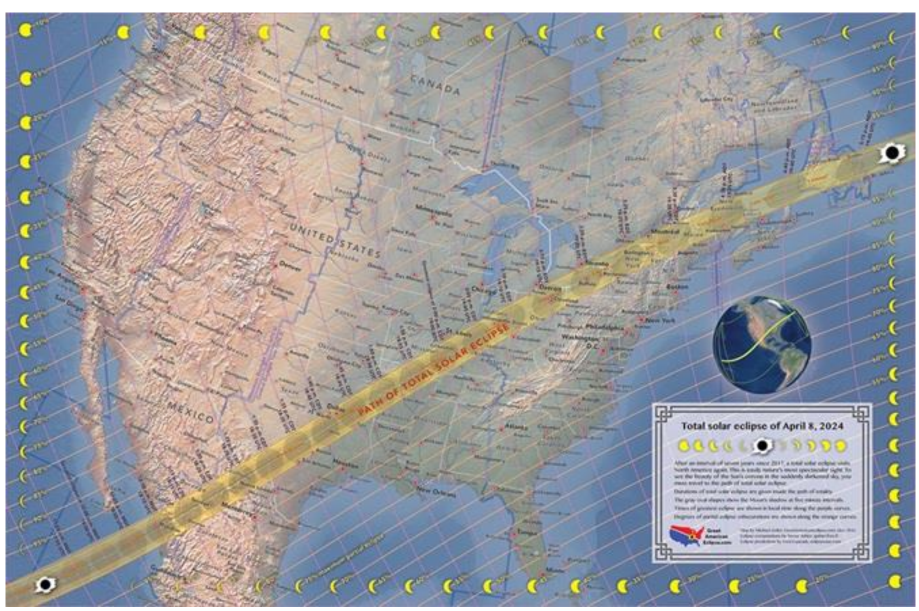

Solar Eclipse Totality Map from https://www.greatamericaneclipse.com/

Events for June 2022

For updates to events, check the Academy website http://www.rasny.org and section websites.

JUNE

1 Wed: Astronomy Board Meeting
7:00 p.m. Farash Education building at the Farash Center for Observational Astronomy in Ionia, NY. Also Zoom meeting. ASRAS members are welcome. Contact: Mark Minarich at mminaric@rochester.rr.com.

3 Fri: Astronomy Members Meeting
7:30 p.m. – 10:00 p.m. Wolk Education Center at Farash Center for Observational Astronomy, 8355 County Road, Ionia. Meeting will also be held virtually via Zoom. Speaker: The Buffalo Astronomical Association (BAA) will be presenting their observatory setup. Contact: Mark Minarich at mminaric@rochester.rr.com.

4 Sat: Astronomy Farash Observatory Cleanup Day
11:00 a.m. – 3:00 p.m. Pizza party. Farash Center for Observational Astronomy, Ionia NY. Contact Roger McDonough, site manager, at rdmcdogz@aol.com.

7 Tue: Joint Fossil/Mineral Section Picnic
6:00 p.m. – 8:00 p.m. The Fossil and Mineral sections will have their annual picnic in the Farash Educational Building at the Farash Center for Observational Astronomy in Ionia, NY. Sections will provide meat, rolls, condiments, and plates. For further details please consult the Section Presidents and Board members.

12 Sun: Astronomy Open House
Open House: 12:00 p.m. - 3:00 p.m. Observatory tours and work parties. Farash Center for Observational Astronomy, 8355 County Road. For cancellations contact Roger McDonough, site manager, at rdmcdogz@aol.com.

11 Sat: RAS at ADK Outdoor Expo. 9:30 a.m. – 3:30 p.m. Mendon Ponds Park, Pittsford NY. Contact your sections officers to help volunteer. Also see President's message on page 1 and the Event website at https://adk-gvc.org/play/outdoor-expo-before/.

NGC4725 - The One-Armed Bandit galaxy. While most spiral galaxies have two or more arms, this has just one prominent arm that wraps around it several times, although there are hints of some short secondary arms. The reason for this unusual arm configuration is its interaction with NGC4747, the galaxy at lower right. You can see the tidal streams of stars pointing from NGC4747 toward and away from NGC4725, indicating the two interacted in the past with a close pass. The third, small galaxy to the left is NGC4712.
(Photo credit: Dan Kuchta, Astronomy Section RAS.)

12 Sun: Astronomy Section Lecture Series/ Demonstration
1:00 p.m. Dave Thompson will give "A simple and repeatable Polar alignment technique" demonstration on the Observing Hill at the Farash Center for Observational Astronomy, 8355 County Road, Ionia. Contact: Mark Minarich at mminaric@rochester.rr.com.

15 Wed: RAS Board Meeting
7:00 p.m. Picnic and facility tour. Farash Educational Building at the Farash Center for Observational Astronomy in Ionia, NY. Also, virtual meeting using Zoom. For details, contact Michael Grenier at mgrenier@frontiernet.net.

18 Sat: Fossil Section Field Trip
Swamp Road and Pompey Center: These are family-friendly large roads cut north of Morrisville and east of Syracuse in central New York. For additional information contact Dan Krisher at DLKFossil@gmail.com.

22 Wed: Life Sciences - Herbarium Workshop
1:00 p.m. – 4 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). At RMSC go to the front desk to meet other participants. At RMSC go to the front desk to meet other participants. If you plan to attend, please send RSVP or any inquiries to Elizabeth Pixley, herbarium curator, at epixley@gmail.com, or call (585) 334-0977.

24 Fri: Astronomy Public Observing
7:30 p.m. – 11:00 p.m. or later. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich at mminaric@rochester.rr.com

(Calendar continued on p.3.)

Events for June-July 2022 (Continued)

JUNE - *continued*

25 Sat – 26 Sun: Astronomy Member Observing
New moon member observing, starting at dusk till last person leaves. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich at mminaric@rochester.rr.com.

JULY

6 Wed: Astronomy Board Meeting
7:00 p.m. Farash Education building at the Farash Center for Observational Astronomy in Ionia, NY. Also Zoom meeting. ASRAS members are welcome. Contact: Mark Minarich at mminaric@rochester.rr.com.

10 Sun: Astronomy Open House
Open House: 12:00 p.m. - 3:00 p.m. Observatory tours and work parties. Farash Center for Observational Astronomy, 8355 County Road. For cancellations contact Roger McDonough, site manager, at rdmcdogz@aol.com.

16 Sat: Fossil Section Field Trip
Little Beard's Creek**:** This is large shale exposure along Little Beard's Creek in a stream near Geneseo. For additional information contact Dan Krisher at DLKFossil@gmail.com.

16 Sat: Life Sciences - Herbarium Workshop
10:00 a.m. – 2 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). At RMSC go to the front desk to meet other participants. We will be working on re-mounting herbarium specimens; no special experience required. 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.

22 Fri – 23 Sat: Astronomy RocheStarfest
Friday evening and all-day Saturday. Farash Center for Observational Astronomy, Ionia, NY. See RochesterAstronomy.org for schedule of events.

30 Sat – 31 Sun: Astronomy Member Observing
New moon member observing, starting at dusk till last person leaves. Farash Center for Observational Astronomy, 8355 County Road 14 Ionia, NY 14475. For weather related cancellations or changes contact Mark Minarich at mminaric@rochester.rr.com.

30 Sat: Fossil Section Field Trip
Jaycox Run: The trip will visit the Jaycox Run site between Avon and Geneseo. For additional information contact Dan Krisher at DLKFossil@gmail.com.

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Graduate Student Research

Hunting Gravitational Waves Using Pulsars

Sophia Valentina Sosa Fiscella,
Laboratory for Multiwavelength Astrophysics (LLAMA), Rochester Institute of Technology.

Sophia Valentina Sosa Fiscella, RIT

(Editor's note: the following is a synopsis of a presentation Sophia Valentina Sosa Fiscella made to the Astronomy Section of the Rochester Academy of Science on April 1, 2022.)

Have you ever looked at a radio observation of a pulsar and been like "man, I bet I can use these things to detect a gravitational wave!" Well, neither have most people. But thanks to the cleverness of astronomers, the most promising technique for detecting long-period gravitational waves is using these dead stars known as "pulsars" as galactic gravitational waves detectors. The results are looking very promising so far!

Sophia will try to convince us that pulsars are among the coolest objects in the Universe. Everyone who's anyone in the astronomical community is talking about black holes, string theories, galaxies, and whatnot. But here, in the pulsar team, we've got something even better: we can use pulsars as galactic gravitational wave detectors! Can black holes do that? We don't think so!

By now we must be wondering: "Okay, but what are pulsars?" "How do they work?" "What's the connection between pulsars and gravitational waves?" "Why is she asking so many questions?" Well, all those questions will be answered here.

Introduction
But before we start, let us ask a question: "how many of us are familiar with the LIGO observatory and the detection of the first gravitational wave"? The detection of gravitational

(Continued on p. 4)

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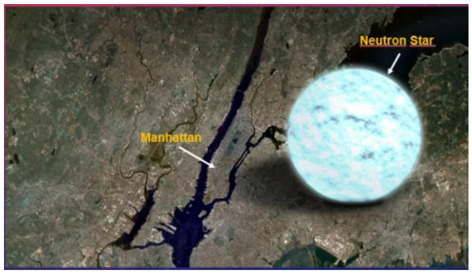
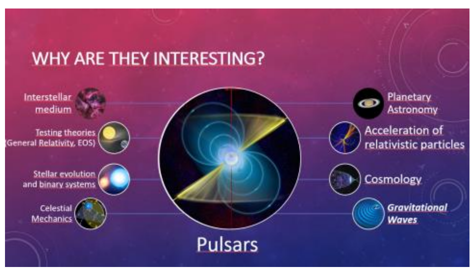
waves is a field of research that gained a lot of attention during the last 50 years or so. As of now, there are several gravitational waves detectors that are specifically engineered to detect *short-period* gravitational waves. That is, GWs with periods in the order of the milliseconds (in the case of Ligo and Virgo) or a month (in the case of LISA), which are usually generated by neutron star binaries and black hole binaries. These detectors have been doing a pretty darn good job, and in 2016 we had the first detection of a short-period gravitational wave, thereby confirming theoretical predictions that had been made over a century ago.
However, this is not the full story. Just as the electromagnetic spectrum has photons with a wide range of different wavelengths, so does the spectrum of gravitational waves. These Earth-based detectors are basically blind to this whole other side of the spectrum consisting of long-period gravitational waves, which are usually generated by massive black hole mergers and supermassive black hole binaries. Since the periods of these waves are bigger, then we're also going to need bigger detectors, the size of the whole Milky Way, and that's when pulsars come to save the day.

Pulsars

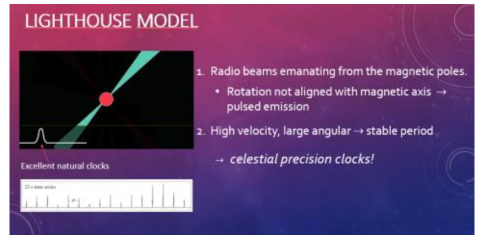
Some of us are well-versed in compact objects and need no introduction to pulsars, but just for the sake of it let us refresh our memory. Pulsars are a type of neutron star, that is, compact objects that are formed when a massive star undergoes a supernova collapse. In the process, a mass of nearly one and a half times the mass of our Sun is compressed in a sphere with a radius of 10km, about the size of Rochester city. Moreover, the conservation of angular momentum and magnetic flux leads to extremely high rotational speeds and incredibly strong magnetic fields. As a result, one get this extremely dense super magnet spinning in the sky at hundreds of revolutions per second. For perspective, this is what a neutron star would look like if it was placed on the Earth's surface. It's barely larger than a city, but inside that small sphere we have one and a half times the mass of our Sun. So, as we can see, they're indeed very dense objects.



Pulsars are like a playground for astrophysicists since they enable the study a wide range of phenomena: from the very big like testing cosmological theories and studying the interstellar medium, to the really small, such as studying the acceleration of relativistic particles and the behavior of matter at really high densities.

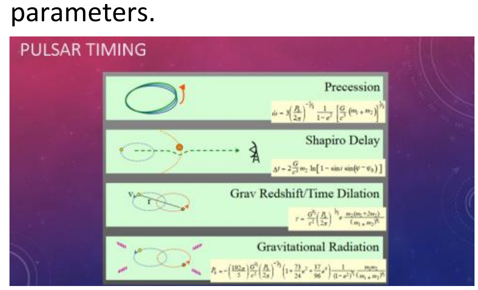


However, for our present purposes, we shall see how to use pulsars as gravitational waves detectors. What makes pulsar especially suitable for detecting gravitational waves is a combination of two ingredients:
First, they produce radio beams emanating from their magnetic poles, mainly in radio, gamma, and X-rays. Moreover, since the rotation axis is usually not aligned with the magnetic axis, this radio beam will be spinning around the rotation axis and we'll only see a pulse of radiation once per each rotational period, each time that the beam sweeps our visual view, just like a lighthouse.
Second, due to their high rotational speed and large inertia moment, the period of a pulsar (and, therefore, the spacing between two consecutive pulses) is highly regular. In that sense, pulsars work like celestial precision clocks. In fact, some pulsars are even better timekeepers than the atomic clocks here on Earth!



Now, if we have an antenna and a good clock here on Earth, then we'll be able to measure the time of arrival of the pulses coming from the pulsar. On the other hand, if we have some physical model describing the propagation of the pulses, we can also try to predict those times of arrival and see how well our predictions match the observations.

However, calculating the pulses' times of arrival is tricky since they are affected by several physical phenomena. For example,
The interstellar medium will produce a *dispersion* of the signal, where low-frequency pulses suffer a longer delay than the high-frequency ones.
If the pulsar is in a binary system, then the measured period of the pulses will be Doppler-shifted towards shorter periods when the pulsar is moving towards us, and longer periods when moving away. If we have a basic understanding of the physics behind each of these effects, then we can reduce them to their most fundamental mathematical equations and model them using a set of parameters.



The collection of all these effects results in an extremely intricate mathematical model known as the *timing model*. If this model is totally

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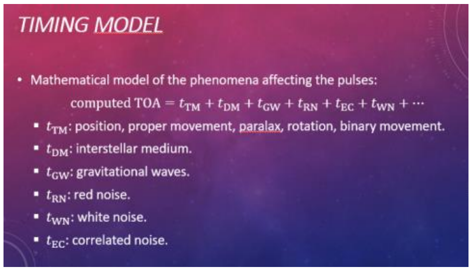
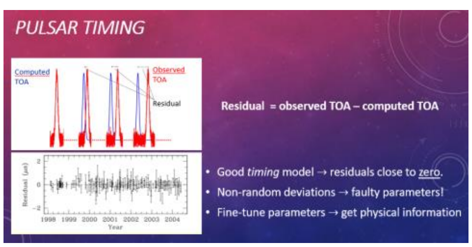
correct, then we should be able to predict the time of arrival of each of the pulses exactly.

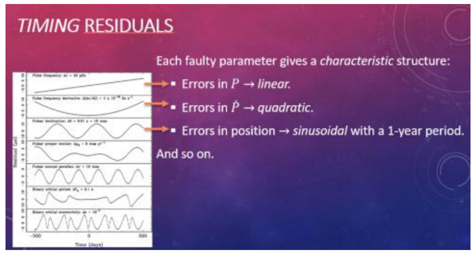


However, if we observe any deviation between our predictions and the observed times of arrival, then this difference can be attributed to some astrophysical effect that isn't being taken into account or that isn't being correctly modeled. Our objective then is to 'tweak' the parameters in the timing model in order to obtain residuals that are as close to zero as possible. Once we have achieved this, this new set of optimized parameters will provide information about the underlying physical phenomena affecting the pulses. This kind of fine-tuning process is usually referred to as "pulsar timing".



Now, one may ask themselves – if one measures the times of arrival of a pulsar, and compares thise observations to a timing model, and consequently obtained a nice set of residuals – how do I know which parameters I should be tuning? Is the interstellar scattering to blame for these residuals? Or maybe a faulty rotation period of the pulsar?

Well, luckily enough for us, each faulty parameter induces a characteristic structure in the residues, as you can see in the figure below. Here the x-axis represents the observation day, the y-axis represents the residues. If we see that the residues steer linearly from zero, then what we need to fine-tune is the pulsar rotation period. If we see a quadratic signal, then we need to tune the derivative of the period. And so on.

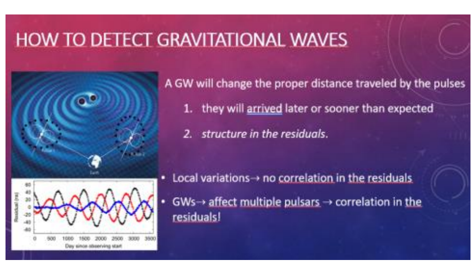


Gravitational Waves

One of the many astrophysical phenomena that may affect the time of arrival of the pulses, and that needs to be taken into account in our models, are gravitational waves. In a nutshell, gravitational waves are perturbations in the curvature of space-time, generated by the asymmetrical movements of bodies (especially bodies with large masses), where the shape of the system changes with time, such as – two highly massive objects in orbital movement one around the other, such as a black hole binary system, or a rotating neutron star that is not spherically symmetrical, but which has a "bump" on a side.

What's really interesting about gravitational waves is the effect that they have on objects. If we had a particle on a pond with water and we generated a mechanical wave, the particle would start moving up and down.

In contrast, if we have a particle initially at rest in an inertial system and we introduce a gravitational wave, this particle will remain at rest. However, its distance to other particles will oscillate by a very small amount.



Now, let's imagine for a second that one of these particles is the Earth and the other is a pulsar. If a gravitational wave is moving between the two of them, it'll increase the proper distance traveled by the pulses, therefore causing pulses to arrive earlier or later than expected if there weren't gravitational waves. As we've mentioned before, this offset in the times of arrival will result in a specific pattern in the resulting residual.

Supposing we find a pattern like this in our residuals, how can we be sure it was caused by a gravitational wave and not by some other effect? If the source of the signal was a gravitational wave, this would affect the observations of multiple pulsars, and all their pulses should present this type of signal. Then and only then we can say we've detected a gravitational wave, and we can pop open the champagne sitting in the fridge.

Therefore, if we want to detect gravitational waves then we need to observe several pulsars to compare their residuals and analyze their correlations. To this end, there are huge international projects known as *Pulsar Timing Arrays*, which are basically sets of pulsars that are constantly being monitored by radio antennas all over the world.

As of now, there are three of these big projects that are in the search of gravitational waves: [The European Pulsar Timing Array](), in Europe. The [Parkes Pulsar Timing Array](), in Australia, and the [NANOGrav collaboration](), in North America, which has some members working right here, at the RIT. The precision achievable by these instruments is truly astonishing. They're able to tell apart features in the observations that are separated by less than a millisecond.

However, all of these observatories have two major setbacks – none of them have exclusive availability of the telescopes they're using. Instead, these instruments are used for a variety of projects, and they're only able to obtain pulsar observations maybe once or twice per week, which

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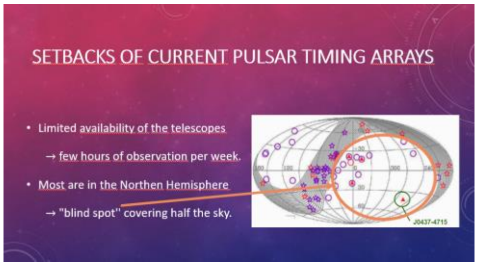
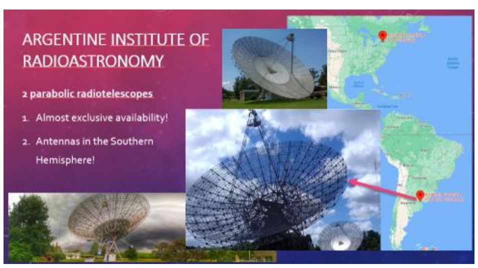
restricts the smallest gravitational wave period they can detect. With the exception of Parkes, all of them are placed in the Northern Hemisphere, resulting in a blind spot when it comes to observing some regions of the Southern sky, as we can see in this picture where the shaded region is the sky area observable from NANOGrav.

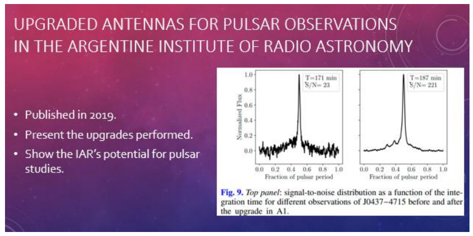


This is regrettable since some of the brightest and most interesting pulsars are, indeed, in the Southern sky.

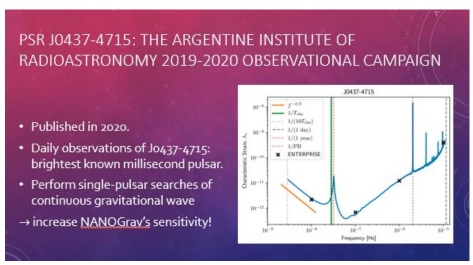
This is where the RIT makes its big entrance. Over the last four years our group has been working in collaboration with the Argentine Institute of Radioastronomy to restore and refurbish two 30-m radio antennas, situated in the outskirts of Buenos Aires, Argentina.



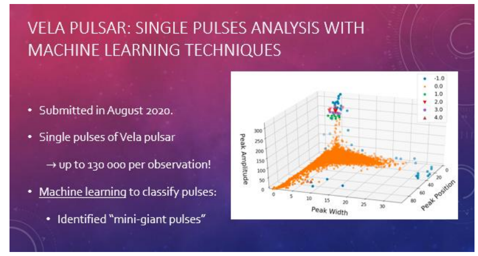
We may not have the best bandwidth ever, and our hardware still a bit of a fixer-upper, but we do have two big advantages over the big observatories like Arecibo and Greenbank – we have a nearly exclusive availability of these antennas, and we can take 3-hours long observations with a daily frequency. *Secondly*, they are among the few pulsar radio telescopes in the Southern Hemisphere. We can then use them to tap into invaluable astrophysical data from pulsars that haven't been studied in detail yet. Just to give you a taste of the type of research we´re currently conducting, over the past three years we have published three papers. Our first paper was published in early 2019 to introduce to the international community the upgrades performed and to show that the IAR observatory has become suitable for investigations in numerous areas of pulsar radio astronomy. For instance, in this figure we compared the signal-to-noise for different observations of the same pulsar before and after the upgrades.



In our next paper, published in 2020, we performed daily, 3-hours long observations of a single, extremely bright millisecond pulsar, PSR J0437--4715. This pulsar, which is at the center of NANOGrav's "blind spot'', could greatly increase their sensitivity, thus fixing the gap in our overall sky coverage, and providing sensitivity to a number of potential detectable supermassive black hole binaries. By doing this, we were able to calculate the first gravitational wave sensitivity curve for the observations at the IAR, which you can see in this figure.



Our latest paper, fresh out of the oven, was submitted for publication last August. In this paper we used observations of the Vela pulsar, but instead of taking one average pulse per observation as we usually do in pulsar timing, we worked with single pulses. However, in a 3-hour long observation we can get as many as 120000 single pulses, so classifying them by hand is nearly impossible. Therefore, we collaborated with people from the computing department here at the RIT by applying machine learning techniques to classify these single pulses into clusters, just as you can see in this figure.



Future Work

As of now, we're working on applying those very same machine learning techniques to analyzing the single pulses around a very rare spin-up event known as a glitch, which we were lucky enough to observe last July. We would also be interested in using deep learning to search for fast radio bursts in our data. Another promising project would be using our antennas for monitoring the magnetars in the Southern Hemisphere. Finally, we'll keep collecting and processing pulsar observations, while we improve our precision, in order to contribute to increasing the sensitivity of the existing pulsar-timing arrays. In this way, with a little bit of luck and a lot of effort, someday we may be able to get our first detection of a long-period gravitational wave using pulsars.

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View of the Sun taken May 21, 2022, using a H-alpha filter at the Solar Observatory of the Farash Center for Observational Astronomy, Ionia, NY for the benefit of visiting Boy Scout troop. Photo credit: Douglas Kostyk, RAS.

Hiking Trails at the Marian and Max Farash Center for Observational Astronomy, Ionia, NY

By Michael Grenier

If you look at the bulletin board in the kitchen of the Louis Wolk Education Center at our astronomy observatory, you will see a map down low showing the trail system. At the top, in green, it shows a "proposed trail." We are pleased to announce that it is no longer just proposed, but as of May 8 of this year, it is real and complete. It is now "The Blue Trail".

Trail system at the Farash Ionia Observatory, showing the new Blue Trail, in addition to our showcase Yellow Trail.

During summer weekends, visitors to the observatory will often see scout troops camping in the lower meadow. They are attracted to the opportunity to work on astronomy badges and view celestial wonders with ASRAS volunteers, notably Joe Altieri who oversees our scout programs. In return, these Girl Scout and Boy Scout troops do service projects on site for us.

One group that we love to have is Venture Crew 7 of the Boy Scouts, who first came in 2013 and took on the project of finding the location of the long-overgrown Yellow Trail. They succeeded and returned in 2014 to clear the trail and again in 2016 and 2017 to maintain both it and the White Trail. In 2018, they made Yellow Trail signage and installed it at all turn points on the trail. Excepting 2020 and 2021, they have been back every year since. They report that one of the high points of the weekend is the Saturday afternoon "Year in Astronomy" presentation by David Bishop.

Venture Crew 7 is a high adventure unit of young men and women ages 14 to 21. They are sponsored by the Henrietta Fire District Station 3 at 9 Riverview Drive.

These trails are an enjoyable nature hike, easy walks, and easy to follow. The Yellow Trail is just a bit over 1 mile and the Blue Trail about ¾ mile including the north loop of the Yellow Trail. The short White Trail is intended for little kids.

The trails are open to the public and are available to any RAS member, whether an Astronomy Section (ASRAS) member or not. There are a wide variety of tree and shrub species on these trails. Wildlife and their traces are often seen. There is more than astronomy here at 8355 County Rd 14, Ionia.

The new "Blue Trail" entrance at the northwest corner behind the Tinsley Dome is marked by Emily Cosgrove, Crew President.

Sign at the entrance of the "Yellow Trail" heading West.

Another "Blue Trail" marking applied by Crew 7 member Dylan Lynch.
Full disclaimer – Michael Grenier is an advisor to this Crew.

Fireball seen from Rochester!

By Michael Grenier, RAS President

A *fireball* is an unusually bright meteor that reaches a visual magnitude of -3 or brighter when seen at the observer's zenith. A fireball seen in Arkansas and Louisiana on April 27th broke up over Mississippi and hit the ground with the energy equivalent of 3 tons of TNT. NASA calculated that it was traveling at 35,000 mph and confirmed that meteorite fragments have been found by several people. That led me to wonder when the last one was seen from Rochester. Not all that long ago, it seems. A woman in Webster was one of several New Yorkers who reported seeing the well-documented one over Ontario Province at 11:38PM on April 17th of this year. (https://fireball.amsmeteors.org). There have been 1,878 verified meteorites in the U.S. from 1807 to August 2021 according to the Meteoritical Society as reported by USA Today (May 9, 2022).

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ROCHESTER AREA RESEARCH IN REVIEW

May 19, 2022, Cornell University, Cooperation rewards water utilities: Supercomputer simulates water supply in inter-utility agreement study.

May 13, 2022, Cornell University, Dragonflies use vision, subtle wing control to straighten up and fly right.

May 12, 2022, Cornell University, Jellyfish's stinging cells hold clues to biodiversity.

May 11, 2022, University of Rochester (UR), Laser bursts drive extremely fast logic gates: Decisive step toward creating ultrafast computers.

May 9, 2022, Binghamton University, Spider can hide underwater for 30 minutes.

May 9, 2022, Syracuse University, Lake Erie quakes triggered by shifting water levels? Study finds no smoking gun, urges further research.

May 5, 2022, Cornell University, Mechanism 'splits' electron spins in magnetic material.

April 26, 2022, University of Rochester Medical Center (URMC), Risk of psychotic-like experiences can start in childhood.

May 15 – 16 2022 Total Lunar "Blood Moon" Eclipse. (Photo Credit: Joe Altieri, Astronomy Section RAS.)

ABOUT THE ACADEMY

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