issue 1

the neurite

west virginia's STEM magazine for students

Antonia Orsini
West Virginia University

Editor's Corner

Hi!

My name is Elisabeth, and I am the editor of this magazine. I have always liked and enjoyed mathematics and science. What you also have to know though is that I was not always necessarily an A student in these subjects. The drive to work hard in these fields stemmed from my curiosity for how things work and my fascination with challenging problems.

But me liking these fields was not enough for me; I wanted to know why others did not. So, I made it my mission to find out so I could help change their minds.

On this mission, I completed undergraduate degrees in mathematics and physics, a Master's Degree in physics with a specialization in astronomy, and a Doctoral Degree in mathematics and science education.

During this 11 year journey, I found out that not everyone had supportive parents with a STEM background and higher education experience, engaging physics and mathematics teachers in middle and high school, or the same STEM experiences or learning opportunities that I have had.

It turns out that all of these factors play a huge role. Another such factor is STEM awareness. How are you supposed to know what you want to be if you don't even know about half the fields and careers that exist?

This is where this magazine–The Neurite–comes in. It will help you explore STEM areas and STEM careers by introducing you to one field at a time. This issue is about Astrophysics.

The cover story of The Neurite will be about one young person from West Virginia who has been a part of an activity or research project in a STEM field. The Neurite will also feature one interesting theory or discovery related to that field, an exploration of current job postings to see different career options, some college and financial aid advice, and tidbits of STEM education facts.

I hope you will enjoy this and the following issues of *The Neurite!*

Elisabeth Kager

Elisabeth Kager, Ph.D.
Education, Outreach and Diversity Manager

If you want to stay connected between issues, please "Like" us on Facebook: TheNeurite
Follow us on Twitter: @TheNeurite

Want a free subscription to future issues of the Neurite? Send me an email, elisabeth.kager@wvresearch.org.

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Antonia's photos by Alex Wilson

Antonia's Story
it's all about creating your own opportunities

Antonia Orsini is originally from Weston in Lewis County, West Virginia. There, she graduated first from Robert L. Bland Middle School and then from Lewis County High School. Today, Antonia is a physics student at West Virginia University (WVU) who is doing research in astrophysics and traveling the world because of it.

Antonia has "kind of always known" that she wanted to go to college, but she was not always that sure about what she wanted to be.

First, she applied to art school but, despite her acceptance, she reconsidered and instead took the year after high school to find out what else she could do with her life.

How, you may ask? Well, here is Antonia to tell her story.

Antonia I looked up a lot of things about the different fields to see what I might end up liking better and tried to figure out where I would be the happiest. I mean money is important as well but you want to enjoy what you are doing.

Neurite **What fields were you considering at the time?**

Antonia Well, I've kind of always considered a science field… it was a toss-up between biology and physics. I wanted to either be a Zoologist or an Astronomer.

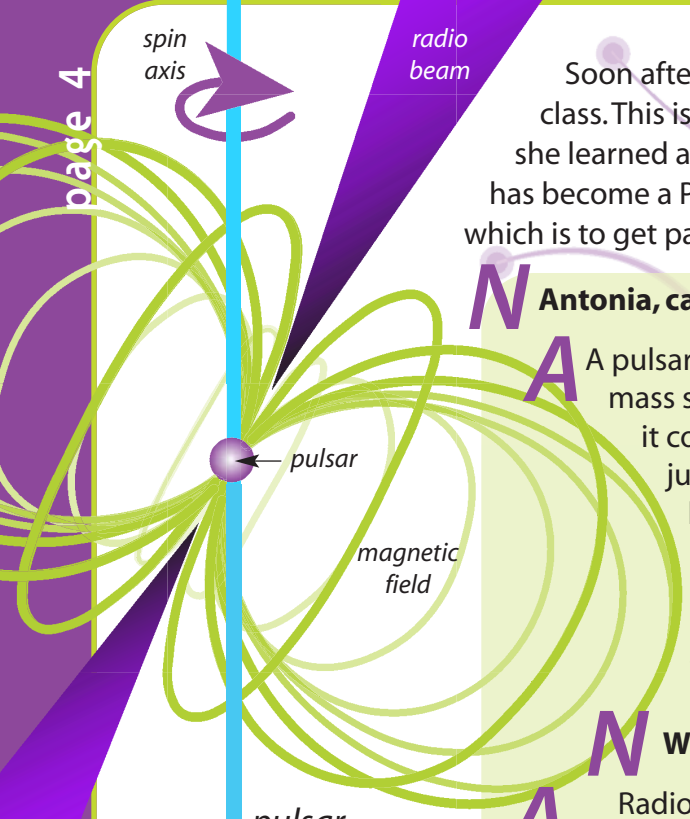
Once at WVU, Antonia started out as a biology major, but after her freshmen year she decided to switch to physics because an astronomy class made her see "everything that astronomy is and could be" and she "just got really interested".

N **Antonia, what do you like about studying physics and astronomy?**

A It's a community. I mean, you go into the undergrad physics lounge and everyone is working on their homework together or talking about this or that that's new, and it's kind of like a sciency family. It's really interesting to learn about how everything in our environment works and you start to see things a little bit differently… and it's fun, it's definitely fun.

N **Statistics show that women are still a minority in physics; how has your experience been?**

A I took an orientation class, just last semester, and there were four women in the class out of 32, so there is definitely that disparity there, but I don't feel like I've ever been talked down to. … I have had a lot of opportunities to do things and everyone seems to take me pretty seriously and all of my classmates are really nice and don't treat me poorly or less than they would another.



pulsar graphic

Soon after Antonia switched to physics, she took a Pulsar Astrophysics class. This is where her passion for research was sparked because there she learned about pulsars and the search for them. Since that class, she has become a Pulsar Fellow, which comes with many benefits, one of which is to get paid to look for pulsars.

NA Antonia, can you tell us what a pulsar is?

A pulsar is the remnant of a star after it collapses. It's a high mass star, not big enough that it would be a black hole when it collapses but not small enough, like our sun, where it would just turn into a white dwarf. Pulsars spin extremely rapidly, like up to several times a second, so very, very, very quickly, and they are about the size of a city and they have two pulses that kind of beam out radio waves. If the Earth happens to be in front of one of those pulses, then we can see that pulsar and detect it.

NA With what are you detecting these pulse signals?

Radio Telescopes, like the Green Bank Telescope (GBT) in Green Bank, West Virginia, and Arecibo Observatory in Puerto Rico.

NA How do you find pulsars?

I look at a bunch of graphs and various images on which I am looking for really specific signs to tell whether something is a pulsar or maybe just a signal from a radio tower or an airport.

Antonia has been searching for pulsars for over one-and-a-half years now and found 11 so far. Antonia's research mentor, Dr. Maura McLaughlin, thinks that Antonia might have the most pulsar detections in WVU's history.

NA Antonia, how did it feel when you discovered your first pulsar?

The first one I ever found, I was sitting in my best friend's living room. I see it and I am like ok, well this is definitely a pulsar. I try not to get too excited right off the bat because you find a lot of known pulsars in the plots. So, I am going through all the data bases of known pulsars, looking for one that matches the one that I found, and I didn't see anything. And I grab my friend, and I am like oh my God, oh my God, I found one! I immediately sent it off to my professor, and then went out for ice cream.

Antonia and Dr. Maura McLaughlin

Being a Pulsar Fellow doesn't just involve doing research, it also means tons of traveling and meeting many people along the way. Antonia got to go to a pulsar workshop at the GBT where she learned to write her own code to observe pulsars; she visited Arecibo Observatory where she met Victoria Kaspy, a famous astronomer from Canada; and she attended the International Pulsar Timing Array (IPTA) conference in Australia, where she took part in a once-in-a-lifetime radio frequency interference experiment. This summer, Antonia is deciding between going to Italy for an internship and attending the IPTA conference in South Africa.

Students at Arecibo Observatory in Puerto Rico. From left to right: Pete Gentile, Tyler Matheny, Jeremy Thorley, Joe Swiggum, Christiane Ebongue, Natasha McMann, Antonia Orsini.

N **Antonia, what are some advantages to doing research as an undergraduate?**

A It's just really fun to be able to add something to the greater good and of course traveling to different places and meeting new people and learning a bunch in general. It's a lot of good experience, you know, real research opportunities.

Also, whenever the researchers publish any papers on pulsars that I found, my name will be attached as an author, so I'll get that kind of recognition for my discoveries … it's definitely a bonus.

N **What are some of the challenges that research brings with it?**

A Sometimes, you really want to look through plots, but you have loads of homework and have to study for exams, so you don't always have the time to put in.

Antonia's story is a success story, not just because she has found 11 pulsars but because she went to college and despite switching majors after her freshmen year, she stuck with it and now does what she loves. Since Antonia is almost a college veteran, **she has some advice**.

A College takes some dedication. It's good to make friends as well because you're probably going to need help at some point. No one is perfect. You're gonna stumble with some lecture or whatever and it's good to have people who you can talk to and talk it out with to get a better idea of the concepts. If you need help, get it, get it! I know, everyone says that but, get it!

Antonia knows what she is talking about when she says "create your own opportunities." She decided to attend WVU with scholarships (PROMISE, Mountaineer) and a grant (WV Higher Education) paying her way through college. She applied to become a Pulsar Fellow to get involved in paid research. After overhearing a graduate student talking about going to Australia, Antonia just asked her research advisor whether she could go, and she was funded to go. A similar scenario happened with the internship opportunity in Italy this summer.

Antonia will graduate with a Bachelor of Science in Physics once she completes all her requirements at WVU, and she definitely has plans to go to graduate school to get a degree in Astrophysics. At this time, she isn't sure what exact area she wants to study, but she knows that in the future she would like to work for NASA.

"More advice would be to **create your own opportunities.** I mean, if you just ask around then I guarantee someone is gonna be, **'hey yeah, I could use you.'"**

Department of Astronomy at The Ohio State University
Columbus, Ohio
Scientific and Technical Staff
Design and develop astronomical instruments.
Ph.D. in Astronomy or Physics

Smithsonian Institution
Cambridge, Massachusetts
Technical Assistant
Write code and software for observations at the observatory.
Bachelor in Astronomy or Physics

I studied and taught here

Swiss Federal Institut of Technology (ETH)
Zuerich, Switzerland
Graduate Position
Observe the evolution of galaxi
Master's in Astrophysics

The National Radio Astronomy Observatory (NRAO)
Soccoro, New Mexico
Assistant Director of Education and Public Outreach
Develop and execute fun astronomy activities for students and the public.
Bachelor of Science

Springer Nature
New York, New York
Publishing Editor
Review scholarly book and journal proposals, prepare their manuscripts, and promote their sales in fields such as Astronomy, Engineering, Mathematics, or Physics.
Bachelor Degree

Carnegie Observatories
Pasadena, California
Scientific Programmer
Develop applications to help handle the large amount of data coming from all the observations.
Programming Experience

National A Admi
H
Expe
Participate in experimen that orbits above Earth a
Ph.D. in

Frost Museum of Science
Miami, Florida
Community Engagement Content Facilitator
Engage museum visitors in science demonstrations and laboratory experiments.
Bachelor of Science

The Universities Space Research Association (USRA)
Arecibo, Puerto Rico
Post-doctoral Scientist
Conduct radio astronomy research.
Ph.D. in Astronomy

Institute of Radio Astronomy & Astrophysics
Michocan, Mexico
Professor of Astrophysics
Teach and mentor astronomy graduate students and do research.
Ph.D. in Astronomy

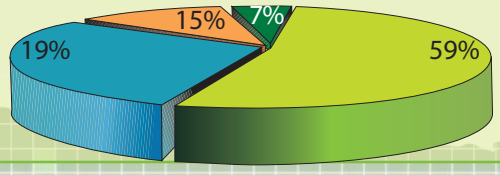
where do ast

Some job options available right now

Leiden Observatory
Leiden, Netherlands
Calibration Scientist
Adjust observatory equipment and use the observatory to do research.
Ph.D. in Astronomy or Physics

An Astronomy degree opens doors to many different employment sectors:

- College and University
- National Observatory and Government Laboratory
- Business and Private Industry
- Other (Museum director, science journalist, science educator, etc.)



Space Research Institute, Austrian Academy of Sciences
Graz, Austria
Post-doctoral Position
Theoretical modeling of atmospheres of planets that orbit stars other than the sun. These planets are called exoplanets.
Ph.D. in Physics, Geophysics or Astrophysics

Korean Astronomy and Space Science Institute (KASI)
Daejeon, Republic of Korea
Junior Research Leader
Do research in optical astronomy, radio astronomy, space sciences, theoretical astronomy or computational astronomy.
Ph.D. in Astronomy

Aeronautics and Space inistration (NASA)
Huntsville, Alabama
erimental Scientist
ts involving the Chandra X-ray Observatory nd help develop X-Ray optics and detectors.
n Astronomy or Physics

National Astronomical Observatory of Japan (NAOJ)
Mitaka, Tokyo, Japan
Project Assistant Professor
Help astronomers do radio astronomy research.
Ph.D. in Astronomy

rophysicists work?

W in the field of astronomy and physics

The Universe Has Been Making Sounds,

NOW WE CAN FINALLY HEAR THEM!

Space-time – The Trampoline of the Universe

What is the first famous scientist that comes to mind? Was it, by any chance, Albert Einstein?

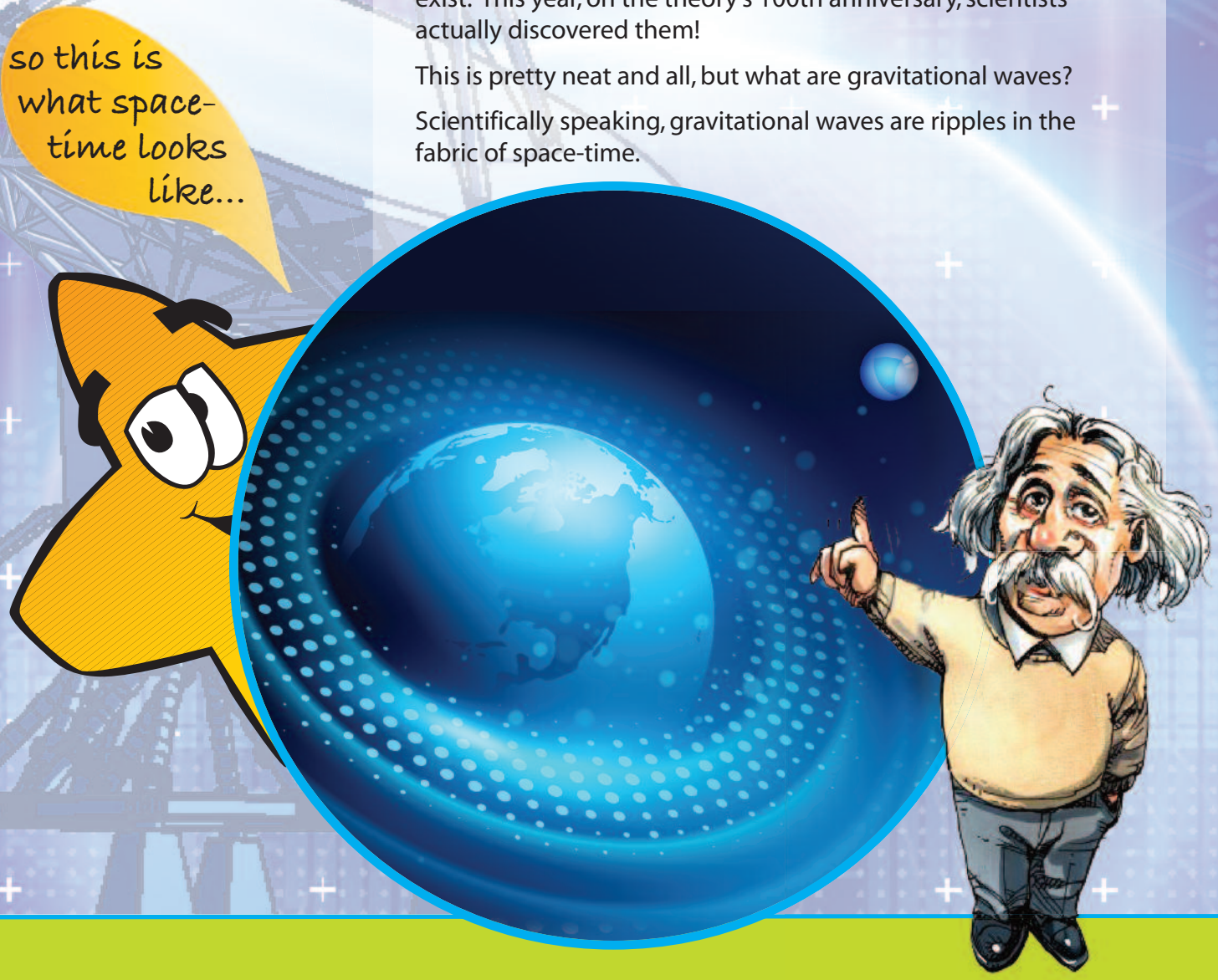
Albert Einstein has become the household name and face when thinking about a scientist. What did he do to deserve this honor?

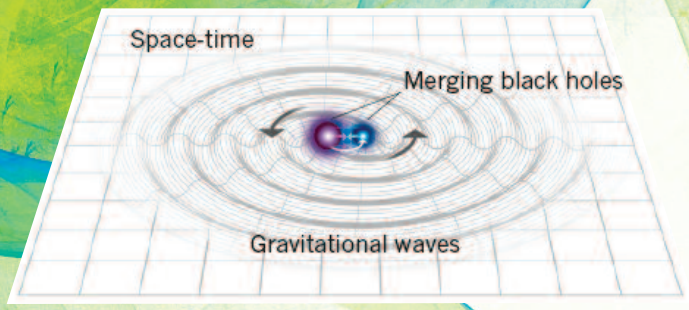
Einstein came up with a lot of theories or ideas that, over the years, were shown to be true.

The theory that you are going to read about here originated in 1916. Then, Einstein was convinced that gravitational waves exist. This year, on the theory's 100th anniversary, scientists actually discovered them!

This is pretty neat and all, but what are gravitational waves?

Scientifically speaking, gravitational waves are ripples in the fabric of space-time.





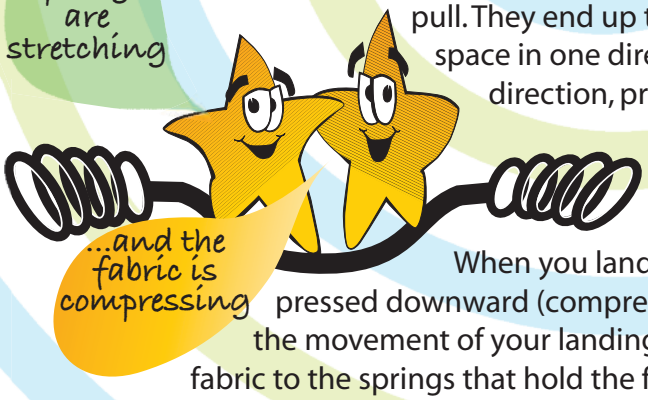
The gravitational waves were produced when two black holes - one weighing 36 solar masses and the other 29 - spiralled toward each other and merged, distorting the space-time around them in the process.

In his theory of general relativity, Einstein described space as a fabric made out of space and time, so a 4-dimensional space!

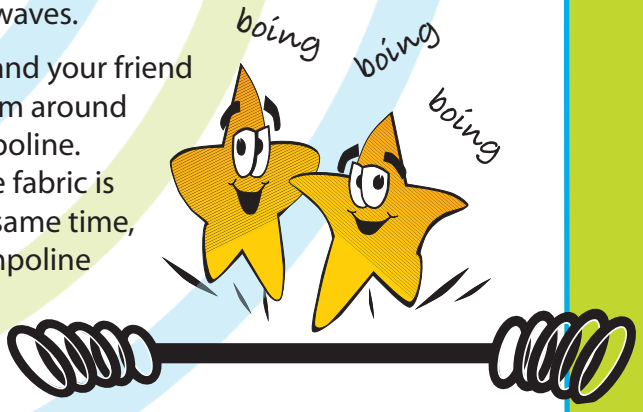
When a massive object is placed in this fabric, the space around the object is bent. The more massive the object the more the space around it bends. This bending of the space creates gravity. That's also how the Earth keeps our moon orbiting us!

You might want to imagine this space-time as a trampoline. If you stand in the center of the trampoline, the space around you bends. If you were to place a marble on the edge of the trampoline, it would plummet into the center. Think of that "pull" toward the center as gravity. Envision a friend joining you at the center of the trampoline–together you are more massive and so the space around you bends even more.

If we have two massive objects in space placed near each other, they will accelerate toward each other due to gravitational pull. They end up twirling around each other, stretching space in one direction and compressing it in the other direction, producing gravitational waves.



Now picture that you and your friend are jumping arm-in-arm around the center of the trampoline. When you land on the trampoline, the fabric is pressed downward (compression of space). At the same time, the movement of your landing travels along the trampoline fabric to the springs that hold the fabric in place, which results in their stretching (stretching of space). On your way up in the air, the trampoline fabric moves back up while the springs retract. This motion creates a wave.



If such a gravitational wave moves by the Earth, it will stretch and compress the Earth by less than an atomic diameter, smaller than one millionth the thickness of your hair. Since this is not noticeable to us humans, why should we care? Keep reading and you'll find out.

Learning to **hear** the Universe

Scientists built a precise instrument called the **Laser Interferometer Gravitational-Wave Observatory (LIGO)** to measure the stretching and compressing of space.

Schematic of LIGO

LIGO is made out of two perpendicular arms, each being 2.5 miles long. At the end of each arm is a reflective mirror. The beamsplitter sends the laser light along the two arms which is then being reflected back to a light detector.

If a gravitational wave (GW) would pass through LIGO, one arm would be compressed and the other one stretched causing the distances of the arms to differ and the beams' arrival time at the detector to vary.

This discrepancy results in a rhythmic pattern of light in the detector which can then be transformed into a soundwave.

Now, we have a way to hear the universe, how cool is that?

As Antonia from the cover story explained, "everything that we know about our universe right now is just based on light and if we detect these gravitational waves, then we could learn about even the origins of the universe through gravity" because gravity can travel where light cannot.

But what did the universe tell us through these GWs? It told us the story of how two black holes merged into one bigger black hole giving us proof that black holes exist!

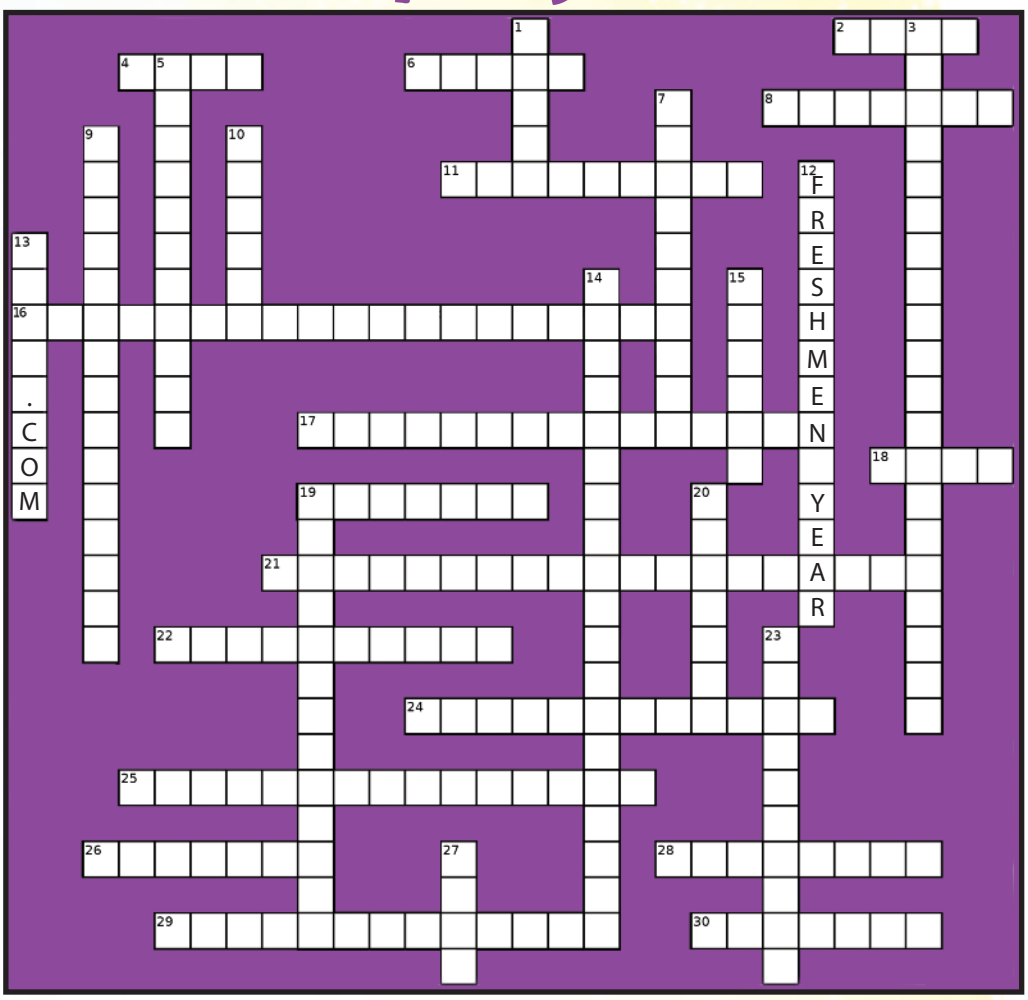
But guess what? LIGO is not the only GW detector out there. LIGO detects GWs that originated from events that have durations of one-hundredth of a second (the merging).

But what about events, such as the spiraling (before the merging) of supermassive black holes which could take months or even years? The answer is pulsars, the stars that Antonia is searching for!

How, you might wonder?
It turns out that these millisecond pulsars are nature's most precise clocks. Antonia said, "they're extremely precise in their spinning so, if there is any variation in the arrival time of the radio waves from the pulse signals, then that could be an indication of gravitational waves pptpassing through."

So, what this discovery boils down to is that, through detecting GWs, we could find out about the origin of our universe and some day we might hear what the big bang sounded like!

Fun with **astrophysics**



Across

2. Acronym for Laser Interferometer Gravitational-Wave Observatory
4. Acronym for science, technology, engineering and mathematics
6. Astronomers working with radio telescopes are called _____ astronomers
8. LIGO's mirrors _____ the laser beams
11. _____ is the part of science that studies celestial objects, space and the physical universe as a whole
16. _____ Grant is a program offering free money for college for West Virginia students with financial need
17. _____ is the scientist who came up with the theory of general relativity-the theory that gravitational waves exist
18. We can now see and _____ the universe
19. _____ is a scholarship West Virginia students can earn by keeping good grades and scoring well on college entrance tests
21. _____ are ripples in the fabric of space-time
22. _____ is the trampoline of the universe
24. Antonia wants to get a graduate degree in _____
25. The words astronomy and astrophysics can be used _____
26. _____ astronomy is the oldest form of astronomy and is also referred to as visible light astronomy
28. Millisecond pulsars are very precise in their _____
29. 19% of Astronomers work at National _____ and Government Laboratories
30. _____ can travel where light cannot

Down

1. Up till now, everything we know about our universe was based on _____
3. GBT is an Acronym for _____
5. _____ astronomers use observations to form numerical simulations to understand astronomical phenomena
7. Planets that orbit stars other than the sun are called _____
9. Pulsars are detected with a _____
10. Computational astronomy is a _____ of theoretical astronomy
12. _____ is the year in school in which your grades begin counting toward earning the PROMISE scholarship
13. _____ is a free website for West Virginia students that provides information about college, scholarships and careers
14. _____ are nature's most precise clocks
15. Antonia found _____ pulsars
19. The arms of LIGO are _____
20. _____ are radio waves emitters
23. The GBT is in _____ County, West Virginia
27. Gravity keeps the _____ orbiting the Earth

Having difficulties? Are you sure you read all the stories...?
For solutions to the crossword puzzle, visit **www.wvresearch.org.**

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Did you know that ...?

- In 2015, only 34% of West Virginia high school graduates were prepared to take college-level math and science classes?[1]
- By 2020, 89% of Astronomy jobs will require you to have at least a Bachelor's Degree?[2]
- By 2020, 65% of all jobs will require you to have training or a degree after high school?[2]

These statistics should not worry you but serve as an eye opener. Yes, most of you will have to find a way to go to college but your number one concern shouldn't be finances but academics! There are plenty of scholarship and grant programs out there to help you pay for college and you can start as early as middle school to apply for them.

Antonia from our cover story, for instance, took advantage of the following two programs sponsored by the state of West Virginia:

1. The **PROMISE Scholarship** is a scholarship you earn by keeping good grades and scoring well on tests. As soon as you enter high school, your grades will start counting toward your high school grade point average (GPA), which will be used to determine whether or not you qualify for PROMISE.
2. The **West Virginia Higher Education Grant** is free money for college if you have a financial need, which is determined by your family's income.

For more scholarship and grant opportunities, please stay tuned for the next issue of *The Neurite* and visit West Virginia's free college and career-planning website at **CFWV.com** in the meantime.

[1] www.act.org
[2] https://cew.georgetown.edu