Science AMA Series: I'm Dr. Emily Petroff, I just completed my PhD at Swinburne University of Technology. I look for bright radio pulses from space including distant fast radio bursts and also found ra

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Abstract

Hi Reddit! My name is Emily Petroff and I just finished my PhD at Swinburne University of Technology in Melbourne, Australia. My research focuses on finding short, bright bursts of light with large radio telescopes like the Parkes telescope in Australia. I mainly study things called "Fast Radio Bursts" which only last a few milliseconds but release more energy than the Sun does in a day. These bursts seem to be coming from distant galaxies in stellar explosions or collisions of neutron stars but we still don't know exactly what causes them. Last year, I led a team that discovered the first fast radio burst in real-time and used telescopes around the world to try to find out where it came from. Since then we've been learning more about these bursts and our team just published the discovery of 5 more from the past 6 years of data. Less than 20 of these bursts have ever been found, but more than 1,000 are happening every day throughout the Universe. We are hoping we will be able to use these bursts to learn about the extreme objects that caused them and the galaxies they live in. This year I also led a team that found that other curious signals in our data were actually coming from microwave ovens at the telescope site. We were able to show that these nearby signals don't have anything to do with fast radio bursts but that local interference can show up in unexpected ways, especially with more and more electronics encroaching on sites for radio astronomy. Have questions about radio astronomy? Signals from space? Pulsars and neutron stars? I'll be back at 1 pm EST (10 am PST, 6 pm UTC) to answer your questions, Ask me anything! UPDATE: Thank you to everyone for the questions so far; I've had a great time! I'll be back later today to answer more questions!

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REDDIT

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DR_EMILY_PETROFF R/SCIENCE

ABSTRACT

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Hi! Thanks for taking the time to do this. I am an aspiring Astrobiologist, and often follow /u/Andromeda321's answers on these types of things. I have read her mention of it before; in lamen terms - what does this mean and how can it be used to help us in the field of Astronomy?

RyllaeBruis

Hey thanks for the question! Fast radio bursts specifically are a pretty interesting new discovery. In simple terms they are short, intense pulses of radio waves. How short? Each one only lasts about a millisecond. How intense? We think that each one gives off enough energy to power the Sun in that one short millisecond! And we think they are coming from violent events in other galaxies that are very far away. So these sources are really interesting from an extreme physics point of view. There has to be some very unusual and very powerful physics happening, and that is exciting in astronomy in and of itself!

University of Technology. I look for bright radio pulses from space including distant fast radio bursts and also found ra, *The Winnower* 2:e144983.36826 , 2015 , DOI: 10.15200/winn.144983.36826

But wait there's more! Short radio pulses have a really cool property called "dispersion" where the pulse arrives at different times at different wavelengths and the reason for it is that the radio waves are getting delayed by all the electrons floating around in space between the source and the Earth. You can use the amount of dispersion to directly measure all those electrons, which is like measuring all the mass along the line of sight. It's very hard to directly measure the electrons outside our own Galaxy, but with these fast radio bursts, since the information about the electrons is already imprinted on the signal, we can do just that. That has big implications for nailing down just how much of the 'stuff' in the Universe is matter, which would inform dark matter and dark energy studies.

Hi - how personally worried are you about Gamma Ray Bursts? I heard they are a potential culprit in a mass exitinction event a few tens of millions of years ago.

EDIT: Are these Fast Radio Bursts also dangerous if pointed at us?

translunar_injection

Hello! I'm not too worried about death by Gamma Ray Burst myself. The GRB extinction theory has been proposed for the Ordovician-Silurian extinction event which happened about 450 million years ago. It's still not clear if that was the real reason, but a GRB in our own Galaxy pointed straight at the Solar System could indeed do some real damage. BUT, GRBs are pretty rare in an individual galaxy - one every million years in a galaxy like ours in the present-day Universe. And on top of that they are very highly beamed meaning that the really intense radiation only comes out in a very narrow beam at the poles so even if one happened in our Galaxy it would have to be oriented just right to make it to Earth.

We think that Fast Radio Bursts are similar to GRBs in that they are coming from distant galaxies and are maybe also highly beamed. If that's true and we finally did get one in our Galaxy oriented towards us it might interfere with radio communications and things like that, but wouldn't cause the type of extinction you might see from a GRB-type event. Unless of course FRBs and GRBs come together, in which case all bets are off!

Hi there, I'm pretty much interested in physics as a whole (not an expert). I would love to ask, how do you sort out all those signals received and decide which one to investigate? Like, lots of EM waves are out there, cosmic background radiation, and waves generated from daily activities on earth; how do you decide which is worth researching? Also, what are you specifically looking for from the signals? Space object location, ET life?

GodMode_Activated

Great question! Thanks! This requires a long answer...

Because radio waves are really low energy they're very easy to produce and use, so they're basically everywhere now since our mobile phones, computers, car radios, and (of course) microwaves use them. Sorting out the signals we receive at a radio telescope is tricky at the best of times. First you have to separate the signals from space from the signals coming from Earth. Fortunately human-made emitters are locked into certain radio bands by frequency allocation so we know, for the most part, what bands to block out to avoid seeing human chatter.

But even when looking at the signals from space it is hard to sort things out. The types of things that I study are all very short duration, so we start by only looking for bright pulses that last between a millisecond and a second. This cuts out a lot of other signals. Then we look to see if those pulses have dispersion, basically a marker for whether or not they have traveled through the free electrons in the space between stars. This is the biggest marker we use to find the fast radio bursts that I study. We

look for them all over the sky, so position in the sky doesn't matter much to us but we do want to make sure they look like they have traveled through space!

As for what is worth researching, that is a tough one. By applying the filters I described above we are very much restricting the types of things we look at. This can be a good approach when you're looking for more of something you already know about, but problematic when you want to find something no one has ever thought of or seen before. FRBs were first discovered by looking for signals in a part of the parameter space where no one expected anything. The data rates for telescopes are really high these days, but hopefully we'll be able to keep looking for the unknown as we go.

Do you think there are other life forms out there and if so, how close are we to communicating with them?

n1tr0us

I think it's almost certain that there is life somewhere out there in the Universe, and probably life somewhere else in our own Galaxy. But it's more difficult to say if there's *intelligent* life that we're able to communicate with. If there are lifeforms out there sending us signals we'll be able to pick them up within the next 50 years with the Square Kilometre Array which will be built soon. But communicating back will be more difficult since it's easier to listen than to transmit!

What are the most interesting sources of radio waves for you?

vladamir_pootin

I would definitely have to say fast radio bursts! They're my main area of study and I find them fascinating, so I'm biased :)

The 'Wow!' Signal is still an interesting one for me, though. Even if it didn't come from space, what the heck was it?

Nice! Congrats from a Norwegian Swinburne University alumni!:D

Awesomme to see someone making a bigger impact in the world than me:)

I guess I don't have a really good question for you since I have really no idea of what a study in this field would indicate. So maybe where do you see (or wish/hope to see) this field going next?

TobyTrash

Hello fellow Swinburnite! Thanks for the question!

Right now we only have less than 20 of these fast radio bursts that we know of. That's not very many!! So I definitely wish to see the number of FRBs grow in the next few years! We think these bursts are coming from other galaxies but we won't know for sure until we find an FRB/galaxy association, so hopefully with one of the next discoveries we will find out how far away these things really are! It's a very new field, so there are lots of hopes and dreams right now, but even if just a few of the big questions get answered in the future I would be happy!

Kind of a basic question but can we use these bright radio pulses to find alien life?

Rointhepro12

Thanks for the question! I don't think we can use fast radio bursts in specific to find alien life, but the folks at SETI are actively looking for radio pulses that might be from intelligent life. We see bright radio pulses from things like pulsars and these fast radio bursts, so you might expect an advanced civilization to know these sources exist and other civilizations would be studying them. So in an attempt to contact others they might broadcast a signal that looks similar to these but different in some meaningful way. This is what the SETI researchers are looking for, but nothing like it has been found yet.

Hi Emily! Very sorry about the microwave oven perytons that we all joke about but that was a cool result that helped solidify the position of FRBs. FRBs are the hot topic everyone I know loves to talk about and sometimes I wish I were involved in the excitement (but only sometimes :)).

My question: Now that a two-component FRB has been detected (source for others), what do you think this means for the future of FRB science? Does it change anything from an operational/observational standpoint? Or are all programs going ahead as they were before?

themeaningofhaste

Thanks for the question! I think the two-component FRB is pretty interesting. So far we have less than 20 FRBs and one of them has internal structure. That could say something interesting about the population as a whole, or about there being multiple sub-populations. This wouldn't be the first time, since GRBs were also found to come from multiple sub-populations. But I think we need more bursts to know for sure.

Now we want to answer the question whether other bursts are like this one and we just haven't been looking with fine enough time resolution to see them. So hopefully future searches will take this into account and start looking in finer detail for sub-structure. Right now the surveys that I'm involved with don't have the ability to do this, so our strategy hasn't changed, but if the telescope gods are listening, I'd like to do that on future searches :)

Hi Dr. Petroff! Thank you for doing this AMA.

In Carl Sagan's "COSMOS" he states "We define an advanced civilization as one capable of radio astronomy."

Sagan acknowledges that this is a narrow definition by saying "There may be countless worlds on which the inhabitants are accomplished linguists or superb poets but indifferent radio astronomers. We will not hear from them."

Has the definition of an advanced civilization changed at all since the publication of COSMOS in 1980?

RodneysBrotherCheese

Thanks for the question! As a radio astronomer I quite like this definition! The definition for "advanced civilization" may have changed, but the statement still holds true. The most cost-effective way to communicate is with radio waves, whether over short (radio tower to receiver) or long (planet to planet) range, so if we ever do pick up signals from other civilizations they are likely to be in the radio band. That's where the majority of searches currently underway are focused, although there are some with optical telescopes. Most researchers looking for extraterrestrial life are focused on radio transmissions, though.

Hi! Given the cosmic distances that known FRBs seem to originate at, taking into account their red shift, what frequency range do we think they originate at? Do they seem to be narrow-beam like GRBs, or omnidirectional? If there are thousands every day, what should we be doing to observe more of them? Thanks for doing the AMA!

Anarchaeologist

Hello! For the FRBs that have been observed so far, most of them have been found at around 1.4 GHz. For the FRB with the highest estimated redshift that puts the emission frequency around 3.5 GHz, so still well within the radio band. We estimate that all the signals we see were emitted between 3.5 and 1.4 GHz.

We're not sure if FRBs are beamed like GRBs or omnidirectional. The energy requirements if they are omnidirectional go up quite a lot, so the physics is a bit easier to explain if they are beamed, but we can't say for sure yet! To find more of them we need to spend more time looking and we need to look at more sky at once. So far, FRBs have been found at telescopes like Parkes and Arecibo that only look at a small patch of sky at once, but now interferometers are starting to look meaning you have a bigger field of view on the sky, but also you're able to localize a detection better.

The last sentence of my thesis deals with this very topic: "The greatest gains will be achieved when the largest number of telescopes are looking for FRBs, preferably in real-time, over the largest amount of sky possible."

I toured a radio telescope site run by the NRCC (National Research Council of Canada) at Okanagan Falls and they choose a place surrounded by low hills to shield themselves from stray radio signals.

Why would you even allow microwave ovens on the location?

jhenry922

The microwave ovens that are on the Parkes telescope site went through extensive electronics tests before being allowed. They were known emitters of 2.5 GHz signals, so if observations were being taken at 2.5 GHz everyone was told not to use them. But they were only tested under normal design specifications - no tests for opening the door to turn off the microwave. Under the tests they conducted the microwaves were deemed safe for use on site. Other than this obscure emission we pinpointed this year there have never been any issues of microwaves interfering with the observations.

How can the average person help support the field of radio astronomy?

RodneysBrotherCheese

Wow this is a good question that I don't have a good answer for. I would say continue being enthusiastic about radio astronomy! The more public support our work gets the more likely it is to continue to receive funding. That and turn off your phone when you are close to a radio telescope!

Do you think NanoGrav will actually find anything?

iorgfeflkd

I sure hope so! There are three teams using pulsar timing arrays to find gravitational waves - NanoGrav, the European Pulsar Timing Array, and the Parkes Pulsar Timing Array. All are producing

really interesting results so far without having found gravitational waves, but hopefully one of them will find something soon! Recently they've been working together as an international collaboration and I think the combined dataset is what is most likely to produce a detection.

Hi Dr Petroff,

Thank you for doing this AMA!

Are there any places, databases, or online resources that list these kind of extragalactic, and extreme signals from the Universe, and who's working on them, what data is available and what's been published about them?

Kind of a "Wiki-signals_from_space" of sorts maintained by the very few scientists who know about them? With so few signals known, it would be fairly small, but super interesting for the general public!

If not, are there particular publications or books that talk about "signals from space" for the science engaged public?

Thank you, again.

jmdugan

Hello!

There's no definitive database for these types of events yet that lists all the sources or all the people working on them. If you're interested in reading the scientific literature about fast radio bursts in specific you can search for them using the arXiv which is where most astronomy papers are available for free access. But there are lots of types of signals from space so it becomes difficult to compile them all.

A good book about these kinds of things for the engaged member of the public would beExtreme Cosmos which goes through a number of very exciting and incredible signals we pick up with our telescopes.

Wow Hey!

Since I read your discovery I fear opening the microwave early for fear of becoming doused in *universe*. It's probably best that stuff stays at the edge where it belongs.

So my question is, can I have my 4 seconds back or should I fear turning into some sort of radioactive sludge?

Glycerine

Hey those 4 seconds can really add up over time, so it's a valid question. Fortunately, I think you're quite safe. The little pings we picked up from the microwaves were bright when we detected them, but we also picked them up on *a super powerful telescope receiver* so in human-sensitivity terms it's basically nothing. Not to worry. Use your microwave how you want!

Hey Emily! No question specifically I just wanted to say GOOD LUCK with all of your future science endeavors. We went to high school together what seems like a very long time ago and I saw your name on reddit and had to stop by! Your work is inspirational, creative, and fascinating, and it's awesome to see you've come so far. Best of luck in the future!

futuregoatfarmer

Thank you! Hello back! Thanks for the kind words! Best of luck to you too!!

Thanks for doing this!

What made you get into this field, and how can we inspire more girls to approach, and make contribution to, the sciences?

ButterApe

What made me get into this field - a combination of passion and luck! I have been fascinated by astronomy for a long time. I think I started wanting to do space-related things when I was around 10 years old. I went through a phase where I really wanted to be an astronaut but then I saw Apollo 13 and decided that being an astronomer would be safer. But I think what made me stay interested was that all along the way from when I was younger I had a series of mentors, teachers, and friends telling me I could do it, not telling me I couldn't.

I hope that more girls will find the sciences approachable as more mentors and role models are visible in those areas to encourage them. It's hard to see yourself as an astronomer when all you see are people that aren't like you! But on top of that, I think it's so important to tell girls they can do it. If they express an interest in science to connect them with an expert rather than tell them it's not right for them. I love speaking to young people who are interested in careers in astronomy. So if you know any, send them my way!

How did you feel when your team realized that the radio signals were coming from the microwave? Also, is there still a microwave in the facility?

OateyMcGoatey

Relief! We'd known about these weird radio signals (that we called 'perytons') for about 4 years and they made everyone on our team very nervous. How were we supposed to be sure about these signals from space if we couldn't even locate the signals from nearby?! And the presence of the perytons made for a lot of skeptics in the audience at my scientific talks. So it felt great to finally have an answer!

There is still a microwave on site at the Parkes telescope but now there are strict measures in place to make sure no one opens the door of the microwave while it's running!

What exactly do you hope to accomplish as a result of studying these bursts? Are you more into seeking knowledge on a lesser known subject or are there ideas for some practical uses for them?

DNAtaurine

Partly I'm just interested in these bursts for the sake of finding out where they're coming from. Mysterious explosions in space? I'm in! But also because they may have some powerful uses in cosmology. If we're able to get the distances to these bursts (by finding the galaxy they come from) we could combine that information with the mass information we get from the radio pulse (see response to the question from /u/RyllaeBruis) to learn about the mass of the Universe at a range of ages. Ultimately, these could be powerful probes of the evolution of the regular matter in the Universe and we might be able to use them as cosmic rulers like Type Ia Supernovae.

"Less than 20 of these bursts have ever been found, but more than 1,000 are happening every day throughout the Universe"

This is a perfect example if how modern "scientists" can just invent false information without any actual data to back it up. No doubt you're seeking more funding for research. It's unethical and counter productive at best.

ChyneezStars4TheWin

Just to be clear, I wouldn't make those kinds of statements just to get research funding and I hope others wouldn't either.

Our estimates for how many bursts happen per day comes from the amount of sky we have managed to observe with our telescopes and the number of bursts we have seen in that observing time. Our telescopes look at a very small patch of sky at once and we have been looking for a relatively short amount of time total. And yet we have seen several of these bursts. Scaling this up to the whole sky based on what we see with our limited surveys is where we get this number. It is definitely an estimate, but I would argue it is hardly unethical. Just math!