Science AMA Series: We are MilkyWayatHome and Prof. Heidi Newberg of Rensselaer Polytechnic Institute. We are here to talk to you about mapping the Milky Way and general astronomy. AUA!

MilkyWayatHome [1] and r/Science AMAs[1]

[1]Affiliation not available

April 17, 2023

Abstract

Hi, everyone! We are the developers and scientists behind the MilkyWay@home distributed computing project and the LAMOST PLUS group, which collaborates with a Chinese-run spectroscopic survey that has so far produced over five million spectra of stars. Our research focuses on the study of the structure of the Milky Way, primarily in the galactic halo and disk. This includes tracing stellar tidal streams formed in dwarf galaxy merger events, measuring the distribution of dark matter, identifying disk structure, mapping stellar clouds like the Hercules-Aquila clouds, and much more. Our group has discovered new stellar tidal streams, created the most comprehensive characterizations of some of the Galaxy's largest stellar tidal streams, and most recently discovered an oscillation pattern in the Milky Way disk that is thought to be caused by the interaction with small galaxies in the the halo of our galaxy. This disk-halo interaction could explain how spiral structure is formed and maintained. For more information about our work over the last year please have a look at our newsletter, with links to recent public lectures and news articles. Our group also actively participates in public outreach, most of which includes educating the public about our research. Since we run a crowd sourced distributed supercomputer, MilkyWay@home, we provide our volunteers with an explanation of what they are contributing towards. To this end, we enlist multiple social media outlets, have a brief science page on our website and provide links to all of our publications. Recently, Professor Newberg has been producing videos with her children designed to help young kids understand basic science concepts. These can be found on our YouTube channel. We have several members of the team here to answer your questions: Professor Heidi Newberg: The leader of MilkyWay@home and the LAMOST Plus groups at Rensselaer Polytechnic Institute. Previously worked on the Super Nova Cosmology Project, and the Sloan Digital Sky Survey. Dr. Jeff Carlin: Post-doc working in the LAMOST Plus group. Looks for galactic structure using 3D kinematics of stars and 3D position data. Charles Martin: PhD student working with the LAMOST Plus group. Discovered the Pisces stellar stream and now is focusing on the Hercules-Aquila cloud. Siddhartha Shelton: PhD student working with MilkyWay@home. Currently developing our N-body application and optimization methods. Jake Weiss: PhD student working with MilkyWay@home. Currently improving our stream finding algorithm to allow accurate, simultaneous fitting of many different streams. Paul Amy: PhD student working with MilkyWay@home. Preliminary study of modeling simultaneous Milky Way merger events with N-body simulations. Travis Desell: Former PhD Student who initially developed MilkyWay@Home and the evolutionary algorithms it uses. Now an assistant professor at University of North Dakota. We will begin answering questions as 12pm ET (9am PT). Anyone interested in joining our community of volunteers, or learning more about the MilkyWay@home project should check out our website, twitter, instagram, facebook page, and YouTube channel. Recently, both of these projects lost their National Science Foundation funding as grants becomes increasingly harder to get in astronomy. If you are interested in donating to our group please visit our fundraiser page. Edit: We are starting to answer questions now. We will be answering questions for the next two hours (until 2pm) and will probably pop back in throughout the night to answer more. Thanks for all of the great questions here so far. Edit 2: Hey everyone, thank you for all of the fantastic questions. Please remember to check out our website and follow us on social media to keep current with our work. We are going to take a break from answering questions, but we will be checking back in throughout the day to answer any new questions that might pop up. Sorry if we didn't get to your question.

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MILKYWAYATHOME R/SCIENCE

ABSTRACT

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We will begin answering questions as 12pm ET (9am PT). Anyone interested in joining our community of volunteers, or learning more about the MilkyWay@home project should check out our website, twitter, instagram, facebook page, and YouTube channel.

Recently, both of these projects lost their National Science Foundation funding as grants becomes increasingly harder to get in astronomy. If you are interested in donating to our group please visit our fundraiser page.
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READ REVIEWS

WRITE A REVIEW

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Once we begin mapping, by what "compass rose" will we identify direction in our Galaxy? Since North South Up Down. Etc are not relative directions for space I am curious how we would navigate or give relevance to celestial bodies? Thank you for taking the time for this AMA!

Nixplosion

Okay, I googled "compass rose," so I'm with you now. We define a whole new coordinate system for the Milky Way, that is aligned with our Galaxy. The Z-axis is perpendicular to the plane of the Milky Way. The X-axis is towards the Galactic center. The Y-axis is in the direction of the Sun's motion in the Galactic plane. I like this definition because it is right-handed, though some people define the x-axis in the opposite direction. We can also define the position of things in the Milky Way by angular position in the sky (Galactic latitude and longitude) and distance from us - if we can figure that out. North, in the Galactic sense, is the the Z direction.

Prof. Heidi Jo Newberg

First of all, I think the science you all do is amazing. I'm fascinated by stellar mapping projects (in fact as a young engineer, I was part of the team that worked on ESA's Gaia space observatory vehicle).

What's your favourite discovery about the Milky Way that you've been involved in finding out?

What do we know about the oscillation of the Milky Way structure (how it's "corrugated"), like the period etc?

Is crowdfunding an effective alternative to losing grant money?

Multidisciplinary

I'm glad you're interested in my research! I am looking forward to using data from Gaia, myself.

My favorite discovery was that the stars in the outer parts of the galaxy are clumped. It turns out that they are clumped because small galaxies are falling into our galaxy and being ripped apart by gravity (the remnants are the lumps). This was my first, really big personal discovery.

Currently second favorite discovery is the oscillations of the disk stars. We see these oscillations in density (corrugations - or ripples up and down in the disk, and also oscillating densities perpendicular to the plane of the disk) and also in velocities of the stars. We do not get have a map of the disk that puts the oscillations together, and we do not have the oscillations measured on all scales. The wavelength of the corrugations we see in the disk is something like eight kpc (like the distance from the Sun to the center of the Milky Way). But there are probably much smaller structures as well.

Okay, crowdfunding. A few years ago, crowd funding would not even have been considered, because it would have made more sense just to submit another proposal to NASA or NSF. But now only 13% of proposals are funded. If the funding rate drops to 6%, then it will cost more to write the proposal than

one expects to get (the amount we ask for times the probability that we get it). So we are trying crowd funding.

Prof. Heidi Jo Newberg

What sort of software do you use to map/plot the Galaxy? Is there room for more players in that sphere in terms of applications?

TheWeebbee

Hey TheWeebbee,

We use quite a few different programs in our project. We look for and characterize substructure in the Milky Way using our separation application and we try to recreate this substructure using n-body simulations with out n-body application. Both of these applications are open source, but primarily written by students in the MilkyWay@home group.
For Separation: First we pull data from the Sloan Digital Sky Survey to get the positions of stars in the sky and their apparent brightness. This is all done with MySQL queries which is pretty standard. We then use our code for MilkyWay@home, an open source C application, in conjunction with the Berkeley Open Infrastructure for Network Computing (BOINC) to try to pull out substructure from this data. We then have a suite of python tools to plot and analyze the substructure fit by our MilkyWay@home application. This lets us stitch together the results we have into a big map of the substructure through the galaxy or have other ways of visualizing and verifying our results.

For n-body: We take data from our separation application or other sources to create histograms substructure as we see it in the sky. We again use BOINC with our n-body application, an open source n-body simulator we wrote in C, to try and recreate this substructure from dwarf galaxies. We can visualize these simulations either with blender or another one of our other visualizing programs. Examples of this can be seen on our youtube page. We also make still plots of our simulations using python with matplotlib for other views.

There is still a lot of work to be done in mapping the galaxy and as such plenty of room for other people to make mapping applications. Our group focuses on looking at the density of stars in substructure in the Milky Way. Other applications written by different groups try to map how different properties of stars change throughout the galaxy (think age and chemical composition aka metallicity). For living in the Milky Way we know surprisingly little about how it was formed and its structure.

--- Jake

Why should the general public care about mapping the Milky Way? Why is this important?

Thanks for doing this!

drbadskwerl

The research that we do is basic research. That means we do not have a plan in place for how this is going to cure cancer, make your computers run faster, or create spinoff businesses that employ our citizens.

There are four reasons to care about basic research, like ours:

(1) Knowing about the Universe we live in changes us as people. It is astounding to me that my great grandmother lived most of her life not knowing we lived in a galaxy. Can you imagine in this modern age not knowing that the Earth goes around the Sun?

(2) In the very long term, what we learn might be important. Like fusion (that was originally discovered to explain how the Sun could live for 4 billion years - the age of rocks on Earth) might someday give us an energy source that does not produce radioactive waste like the current fission-based nuclear reactors. We are trying to understand, for example, what dark matter is. Who knows what physics we will learn from that and what technology that physics will eventually result in?

(3) Spinoff technologies that we did not expect can change our lives. When I was a postdoc at Fermilab, I worked on the third website in the world. The web was created by a particle physicist who was trying to solve a real-world problem: how can a community of physicists all over the world work together to create and document code for processing particle physics data? To make the documentation accessible all over the world, Tim Berners-Lee created the world wide web. Big technological advances can be made by smart people trying to solve impossible problems, and that technology can change our everyday lives in unanticipated ways. Can you imagine the world without webpages? When I worked on the Sloan Digital Sky Survey, we were early adopters of object-oriented databases, and some of our team members were pioneers in organizing big data. Often scientists, who are always trying to push the envelope, work with their suppliers (whether it is hardware or software) to improve the products that are on the cutting edge. Scientists often put in the effort before the products become cost effective. This helps to spur on industry, even if the scientists themselves are trying to use the database, crystal, electronics, or whatever for what appears to be an esoteric reason.

(4) We educate the next generation. I have worked in inner cities with where we were using the wonder of astronomy to get middle school kids interested in science and math. My students do enormous outreach with our public observing program and also organize hands-on experiments in schools. I have given talks in high school astronomy clubs to kids who are trying to understand what college and careers are, and been interviewed by Glamour magazine for the same purpose. I teach college classes. Oh, yeah. We also answer questions from the public on reddit. The list just goes on and on. Without us, what would they put in those textbooks?

Prof. Heidi Jo Newberg

Is Sagittarius A* our only black hole, or are there possibly more, smaller ones elsewhere in the galaxy that we haven't observed yet?

mnp

Our galaxy, and as far as we know all big galaxies, have a supermassive black hole (like Sgr A*) in the center of them. The mass of the black hole is bigger the more massive the galaxy is.

There are also black holes that form when very massive stars (which don't live very long by Universe standards) die. There are definitely many of this type of black hole in the Milky Way galaxy. We can find some of them by seeing mass from a companion star falling into it. These are X-ray binaries. Yes, I am sure there are many that have not been observed, or that are at this time unobservable because they are not in a binary system with another star.

But if you are hoping to solve the dark matter problem with these black holes, I am afraid there are not enough of these to close the gap.

Prof. Heidi Jo Newberg

Question A: So i once heard that the Universe is drifting apart and getting bigger. First, is that true and how can i imagine the end of the universe? Second, do you assign this drifting in you mapping tools or isn't it even noticable with your technology.

Question B: How precisely can you calculate positions and which factors are problematic for a precise measurement?

Excuse my english, a non-native right here.

johnny0306

The Universe is in fact expanding! Even more amazing, it is expanding faster and faster (that's Dark Energy). I actually was part of the Supernova Cosmology Project (SCP) team that found this result. But unfortunately that doesn't give me a window into the future to know what the end of the Universe will be like. If you extrapolate what we currently see then the Universe will just keep expanding and galaxies will get farther and farther apart and eventually everything will be black and cold. But I don't recommend extrapolating. There are so many poorly understood phase transitions that have happened in the past that we don't know if the current acceleration that the Universe is experiencing will go on forever.

But luckily for us Milky Way researchers, we don't need to worry about it, because the Milky Way galaxy, and everything in it, is not expanding! It turns out the expansion rate is related to the density, and since the Milky Way is dense enough, the space in our galaxy is not expanding with the rest of the Universe. I know that is tough to wrap your head around.

The angular positions of objects in the sky can be measured with very high precision. The distance is really, really tough to get for most objects. Usually we try to determine how intrinsically bright each object is, and then use the brightness the object appears to us (using the inverse square law if you know about that) to determine its distance. We know the intrinsic brightnesses of some stars better than others, so some distances are better known than others.

Prof. Heidi Jo Newberg

Hi.Thanks for doing this. You guys are doing an amazing job.. Sorry if its a noob question? How do you name newer things you discover? is there a naming convention followed?

warlock1992

It's a good question - the simple answer is that for stellar streams and structures in the Milky Way, there is no convention for naming them. Initially, people would name a structure after the constellation in which they first discovered a piece. However, this becomes problematic, because streams span large swaths across the sky, and are thus not confined to a single constellation. [Note: for newly discovered dwarf galaxies, this is still the convention that is used.] So for streams, it has become somewhat arbitrary (as my co-author on a recent review article stated it: "...a delightful anarchy has ensued."). We have one called the "Orphan Stream" (because its parent object is unknown), and many that are named after the rivers of the underworld in Greek mythology (Styx, Lethe, Acheron, etc.). Still others are named after their discoverers (e.g., "GD-1", which stands for "Grillmair & Dionatos"). Ideas for reasonable naming conventions are welcome! -- Dr. Jeff Carlin

Hi everyone. I'll start by saying I love astronomy and I'm so grateful for you guys for contributing to the field that got me into science in the first place.

In spite of that, even though I'm in the final year of a physics/engineering double degree specialising in astronomy, I feel myself getting burned out on space.

What are some things you would suggest to rekindle some of that interest in astronomy/cosmology and the frontiers of science in general?

What kinds of exciting careers in astronomy exist that are possibly overlooked in lieu of becoming a theoretical physicist or an engineer?

PepeLeFrog

Studying physics and engineering can be exhausting, and doing research can be psychologically difficult because it is not always easy to see one is making progress.

I never knew when I started this process that I would end up in a research faculty position. Now that I am here and much more successful than I ever imagined, I still don't know were my next research grant is coming from.

I think what is important is to do what you like doing, and realize that if for any reason it doesn't work out that you have the skills to do whatever it is that you think is exciting. You could teach, form your own company, work in a startup, run a charter school, get a job in finance, or whatever. The important things you have learned will not go wasted. You just have to figure out what is exciting to you.

As a mother of four, I can tell you knowing astronomy is an important asset as a parent. My kids are proud that I can help them with their homework and that lots of other moms bring their children to me to answer their astronomy questions.

Prof. Heidi Jo Newberg

I have a complicated and long question, but since this is the only time I've encountered anyone who might be able to answer it, I have to ask.

I came up with it while considering the fact that Jupiter with its orbiting moons is conceptually very similar to the Sun with its orbiting planets (only smaller), which is again similar to a black hole with its orbiting suns (only much larger); and also the idea that Jupiter is sometimes described as a "failed star", because it has almost—but not *quite*—enough mass to initiate fusion and become a Red Dwarf. It's just about sun itself!

So here goes: When the galaxy formed long ago, it started off as a cloud of atoms, largely hydrogen. Under the influence of gravity, the cloud began to coalesce into individual pockets of matter, kind of like beads of water forming and combining on a window pane in the rain.

The randomness of mass distribution resulted in a large range of sizes of these pockets. And the randomness of the speeds and directions of all the individual particles that made up each pocket resulted in various numbers and groupings of objects that eventually formed from each pocket.

1. Some pockets contained an enormous amount of matter, with particles of a wide range of different velocities, resulting in the formation of a black hole, in orbit with a couple of stars, and a several planets.
2. Some pockets contained a fairly large amount of matter, with particles of fairly consistent velocities, resulting in the formation of just one lone large star.
3. Some pockets contained a fairly large amount of matter, with particles of a wide range of different velocities, resulting in the formation of a large star, in orbit with several planets (like our own system).
4. Some pockets contained a comparitively small amount of matter, with particles of fairly consistent velocities, resulting in the formation of just one lone Red (or Brown) Dwarf.

Assuming the preceding premises are generally correct (please correct them if they're not), my question is this this: Is it possible that some pockets of matter were *even smaller*, containing not even enough matter to form a Red (or Brown) Dwarf?

Rather than a star, could they have coalesced into a large planet-like object the size of Jupiter, in orbit

with a few smaller objects, some the size or Mars, others as small as Mimas? The whole system would be kinda similar to our own solar system, if the mass of every object in the solar system was divided by 1,000.

But this tiny system would have a weird quirk that would make observation very difficult: since the main object in the system doesn't have enough mass to initiate any kind of fusion, it doesn't emit much light/energy, so it's very dark. In fact, you'd probably only be able to detect such a system if it transited a star or a bright nebula.

So is it possible that half of the "stars" in our galaxy are actually systems such as these, but that they go largely unnoticed by astronomers due to their dim, shadowy nature?

Flight714

Hey Flight714,

So while your general description of what happened to form the galaxy might be correct, these are still a lot of unknown factors in formation of all of these things you described. I won't try to discuss how it actually happens here because it will be full of speculation, but there are plenty of papers describing a number of theories about how galaxies are formed.

I can still try to answer your question though because there have actually been surveys done to try and put limits on the mass of the galaxy that can be attributed to these systems using a technique called microlensing. We actually call these objects MACHOs or Massive Compact Halo Objects and for a while they were thought of as a good candidate for dark matter. When the results from these surveys came back though, they could not find enough of these objects to account for the effects of dark matter. They did find some examples of these objects though.

--- Jake

Hello, I was wondering about the mass of nebulae, such as the Lagoon, or the Coal Sack. How many solar masses are contained in these regions?

How long do such regions last?

Do they slowly dissipate or are they used up in star formation?

Was the material in larger nebulae created from super nova explosions or is it mostly left over from the beginning of time?

I ask because my friend and I are working on a star cluster simulation game.

edit: weight to mass

Nirriti_the_Black

It really depends on the type of nebula--comparing different types of nebulae is like comparing apples and oranges. The Lagoon nebula is a star-forming HII region; that is, a cloud of hydrogen that forms hot blue stars that put out sufficient energy to ionize most of the gas (HII refers to ionized hydrogen). The Coal Sack nebula, on the other hand, is a dark nebula. It's a cloud of dust that we can see because it obscures background stars, but emits very little light of its own.

Anyway, the answer depends on type. Star-forming clouds are large, containing tens or hundreds or even thousands of solar masses of material. They don't dissipate as they're gravitationally bound, but matter may be used up in star formation.

Dust clouds like the Coal Sack nebula are also large, again containing anywhere from tens to

hundreds of solar masses. They are also gravitationally bound together and don't dissipate.

There are also planetary nebulae, which are the ejected outer layers of dying red giant stars. These are smaller, since they're due only to a single star. They tend to be colorful since the heat from the exposed core of the star ionizes the gas in the nebula and causes the gas to glow. Planetary nebulae do dissipate over time, as the gas gets further from the star, cools off, and ceases glowing. It eventually recombines with the interstellar medium.

--Paul

Do we live in a "special" place in the Milky Way?

What would a special area within a galaxy even look like?

Peeling_Paint

I think we live in a special place because we are here. Even though we are finding planets around lots of other stars, we don't know if those planets have any forms of life - let alone a life form that can communicate through reddit. Our star is probably at a special place in the Milky Way that was not disturbed by a supernove. But these are the kinds of questions astronomers are still pondering as they try to figure out whether there is life elsewhere in the Universe.

Hi! Several questions:

1: RPI maintains its own supercomputing cluster. What's the advantage of doing this work as a volunteer distributed computing project over using that cluster?

2: Can you give us an idea of the size of the data and the scale of the computations that need to be performed?

3: I've never heard of crowdfunding for scientific research before. How common is it? What challenges did you face?

Thank you! Really cool work you're doing.

adipisicing

Hi! Travis here.

1: RPI maintains its own supercomputing cluster. What's the advantage of doing this work as a volunteer distributed computing project over using that cluster?

When we started working on MilkyWay@Home we initially did run what we did on RPI's BlueGene. In fact, a lot of our earlier papers compare how well our evolutionary algorithms run on the BlueGene vs. MilkyWay@Home, like The Effects of Heterogeneity on Asynchronous Panmictic Genetic Search, Asynchronous Genetic Search for Scientific Modeling on Large-Scale Heterogeneous Environments, and An Asynchronous Hybrid Genetic-Simplex Search for Modeling the Milky Way Galaxy Using Volunteer Computing. In a nutshell, initially we showed that we could get similar results with MilkyWay@Home in not much more time than using the BlueGene, and that was back when we only had a couple thousand volunteered computers, and no GPU application. Once the project took off, MilkyWay@Home was running at 1.7 petaFLOPS (as no other BOINC projects used GPUs at the time, now we're down to 0.4 petaFLOPS or so) -- this made us the 3rd fastest "computer" in the world at the time, whereas I think the RPI's BlueGene at that time was 90th. On top of that, the MilkyWay@Home server only cost $6,000 as opposed to the multi-million dollar blue gene, and we didn't have to share it

with anyone. So that's a lot of reasons. :)

That being said, supercomputers aren't useless -- it's just that our particular problem (numerical optimization via evolutionary algorithms) is "embarrassingly parallel" and well suited to volunteer computing. Other problems such as advanced simulations require a lot of really fast inter process communication and need a BlueGene or other super computer. So it's much better for us to use BOINC so other people who really need the BlueGene can use it.

2: Can you give us an idea of the size of the data and the scale of the computations that need to be performed?

MilkyWay@Home does two things at the moment, the first (our original application) was fitting models of the halo to the observed stars in the sky -- basically fitting multiple connected cylinders across different stripes. To evaluate a particular model with a particular set of parameters (one MilkyWay@Home workunit) takes about 15 seconds on a GPU or 30 minutes on a CPU. We need to do this about 1-4 million times (which takes about 4 weeks per run).

Then for the other application, which is optimizing input parameters to n-body simulations of how the halo might have formed takes around 20 minutes or so depending on the computer and how many cores are available. This takes about 250,000 evaluations (or 2-3 weeks a run). So these are pretty large scale.

In terms of the data, it's not too much as we're really only dealing with input parameters to the n-body simulations or stream fitting application. We do match the results of these to stars in the sky, which are about 3MB per segment/slice of the sky and there 29 of these for the northern sky and 17 for the southern sky. So the challenges here are really more computational than data related.

3: I've never heard of crowdfunding for scientific research before. How common is it? What challenges did you face?

It's not too common mainly because it's pretty difficult to raise the amount of funding needed to do research for a lot of fields, especially if the science isn't easily package-able/presentable to the general public. It's a bit easier for MilkyWay@Home because we have a pretty large audience for the project, but even funding a graduate student for a single year can easily get above $50k and most graduate students would like to have a little security that they'll have funding for the time it will take them to complete their degree. In general, there's a pretty large problem facing most scientists in that research funding is drying up due to budget cuts while at the same time more researchers are competing for it. Because of that a lot of us need to look for creative, if less optimal solutions to be able to keep cool projects like this one going.

What would (theoretically) happen if. Two or more black holes came within each other's event horizon ?

TheZ1mb1nator

If two black holes were to come within each other's event horizon they would merge into a single more massive black hole. If two black holes were to orbit one another closely or merge it is theorized that they would produce gravitational waves. None of these have yet been observed.

-CM

What do you think about Gridcoin? Has the Gridcoin community had an impact on BOINC contribution?

jdheeter

The Gridcoin community, it turns out, has made a big contribution to processing power for MilkyWay@home. They have also been sweethearts in helping to fund our project. Last year I spent considerable time trying to figure out what a Gridcoin was, because some of our volunteers suggested using Gridcoins to fund our operations. I had absolutely no idea that our compute cycles were being used to mine gridcoins, or that we were the biggest gridcoin mint around.

This really supports my assertion that one never knowing what the practical spinoffs of research projects will be.

To be honest, I am still struggling to understand cryptocurrency.

Prof. Heidi Jo Newberg

What do you think about Gridcoin? Has the Gridcoin community had an impact on BOINC contribution?

jdheeter

Hey jdheeter,

Gridcoin has been fantastic to MilkyWay@home. Bitcoin Utopia has been collecting gridcoins and converting them to bitcoins and money for our fundraisers and have made significant contributions. (thousands of dollars) Its also nice to have the computations for mining cryptocurrency going to good causes rather than just breaking hashes.

-- Jake

What is your favorite astronomical object discovered in the known universe?

i.e. The one you think is most interesting or cool

TR7237

I personally think it is the discovery of blackholes. Especially the existence of supermassive blackholes at the center of every galaxy. My reason is because, with blackholes, you are dealing with a region of space where laws of gravity and laws of quantum mechanics are going head to head in a way we still don't fully understand. Now that they are shown to be real, finding a theory of quantum gravity is less of a theoretical exercise and more necessary in fully understanding objects in the universe. Another great mystery is the existence of these supermassive blackholes at the center of galaxies, leading to the question what is their relationship with galaxy formation?

-ss

What would you say is more valuable, the computing time donated by your users or the outreach impact of the project?

Robo-Connery

What would you say is more valuable, the computing time donated by your users or the outreach impact of the project?

Travis here: I think they're both very important, however maybe the computing time donated is a bit

more important because without that we can't do the science we need to do. Good science (even if not widely known) has a lot more potential for impact in the long term. There's some great potential here to better understand our galaxy and the universe here, and we can't answer those without those donated compute cycles.

On the other hand, anything that gets people interested in science, especially anything that can help excite future generations of scientists has great impact to us all as well!

What would you say is more valuable, the computing time donated by your users or the outreach impact of the project?

Robo-Connery

We built MilkyWay@home for the computing cycles. We do outreach to return the favor and keep people interested. Huh. How do I figure out which is more important?

Hello! First of all, thank you for the fascinating work you do and for taking the time to make an AMA.

I have a question. As scientists and developers in your field, what kinds of things blow your mind when studying the Milky Way?

tcp90

Speaking for myself I'm always amazed at how little we actually know about our own galaxy. For example, up until this summer, we thought the galactic disk for the Milky Way was flat, and only half the size we think it is now. Now we think that the galactic disk is much larger and that it is wavy or corrugated. Another example of something that surprised me was how little we know about one of the largest stellar streams in the Milky Way, the Sagittarius dwarf galaxy tidal stream. It is currently accepted to be the remnant of a single dwarf galaxy but it is two seemingly different streams. It is possible that it was actually created by two dwarf galaxies, but no one has been able to find the galactic center of the second dwarf galaxy, nor have they been able to find a way to recreate what we see. Its actually one of the major components of my research so maybe I can come up with an answer in the next couple years.

Hope that answers your question.

-- Jake

Hello! First of all, thank you for the fascinating work you do and for taking the time to make an AMA.

I have a question. As scientists and developers in your field, what kinds of things blow your mind when studying the Milky Way?

tcp90

I guess dark matter still blows my mind. The theorists tell us that there are thousands of lumps of dark matter orbiting around the Milky Way, in addition to the dozens of dwarf galaxies that we *can* see. If that's true, I want to find one.

Prof. Heidi Jo Newberg

Hello! First of all, thank you for the fascinating work you do and for taking the time to make an AMA.

I have a question. As scientists and developers in your field, what kinds of things blow your mind when studying the Milky Way?

tcp90

Travis here: As a computer scientist it blows me away that we can have over 27,000 computers from all over the world collectively working on what the shape of the Milky Way Galaxy is and how it's formed!

Just as cool, is that we're finding answers to this by using computer algorithms that essentially simulate evolution. We find the best parameters to the models and n-body simulations by treating particular parameter sets as "individuals" and then have them mutate and generate offspring. We kill off the weakest individuals and over time the population of individuals evolve to those with the best parameters to our models/simulations.

Hello! First of all, thank you for the fascinating work you do and for taking the time to make an AMA.

I have a question. As scientists and developers in your field, what kinds of things blow your mind when studying the Milky Way?

tcp90

The scale of everything. The Milky Way is incomprehensibly huge, and yet is only one of billions of galaxies in the visible universe.

--Paul

I wanted to say thank you very much for your contributions.

My question is rather simple, since the Milky Way is warped (twisted, what ever other terms we want to use), how has this affected your mapping algorithms or discovery of other systems?

exaltedgod

Hey exaltedgod,

Actually the efforts of our research in MilkyWay@home have not been focusing on the disk of the Milky Way. In fact we cut the disk out of our data and try to find substructure outside of the disk. However, we will be starting a new project soon that will be focusing on the disk and try to map these disk warps and their density so other scientists can try to figure out how they were formed.

-- Jake

Just out of curiousity, it's ok that science is made just for the sake of science - are there any practical applications that you expect your research / astronomy in general will have? Something that will affect our lives / our children's lives? Thanks!

BigSwerty

Travis here: I can't speak to the astronomy, but just getting this project up and running led to some really interesting advances into how you can run really large scale evolutionary algorithms to fit models and optimize simulations. These algorithms are actually extremely useful for any scientific field that

needs to do numerical optimization on computationally expensive problems (which is almost all of them). For example, I've been using these algorithms for various bioinformatics projects which could lead to advances in cancer research, as well as for flight data prediction to prevent accidents in general aviation.

When it comes to research a lot of times the things you come up with end up being very useful, even to things pretty far from the original use. Sadly I think that's why some people in the public don't view research to be as valuable as it really is -- the benefits are really wide spread and might not happen immediately, or they might not happen in a direct one-to-one correspondence. But over time even some of the most obscure advances can have really large beneficial effects.

How do we know what the milky way looks like, when we are in it?

jojoko

Travis: That's one of the big problems that the project is trying to work on. There are some regions that we can't see because the center of the galaxy is in the way, but given what we know about the stars we see in the sky (estimations of their distance and things like that) we're trying to fit models to get an idea of what our galaxy look in 3D.

Interestingly, we can't really get 3D information for other galaxies because they're so far away they're essentially flat to us. So being inside the Milky Way gives us some opportunities for understanding galaxy shape/structure that we don't have looking at other galaxies, even if it is really challenging since we're inside it.

How much of our galaxy (percentage) have we observed? At what rate are we finding new things - in twenty years, what will that number increase to?

twentyx2

Hmmm, this is tricky, twentyx2! If you included observations of all types -- imaging at visible and infrared wavelengths, radio observations, spectroscopy, etc. -- I think we've probably gathered light from a good fraction of our Galaxy (say, 30%? I'm just guessing...). However, since the majority of stars are in the disk, and the disk also has lots of dust obscuring some regions, most of the stars in the disk have likely not been observed.

This fraction was much smaller until the past 15 years or so, when we've started to do surveys that image the entire sky (or a large chunk of it), like the Two Micron All Sky Survey (2MASS) or Sloan Digital Sky Survey (SDSS). Many other surveys are forthcoming -- the largest and deepest (i.e., reaching the faintest objects) will be the LSST, which is coming in a few years. With LSST, much of the outer regions will be mapped. But LSST still won't get past the dust obscuration and the fact that in the inner Galaxy, there are so many stars that we can't separate them in images!

As for stellar spectra, the LAMOST survey with which we work is the largest thus far, and it has only observed a couple million of the roughly 200 billion stars in the Milky Way!

-- Dr. Jeff Carlin

How much of our galaxy (percentage) have we observed? At what rate are we finding new things - in twenty years, what will that number increase to?

twentyx2

I don't think about our project in terms of the percentage observed, but rather in terms of how well we understand what we see. All of the data cataloging all of the stars that were used to find the ripples in the disk of the Milky Way was publicly available for ten years before our discovery was made. You could have gotten there first! We would like to understand how our galaxy works. I guess that doesn't lend itself too well to a percentage...

Prof. Heidi Jo Newberg

Via boinc, i've been an enthusiastic participant in this project for quite some time. My work done for this in 'units' is 113767. How far do we have to go to get completed? What is the total # of units will the end result be?

mambotangohandala

Travis here: For this project there really isn't an explicit number of workunits that need to be completed. Each run we do on MilkyWay@Home is being done to answer different scientific questions and we have a whole lot of them!

Is all the information we get limited by the speed of light? How does that factor in mapping since we are basically looking in to the past?

nhilante

Hey nhilante,

According to special relativity, there is a cosmic speed limit c which happens to be the speed of light. So yes all of the information we get is limited by the speed of light in a vacuum.

As far as how we take it into account in our mapping, we don't. The farthest we look away is about 163,000 light-years. The amount of time it takes the sun to revolve around the galaxy is about 250 million years and the structures we look at take about 500 million years. So the amount of distance one of these stars can move in 163,000 years very small.

-- Jake

Do we have any idea what the Milky Way galaxy would look like from outside the Galactcic Plane?

toadofsteel

Because we're inside the disk, it is difficult to know in detail what the Milky Way looks like. In fact that is part of what we want to do with MilkyWay@Home and the LAMOST-PLUS collaboration. Overall, we know that the Milky Way is a disk galaxy, and we can fairly easily measure the thickness of the disk, but mapping things like spiral arms in the disk is difficult.

One of the hardest parts of mapping the Galaxy is measuring distances. For example, we can point radio telescopes in different directions on the sky and measure how much gas and dust is present along each line of sight. However, it is really hard to tell how far away that gas is, so it's hard to make a map of the spiral arms in the disk, where most of the gas and dust is contained. Likewise, measuring distances to stars is difficult. This is improved if you select certain tracers for which you know the intrinsic brightness. In MW@Home, we use F-turnoff stars, but you could also use RR Lyrae variables, blue horizontal branch (BHB) stars, or other types. F-turnoff stars are best for our purposes because they are the most numerous.

One very helpful tool has been the mapping done by the Spitzer Space Telescope (for example, see http://www.spitzer.caltech.edu/images/1925-ssc2008-10b-A-Roadmap-to-the-Milky-Way-Annotated- or the "GLIMPSE360" project). Because infrared light is not obscured by dust as readily as optical light, Spitzer has been able to map the structure of the disk in detail. However, note that the image at the link posted above is only a schematic based on mapping from Spitzer -- there's a lot more to learn about the Milky Way! -- Dr. Jeff Carlin

Do we have any idea what the Milky Way galaxy would look like from outside the Galactcic Plane?

toadofsteel

While we cannot directly observe our galaxy from outside the Galactic Plane, we can assume it looks more or less like any other spiral galaxy. This is because these types of galaxies, though their individual histories would be different, evolved more or less the same way

-SS

Are we eventually going to get a more precise definition of the term, "Galaxy", in the same way as "Planet" was redefined? A great number of people interested in astronomy consider M31 to be our closest galaxy.

If the objects orbiting the Milky Way are, indeed, small galaxies, can you give us an estimate of their population and distribution? If that's part of the @home project, you can count me in.

Heck, count me in anyway.

MidManHosen

Hey MidManHosen,

There are already categories for galaxies similar to the way we now categorize planets. In general, they are classified into dwarf galaxies and galaxies, but these are then subdivided into other categories based on their structure (spiral and elliptical). The only real difference between dwarf and regular galaxies for characterization is their mass.

As for MilkyWay@home, we look at the remnants of dwarf galaxies that have merged with the Milky Way and try to figure out what they looked like before they collided with our galaxy. We then plan on using these galaxies to probe the mass distribution required look them look the way they do now.

-- Jake

Are we eventually going to get a more precise definition of the term, "Galaxy", in the same way as "Planet" was redefined? A great number of people interested in astronomy consider M31 to be our closest galaxy.

If the objects orbiting the Milky Way are, indeed, small galaxies, can you give us an estimate of their population and distribution? If that's part of the @home project, you can count me in.

Heck, count me in anyway.

MidManHosen

Like with planets, there is some controversy about the precise definition on the low mass end. How

small can a dwarf galaxy be before it is a star cluster and not a galaxy? Like with the planet definition, there is some controversy there. And there is some difficulty making a definition that allows for classification from easy observations. For example one might decide all clusters with a central black hole are galaxies, but then one would have to find the black hole in every galaxy (or definitively not find one) to make a classification. We don't have a final solution to this semantic problem.

Prof. Heidi Jo Newberg

I heard that RPI allows the public to use it's space telescope on Saturday evenings. Is this true?

I live in Albany, which is why I ask.

PolarDorsai

The Rensselaer Astrophysical Society (RAS) is the club that opens the Hirsch Observatory for public observing. Public observing is held from 8 - 10 pm every Saturday from February until the weekend before Thanksgiving. The Hirsch Observatory is closed during the winter months due to cold conditions and usually the presence of snow on the dome.

At public observing the students and volunteers in the club operate our telescopes to show off the wonders of the night sky. If you are interesting in learning how to use and operate the telescope then people from the community can talk to the officers and become club members.

Thanks for the question -CM

Have we named all the millions of stars that we see in a normal Milky way photograph ?

bulbaplup

No we haven't named all of the stars in that photograph. Most of the stars that can be seen by eye in the night sky don't even have proper names. In our night sky the majority of the stars are "Named" as a greek letter and the name of the constellation it belongs to. In this naming scheme the brightest star in a constellation is "Alpha", then "Beta", and so on.

For the stars that are specifically targeted by scientific telescopes, they are generally just given ID numbers, such as the ones assigned to the stars observed by Kepler. The other random field stars that aren't being studies are not given names though.

That would be a lot of stars to name. -CM

Hi. Are the angular momentum of all solar systems pointing in the same direction as the galaxy they are part of?

zaimdk

No.

Prof. Heidi Jo Newberg

Where might the average citizen find detailed data on specific Dark Matter distributions, and discrepancies from the Galaxy Rotation Curve? Ideally I'm talking about data, while perhaps not in *completely* raw form, but before any conclusions have been drawn from it. I.e. the data from which you

draw conclusions about how much DM there appears to be in the Milky Way.

Also, how far from classical predictions of the Galaxy Rotation Curve is the Milky Way, relative to other galaxies?

ScholarInRed

This question is difficult to answer. We don't know specifically where dark matter is, and that is something my group is trying to find out. There is data on the rotation curves in published papers. You might try Sofue 2012 (http://adsabs.harvard.edu/abs/2012PASJ...64...75S). I would say the Milky Way is pretty typical of large spiral galaxies.

Prof. Heidi Jo Newberg

What is the correlation between viewing distance and number of stars you can map? In other words, how many more stars would you be able to map if you had a satellite in orbit around the Earth? What about around the Sun? What is the best reachable and feasible point in the solar system/galaxy?

Pnoexz

Hi, Jeff Carlin here... If I understand your question correctly, it seems to imply that we would see more stars from a satellite because we would be closer to them. While it is true that there are huge advantages to observing from space, this is not because we are nearer to other stars. For example, the Hubble Space Telescope is in an orbit about 350 miles above the Earth's surface. The nearest star (besides the Sun) is about 1.3 parsecs away, which is about 2.5e+13 (that's 25,000,000,000,000) miles away. So getting 350 miles closer doesn't change your view much.

Now, the advantage of going to space is that you get above the Earth's atmosphere, which distorts images and absorbs part of the light from celestial objects. The much clearer images you get from space allow you to see fainter objects. [Note also that (thankfully!) some types of light, such as x-rays and most ultraviolet light, do not pass through the atmosphere to the Earth's surface. Thus if you want to observe the behavior of stars/galaxies/etc. in x-ray or UV light, you need to send up a satellite.

Hope this addressed your question! --Jeff

Thanks for doing this!

My question: What kind of space or work related jokes do you and your coworkers make at work? I work in computer network defense and we make binary and computer jokes pretty often, so I was wondering if there's any funny stories or memories you can tell us! Thanks!

zombie_loverboy

Our advisor's favorite joke is "yo mamma is so fat she has little mammas orbiting around her."

You can find this joke as a comment buried somewhere within our code.

-SS

Are you aware that Gridcoin has whitelisted the Milkyway@home BOINC project & now users in team gridcoin are able to offset the cost of crunching work units?

On another note, despite the recent surge of talk about citizen science recently in the Whitehouse

have you still been unable to secure funding for the project?

Are you still attempting to chase up grants/funding outside of crowd sourcing?

Have you considered a patreon funding source? https://www.patreon.com/

Edit:

To cut down on travel costs have you considered sending/hiring a telepresence robot to attend the events? Http://www.telepresencerobots.com

grctest

I don't know what it means to be able to offset the cost of crunching work units - you are going to have to explain that. Does that mean they can receive Gridcoins, and use those to pay for their electricity/computer costs? I do know that MilkyWay@home is used to mine Gridcoins, if that is what you mean.

Talk in the Whitehouse appears to lead to requests for posters, powerpoint slides, and information about what we are doing but does not seem to turn into funded grants, unfortunately.

Yes, I am writing a proposal for NSF funding for MilkyWay@home at this moment, but I am fighting hard to shake of the sense of futility and put myself in sales mode.

I did not know about patreon. Any suggestions along those lines are welcome.

Prof. Heidi Jo Newberg

What do you enjoy the most about your profession? What do you enjoy the least?

Thank you for both your time and your work. Our galaxy is amazing, and it's incredible that we have individuals that will take on a task as daunting as mapping it.

CelestialSock

Travis here:

What do you enjoy the most about your profession?

As a computer scientist, it's just awesome to work on cool projects like this with other scientists and get to continually learn new things. Now that I'm faculty at UND doing computational science, I've also been working with aviation professors, wildlife biologists, geologists and people in our medical school (to just name a few) as so many fields really need the help of good computer scientists to get their science done.

What do you enjoy the least?

There's not enough time in the day to work on everything I want to work on. So sometimes my health (and especially sleep schedule) gets hurt by that.

Thank you for both your time and your work. Our galaxy is amazing, and it's incredible that we have individuals that will take on a task as daunting as mapping it.

Thanks! And I think just as much thanks (if not more) goes to all the people who volunteer their computers to enable us to do this work.

What do you enjoy the most about your profession? What do you enjoy the least?

Thank you for both your time and your work. Our galaxy is amazing, and it's incredible that we have individuals that will take on a task as daunting as mapping it.

CelestialSock

Hi CelestialSock - Jeff Carlin here. I can't answer for the others, but the thing I enjoy most about my profession is that everything you study seems to lead to more interesting questions. Because we can only observe our Galaxy and not run experiments, it's a challenge to combine our observations and our knowledge of physics to derive insights about the Universe. I enjoy that challenge. On a more mundane daily level, I enjoy the process of "problem-solving" that is part of writing code and various programming/data processing tasks. The least enjoyable part of this profession is writing grant proposals (or telescope observing proposals) to try and fund our research. I do, however, enjoy writing journal articles describing our research (though I may grumble about it at times!). -- Jeff Carlin

Im so impressed that you are all willing to do this. is there life out there or not?

SpongeCobNoAss

While we haven't yet discovered extraterrestrial life (that the public knows about, cue the conspiracies!) I completely believe there is. On a statistical basis alone there should be: the universe contains millions of millions of galaxies, each of which contain millions and millions of stars, many of which have planets. Even if we are focused on the parameters that lead to life on Earth, there should be somewhere out there which have these same parameters. Even more interesting is the formation of life somewhere with parameters not like on Earth. We are constantly discovering organisms which are not only surviving but thriving in environments we previously considered uninhabitable (check out the water bear for example).

So, my short answer is probably!

-SS

Im so impressed that you are all willing to do this. is there life out there or not?

SpongeCobNoAss

Given that life on Earth seems to have started as soon as it was possible, it seems likely that there would be life out there somewhere. It took a very long time, however, to make higher life forms and intelligent life. And it is not clear at all why that would happen. And it is not clear that we will survive for a large fraction of the lifetime of our planet. So it is a bigger reach to find intelligent life.

Prof. Heidi Jo Newberg

Im so impressed that you are all willing to do this. is there life out there or not?

SpongeCobNoAss

is there life out there or not?

Travis here: While I don't know, I think a very scary and strange situation would be that we were alone in this vast vast universe!

Just given the sheer size of the universe I'd be really surprised if there wasn't life out there. I hope we find it in my lifetime!

What will happen with the Sun when Milky way will collide with Andromeda galaxy?

adalhaidis

Typical distances between stars are so large that they very rarely interact directly with each other. So in that sense, when the Milky Way and Andromeda "collide", the stellar portions of these galaxies will pass right through each other. However, in this process, the Sun will likely have its orbit changed as the gravitational field of the galaxy is altered. Thankfully, this should have little effect on the Solar System (also, the prediction is that this "collision" will happen 4 billion years from now). The sky will look a lot different than it does now, though -- if you haven't seen it, check out this "simulated" view of the sky when Andromeda is crashing into the Milky Way: http://science.nasa.gov/science-news/science-at-nasa/2012/31may_andromeda/

-- Dr. Jeff Carlin

What will happen with the Sun when Milky way will collide with Andromeda galaxy?

adalhaidis

If you're asking whether the Sun will collide with anything, it's unlikely in the extreme. Galaxies are mostly empty space and stars are tiny on that scale.

When galaxies interact, however, stars and gas can be thrown out along streamers that are thousands of light-years long, and some stars may even be completely ejected from their parent galaxy. So this would be a potential fate for the Sun.

It's certainly not anything we'll have to worry about, though. The projected collision between the Milky Way and Andromeda won't happen for another 4.5 billion years.

--Paul

What range of light do you use in your mapping? Radio, infrared, visible, or something else?

theLabyrinthMaker

Hi theLabyrinthMaker -- for the work on MilkyWay@Home and in the LAMOST PLUS collaboration, we are using observations from visible light telescopes. We want to take advantage of the fact that fairly "normal" stars are much more likely to be seen than short-lived phases of stellar evolution. Because there are a lot more so-called "main-sequence" stars, they give us much better statistics for mapping the large-scale structure of the Galaxy. Most main sequence stars emit most of their light in the visible wavelengths, so this is most convenient for us. However, if you were interested in cooler stars, then infrared would be useful (see my answer to another question where I discussed the Spitzer Space Telescope), and if you were interested in gas and dust, then radio wavelengths would be more useful. --Jeff Carlin

How do you guys tell directions in space? Like there's no North, South, etc., so how is it done?

Shadow_Guard

We define our own north and south. I guess in a sense we as a race defined our own north and south on Earth, but it was a long time ago. We have many different systems for determining where things are, and each one is set up to be the "natural" system for what we are describing. On Earth, the north and south poles are special directions because the rest of the Earth rotates around that axis. In the Milky Way the disk stars are orbiting around the Galactic center. The disk defines a special plane (like the Equator), and the axis the stars are orbiting around is a special axis that defines Galactic north and south.

We actually make up new coordinate systems on a regular basis. For example we have special coordinate systems to describe the positions of stars in a halo tidal stream (which is kind of like a river of stars in the outer part of the Galaxy). We define angle along it and angle across it. We created two new coordinate systems, both describing the angular positions of stars in the sky) for the Sloan Digital Sky Survey. These coordinate systems were conveniently oriented along the directions our telescope scanned the sky. In fact, every time we take a picture with a CCD camera in some sense we are defining a coordinate system (row and column), which we then need to convert to a standard coordinate system.

Prof. Heidi Jo Newberg

How do you guys tell directions in space? Like there's no North, South, etc., so how is it done?

Shadow_Guard

The same way we tell direction on Earth: we pick a reference and describe other objects in relation to that reference.

In galactic astronomy, there are two common coordinate systems. The first is a galactocentric Cartesian system, where the origin is at the center of the galaxy and the x-axis is defined as the line connecting the Sun to the center. The second is a heliocentric spherical system, where the origin is at the Sun's position, the azimuthal angle l is measured counterclockwise from the line connecting the Sun and the galactic center, the elevation angle b is measured relative to the plane of the disk of the Milky Way, and the radial coordinate r is line-of-sight distance from the Sun to the object in question.

--Paul

A question from my mom:

From what we understand, the universe originally started out about the size of a grapefruit, but has since expanded to be infinitely large. How did it expand from a finite to infinite size?

WhoseAlex

The grapefruit thing is a bit confusing. Astronomers frequently say that at the end of "inflation" the Universe was the size of a grapefruit. But what they really mean is that the region that is the size of our current observable Universe was in a volume the size of a grapefruit. Even though the Universe is infinite, we can only see the part of the Universe that is close enough to us that light could get to us in the age of the Universe. Light from the Universe that is farther away than that is still traveling towards us, and we (or our ancestors) will be able to see that at a later time.

Prof. Heidi Jo Newberg

First thanks for doing this AMA. Second approximately how long do you think it will take to map all of

the Milky Way and also do you think there is life in our Galaxy.

Chance0809

First thanks for doing this AMA. Second approximately how long do you think it will take to map all of the Milky Way

Travis here: Heidi says about 3 years. We've fit most of the northern galactic region that we have data for, however this is just a first generation run. With better data and improved algorithms we'll be able to improve on what we've already done and refine things. There's a lot of work remaining, that's for sure!

and also do you think there is life in our Galaxy.

Of course, right on earth. :) As to anywhere else, I don't know but I'd be very surprised if there wasn't. I really hope we find some within my lifetime.

First thanks for doing this AMA. Second approximately how long do you think it will take to map all of the Milky Way and also do you think there is life in our Galaxy.

Chance0809

Hey Chance0809,

So to answer the first part of your question, we hope to finish mapping the Milky Way halo and related stellar streams that we have data for in the next year or two years. Mapping the Milky Way disk data we have will require a new application and much more work. While we hope to have that finished in the next three years, there is always the possibility we will hit some speed bumps on the way.

As for life in our galaxy, of course that exists, we are here! If you mean life besides that on Earth though, our work sadly won't be able to answer that question.

-- Jake

If able, where would you go first to get a look up close?

dDDDDDDDDDDDDDDDDDb

For me, I think it would be to visit a weirder star, like maybe a neutron star, white dwarf or pulsar. A multistar system would be on my list. Seeing a red giant sunrise would be interesting.

-Sid

How will the introduction of the Large Synoptic Survey Telescope (LSST) affect your work in the future? If at all.

DicksWii

Hi - Jeff Carlin here! LSST will be huge for this work, because it will observe much fainter stars than most current surveys can reach. For the MilkyWay@Home studies of the outer regions (the halo) of our Galaxy, the extra distance probed will be important. However, one problem with LSST is that when you get to faint objects (near or just beyond the limits of SDSS), unresolved galaxies (meaning they are point-like, and hard to distinguish from stars) start to outnumber Milky Way stars. Using the faintest stars in LSST will thus require careful efforts to distinguish stars from galaxies, which is not a trivial problem.

how 'big' can an object be and still fit in a stable Lagrange Point? Like if we put one part of a space station in a stable one, is the maximum size of the space station determined by the masses of the objects whose gravity is counteracted?

CircularMatrix

Space stations are held together by chemical bonds. What you would do would be to calculate the force from both objects on one side of the space station, and the force from both objects on the other side of the space station. Take the difference and that is the "tidal force" pulling the station apart. Then ask whether that force would pull the fabric of the station apart. Gravity is pretty weak compared to chemical bonds, so we're taking Death Star proportions here.

Prof. Heidi Jo Newberg

Hi, I am frequently interested in the to-be Gamma Ray Burster Wolf-Rayet 104. So far it has yet to explode, but could do so at any 'moment'. It's detonation will have interesting effects (I imagine) on the intersteller medium; and we will have an almost front-row seat to the show.

How might your work be advanced by this event?

Hecateus

While this would be fascinating if it happens in our lifetimes, it would not be all that relevant to our work. This GRB would affect only a tiny pocket of the Galaxy, while our projects (mostly) address the large scale structure of the Milky Way. As you said, though, we would certainly learn a lot of cool physics from such an event! --Jeff Carlin

How has mapping the MilkyWay Galaxy revolutionized the traditional way of map making?

Kungfufuman

Travis here: I'm not so sure it's revolutionized map making, but what we're doing is quite different. Maybe one major difference over traditional maps is that the "maps" we're generating are 3D (although I'm sure there are geographers working on 3D maps as well).

How has mapping the MilkyWay Galaxy revolutionized the traditional way of map making?

Kungfufuman

Map making seems to have been revolutionized any way, right? Googe maps is way different than anything I ever saw as a kid. And now there is Google sky, which is the same thing but looking up.

Prof. Heidi Jo Newberg

What's the strangest thing you and your team have seen in your mapping?

What would the dream amount of resources be to accomplish your task more effectively, and what could you accomplish?

spikenigma

I would say the ripples in the disk were pretty strange and unexpected. I think there is a misunderstanding about the mapping, though. We are using individual objects discovered in the Sloan Digital Sky Survey, but we are using those to build a picture of the galaxy we live in.

I guess I dream of being able to do my research without constantly having to ask for money.

In a grand version of the dream I would have $5M-$10M to figure out where dark matter is in the Milky Way. I would want to spend it at a rate I determine myself over maybe ten years. Data from the Gaia satellite, that will start becoming available next summer, will be extremely helpful.

A smaller scale version of the dream would be I win my next NSF grant proposal that gives me $450,000 over three years and allows me to fund my current students.

Prof. Heidi Jo Newberg

Perfect timing! I have been watching a planet, I don't remember which, ever since it was really close to us a month or two ago every morning, I noticed the stars in the back ground move a bit each night. Is the planet really moving that fast or is it because of us moving? Basically what is causing the stars to appear to shift behind it?

rockdme

It is both. We are moving and the planet is moving. Try drawing it on a napkin - that's what we would do.

Prof. Heidi Jo Newberg

I've always wondered why is it called the Milky Way? Who named it and where is it derived from? Thanks so much for all your knowledge and info ✌

LastnameJordan

The name "Milky Way" comes from the Latin *via lactea*, which itself is derived from the Greek *galaxias kyklos*, or "milky circle". The "milky" part comes from its appearance as a dim, glowing band of stars.

--Paul

How did you know exactly where everthing was relative to earth?

echudov

We have angular coordinate systems to describe in which direction in the sky each object is. Determining the distance is harder. We usually have to guess or calculate the intrinsic brightness of each object and compare that with the brightness it appears to us to determine how far away it is.

Do you think the laws of physics change in pockets of our galaxy?

osiain

While we cannot know for sure, we assume that the laws of physics are the same everywhere. This will probably be the case until we see something that goes against this assumption.

That being said, I think it is a pretty good assumption. If there were places where the laws were different we would be able to see 'funky' stuff happening there. In fact, we have seen some 'funky' stuff (read on Gamma ray bursts/ gravitational lensing), or at least it appeared that way at first. But we were eventually able to explain and understand these phenomenon within the groundwork of our current laws.

-SS

There has been a lot of new media about space and our galaxy, especially with video games like Kerbal Space Program, Elite Dangerous, and No Man's Sky. Do you feel that this represents a renewed interest in space travel in our newer generations?

essidus

I would definitely hope so. For a while now space travel has not been on anyone's list of priorities in the US. We have seen NASA significantly defunded and now research in Astronomy is being cut dramatically. We have seen in the past how science fiction inspired young adults to pursue careers in science. With the advent of a more interactive media, i.e. video games, it is certainly possible that this would also inspire future scientists. Also, the sudden reemergence of these space travel type simulation games is very promising that there may be a trend of having space travel coming back into the main stream. But at the end of the day we can only hope!

-Sid

[deleted]

[deleted]

I think you may be confusing space-time and reference frames. Space time is everything we see around us, the universe. It is the 4-space that includes time and the three dimensions of space. This space can be warped by gravity, like laying a marble down on a sheet. This can cause light to bend, like with gravitational lensing. You can imagine, this is also why things get trapped in orbits (think a coin rotating around a funnel). But it is all the same space-time.

A reference frame is kind of what a moving object would see relative to itself. Like how when you are on the highway cars going your direction appear to be travelling slowly, and cars going the other direction seem to travel faster even though, from the reference frame of a person standing on the side of the road, you are all travelling at similar speeds. However, the thing about light is that no matter which reference frame you are in, light always travels at the speed of light. Also, according to general relativity, there is no proper reference frames. Physics works the same in every reference frame. Therefore, all of these frames of reference all work.

Now you are correct, every object would have their own reference frame within our space-time. But the entire universe is made up of the same space time. However, if there is another space-time, you would be talking about a parallel universe, which we would not be able to observe.

-sid

Hi guys!

Thanks for doing this AMA. I'm a Physics RPI alum and currently applying to graduate schools and RPI is on the list! Maybe I'll be working with some of you in the future. My question is directed towards Dr.

Carlin-

When I was an undergrad, I did 3D kinematics of supernova remnants in the SMC. What 3D position data are you using and what software do you use to analyze it? I used a lot of IDL routines to visualize SNR data from the CTIO Fabry-Perot Interferometer.

Heysoos_Christo

Hi there -- Jeff Carlin here! Cool that you got to work on SNRs in the SMC! I use IDL for most of my research -- when I was in grad school, IDL had the most robust astronomy users community, and thus a lot of tools and resources for astronomers (as you've seen!). Much of this has transitioned to Python, and I have intended for years to transition to Python myself, in part because it's becoming a default for astronomers, and in part because I would rather use open source software.

I work mostly with the databases of information from the LAMOST spectroscopic survey of stars in our Galaxy. I developed an algorithm to derive distances to all the stars observed by LAMOST using their measured temperatures, metal abundances, and surface gravities (which we derive from their spectra). As this survey grows, I'm also having to consider ways of handling large data sets. The catalogs from SDSS that we use for MilkyWay@Home are vast compared to the LAMOST data, though (tens or even hundreds of millions of stars).

Best of luck with your grad school applications!

--Jeff

Is there really a black hole in the center of the Milky Way Galaxy?

JDG00

To follow up on Charles' response -- the supermassive black hole at the center of the Milky Way has more than 3 million times the mass of the Sun! --Jeff

Is there really a black hole in the center of the Milky Way Galaxy?

JDG00

Our current understanding is that there is a super massive black hole at the center of all galaxies including the Milky Way Galaxy. -CM

I saw photographs labeled "Milky Way Galaxy" when I was seven years old. I figured we sent a camera into space to take the picture.

Here is an example: http://ppc.wikia.com/wiki/File:You_are_here_galaxy.jpg

Now I know that we do not have cameras in inter-galactic space.

Is there a convention for which galaxy to use as a body double for the Milky Way?

Unbathed

A quick search online will reveal many different photographs or drawings of galaxies that are labelled as "The Milky Way Galaxy", like the one you linked.

There is one main convention that applies when you are seeing these "body doubles" of the Milky Way

galaxy, and that is that they are all spiral galaxies. The three main classifications of galaxies are: Spiral, Elliptical, and Irregular.

If you have ever been looking at pictures online of a pretty galaxy with arms that are spiralling around, that is a spiral galaxy. The other classes of galaxy are not nearly as pretty to look at and are more often just described as a giant ball of stars with no real shape to them. While studying our own galaxy and comparing it to others, we seem to be most similar to neighbouring spiral galaxies (like Andromeda).

As far as the size we believe that the Milky Way is similar, or a little smaller, than the Andromeda Galaxy. So taking this into account most images will depict a nice spiral galaxy and place a dot at roughly the distance the Sun is from the Galactic Center. -CM

Kind of off topic but what telescope does your institute use? I want one that will give me a good visual of the stars about 10,000 light year radius from earth. I have about a $900 budget after i get my extra FAFSA money back

PinkTacoDestroyr

At RPI we have several different telescopes that are used for public outreach events, all of which are maintained by a student run club.

The main telescope that we have is a 16 inch Boller and Chivens Schmidt-Cassegrain telescope that was built in the 1960s and donated to RPI in 1980. Other telescopes include a 12 inch custom Newtonian reflector, 10 inch Meade Cassegrain telescope, 6 inch Meade Newtonian reflector, and several other smaller ones.

If you are in the market for a personal telescope and don't want to spend a fortune I would recommend looking for a Dobsonian reflecting telescope. There are many companies that make these such as Orion or Sky-walker where you could get one for ~$500. With an 8 inch Dobsonian telescope and a nice dark sky location, you can easily observe faint objects such as stellar clusters (at distances of more than 10000 light years) and distant galaxies (like Andromeda). The part that requires the most practice is being able to find these interesting faint objects without need something computer guided.

Good luck -CM

Do you think that comets have the potential for bacterial (or other) life on them? If so, could these life forms be the basis for life on our planet (i.e. a comet smacked into the earth <x> number of years ago, bringing bacteria to earth)?

2nd question - how can it be possible that the universe is ever expanding? Explain it like I'm 5. (in my way of thinking, I would assume that it would expand more and more to a certain maximum at which point the force of gravity would outweigh the expanding forces causing everything to retract/receded towards a central point).

giygas73

No known bacteria in space. Amino acids though. Some of my colleagues have been looking into the possibility of amino acids from space.

Your thinking about the Universe crunching back down on itself is basically correct. However, think about a rock being thrown up from the Earth. If *I* throw the rock it comes back down as you suggest. But if the rock is tied to a rocket and is thrown up really, really fast, it can to so fast that it is flung out of the solar system and never comes back. Our measurements of the Universe say it is expanding to fast

(and in fact the speed is increasing with time) to retract back to the central point.

"Recently, both of these projects lost their National Science Foundation funding as grants becomes increasingly harder to get in astronomy. If you are interested in donating to our group please visit our fundraiser page."

Do you get as angry as i do when projects like this get dried up while we sure have no problem funding faux wars,taxpayer paid patriotism,exporting troops overseas to chase high profit margins?

mambotangohandala

Do you get as angry as i do when projects like this get dried up while we sure have no problem funding faux wars,taxpayer paid patriotism,exporting troops overseas to chase high profit margins?

Travis here: I try not to get angry (as that won't help anything), but I do think it's a real sad state of affairs when we have no problem spending massive amounts of money on things that demonstrably do a lot of harm to other humans, while at the same time we don't have the money to advance human knowledge and help each other out. The amount of funding the National Science Foundation, National Institute of Health and NASA receive pales in comparison to these things.

I was reading about the Shapley Supercluster and how it's pulling itself together instead of expanding with the universe. Why would it do this, and is it abnormal? How are the Milky Way and the Great Attractor moving toward it, and is Laniakea in general moving toward it? Is everything observable moving toward Shapley or are there other superclusters with a similar or less powerful pull? Are there structures much larger than superclusters, and if so, what might they look like? (Laniakea reminded me of neurons when I first saw plots or maps of it) Thanks!

wantedwanted

Galaxies, and clusters of galaxies, are dense enough that the gravity pulls them together and the space in those regions does not expand with the Universe. That is because space and mass are tied together as described in general relativity. All galaxies or superclusters are going to attract each other, but if they are far enough apart (the density is low enough) then the space will expand and they will move apart. Laniakea is pretty cool, isn't it?

Prof. Heidi Jo Newberg

I have no questions, I'm just glad that I can help with BOINC.

Keep up the great work!

ThrowinStacks

Thank you!

How far away is it possible to determine whether a source is one star, a binary system or a cluster of stars.

grundalug

Jeff Carlin says: I can't give an exact answer, because there are a lot of variables that factor into this. If

you want to be able to *see* the stars in a binary system as separate entities in an image, then this will only be in the nearby regions of the Galaxy. However, you can take a spectrum of a binary star that is seen only as the blended image of two stars, and sometimes see the signatures of the stars' interaction in Doppler shifts of the lines in their spectra. This can be done for stars even in the Andromeda galaxy, more than 2.5 million light years away. Around much more distant galaxies, even clusters of tens of thousands of stars are likely to look like single points (though they may look fuzzy, which gives away their cluster nature). We can tell they're clusters from their spectra, though.

Hi, I'm really interested in becoming an astronomer, and doing the sorts of things you all do. I'm a college freshman, and I'm currently majoring in computer science. What courses would you advise I take, or major choices? What skills would I need on the job? I am well aware of the physics, math, and computing requirements, but how should I go about getting those?

charizardpimpin

Hey Charizardpimpin,

So I was in a similar position as you when I was a freshman a few years ago, and I asked myself a similar question, so I will tell you what I did. First thing, I did was look for a group at my school that I wanted to do research with, because I knew having on the job experience would be important. After I found MilkyWay@home, I decided to try to tailor my classes to get into the group and have some useful skills for the group. In my case I tried to load up on all of the math, physics, astronomy, and computer science courses I could take. Most importantly, I tried my best to understand the material taught in these classes because being able to do the problems and being able to apply them in research is pretty different. You need a better understanding to than what you learn in class to apply skills. So basically, work hard and try to get a strong foundation if physics, math and computer science you will be in a good spot.

-- Jake

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charizardpimpin

I would recommend taking some intro to astronomy courses before taking anything else. If you really end up liking it then perhaps move on to the heavier course requirements for astronomy. There is a large portion of astronomy that is computational, so having a computer science background is a great start. If you are interested in adding astronomy as a major/minor, I would suggest you speak with your department advisor. They are generally very open to students and can offer much better advice based on your individual needs.

-SS

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charizardpimpin

Travis here: don't skimp on anything involving distributed/concurrent/parallel computing or big data. I think there's a ton of interesting work to be done there. It also makes you highly marketable if astronomy doesn't pan out!

I've wondered for a long time now if our observations of dark matter or dark energy could be explained by some sort of large scale (far away) repulsive force associated with gravitational energy of known matter that we have not yet been able to measure. This comes from my very limited understanding of the strong and weak forces at the atomic scale and the desire to find patterns in common with small scale and large scale physics.

Would a discovery of something like this be within the scope of MilkyWay@Home? Has something like this been considered?

distractionfactory

I am with you on having wanted dark matter and dark energy to be the same thing, or at least not be so nebulous. But understanding these two things is going to take a lot more than MilkyWay@home. It is going to take attacking the problem from many theoretical and observational directions.

Prof. Heidi Jo Newberg

How is our solar system oriented to the Milky Way? Is the orbit of Earth roughly parallel to the orbit of the Sun around the galactic center - if not, to what degree is it tilted? What time of year is Earth closest to the galactic center? Is there somewhere I could read more about these relative positions?

csjpsoft

The plane of the solar system is tilted roughly 60 degrees with respect to the equatorial plane of the galaxy, which is why the Milky Way appears to stretch out overhead when you look up in the sky. The Earth orbits within a degree of the plane of the solar system, so its orbit is also tilted 60 degrees to the orbital plane of the Sun.

The galactic center is in the constellation Sagittarius, and the Sun is in Sagittarius in January, so we are closest to the galactic center six months later, in July.

--Paul

So i assume that part of our galaxy is obscured as its behind the core from our point of view. How do you plan to go about mapping said part.

Trijilol

You are correct that the gas and dust in the disk of our Galaxy obscures certain parts of the sky. This obscuration is only in short wavelengths, though -- if you use radio or infrared telescopes, you can peer through the dusty veil to objects beyond. This is because the wavelengths of infrared and radio light are longer than the size of dust grains, so that they do not get absorbed by the dust.

We don't have any current plans to extend our studies to infrared wavelengths, but we conceivably could do so in the future.

Thanks for the question -- Jeff Carlin

What is your main/most important piece of equipment for observing our galaxy?

Eenjuneer645

Telescopes.

--Paul

Ive seen the "video" of the stars orbiting the Milky Ways central black hole.

What are the approximate minor and major axes of the orbits of the closest stars and when the closest ones approach the black hole, what is their approximate distance from it?

If you had an (yes impossible but humor me) instant live video camera near such a star during their close approach to the black hole, would time and space appear to warp or act differently to the normal limits of human perception?

tam-weightlifter

Sorry, I would have to look up the answer to this question, and this is where I would look:

http://www.galacticcenter.astro.ucla.edu/blackhole.html

Prof. Heidi Jo Newberg

How do we know the Milky Way is a spiral arm galaxy if all we can see is a bunch of stars on a plane? Who's job is it to compute the "current" location of a star that's a million LY away?

ApertureLabia

We try to get the distances, so that we map in three dimensions. And spiral arms are seen in gas (not just stars). The only way to get a "current" location is if you have a velocity so you can extrapolate back a million years. We don't have that for many stars, yet. Luckily stars in our galaxy aren't that far away, and they don't move so fast that they have moved a long way in the time the light takes to get to us.

Prof. Heidi Jo Newberg

Is there an effective way to map the side of the galaxy directly opposite our Sun's position relative to the core of the Galaxy? I imagine the brightness of the core makes it challenging to accurately map the stars on the far side. What kinds of novel scientific approaches have proven successful and what might be on the horizon that would be innovative?

PeruvianHeadshrinker

It is hard to see the other side of the galaxy because of gas and dust in the Galactic plane. The best way to see through the dust is to use infrared light (like the upcoming James Webb Telescope).

Prof. Heidi Jo Newberg

Might be slightly off topic but, would it be possible to use the way object like galaxies and the orbits of stars have formed to prove/disprove gravitons?

Zun_tZu

I would not think so. Gravitons are a theoretical elementary particle which is supposed to mediate the force of gravity like the photon mediates electromagnetism, the gluons the strong nuclear force, and the W and Z bosons the weak force. This is done in the framework of quantum field theory. Since these are quantum mechanical particles, we would not see them in large scale dynamics as in orbits.

-Sid

The shape of the Milky Way as we see it now is a spiral; we can all visualize it.

But, if it takes a huge amount of time for light from the further parts of the galaxy to reach us, and different parts of the galaxy more at different speeds, wouldn't the /actual/ shape of the galaxy (say if suddenly we could see it instantaneously, with out light taking time to move) be stretched out and warped in a way/function of their distance and speed? As an example: A point moving 12 miles per hour for 12 hours travels further than a point moving 3 miles per hour for 15.

I'm probably over thinking this and it's actually not that complex. Just a thought I had.

uhh186

Your thinking is right, but the galaxy is not quite big enough (and the part we look at is not fast enough moving) for this to be a serious problem for us.

Prof. Heidi Jo Newberg

Hi guys, absolutely love your work

one simple question (maybe two)

the galaxy has a coordinate system? what is its name?

what could be an inside joke in your work?

i know, not very scientific

wreckt_um

There are lots of coordinate systems and names. The one I would pick to answer your question in "Galactic coordinates" which is an angular coordinate system with the "Equator" aligned with the Galactic plane.

Jokes? We never joke, do we guys?

Prof. Heidi Jo Newberg

Wow, this whole Boinc/Gridcoin idea is really interesting. Gonna try to get started and do my part when I get home tonight!

Anyone have links to noob-friendly "get started" guides?

Nekrosis13

BOINC is "pretty" user friendly. I'd install the BOINC client and sign up to some projects! You can

always ask for help in the MilkyWay@Home forums (or forums of any other projects you're interested in).

What do you think is going on around KIC 8462852?

goodDayM

No idea. But the press seems to have taken off a little too quickly with the idea of aliens. I have no idea how a brightness change that is not immediately explainable would suddenly turn into a "signature" of aliens.

Prof. Heidi Jo Newberg

I realize this is mostly being done to study the physics and orbital mechanics of the galaxy, but do you think creating this "map" could one day serve as a tool for interstellar travel?

I can see there being routes and such in the very distant future. Thank you for this AMA!

OrbitalToast

Sure, you want to buy it? :)

Prof. Heidi Jo Newberg

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I can see there being routes and such in the very distant future. Thank you for this AMA!

OrbitalToast

It is in the realm of possibilities for sure!

-SS

How can a universe worth of matter and space come out of nothing?

liberty4u2

I don't know. We don't really have a good physical understanding of what happened in the very beginning. The goal in physics is to use mathematical equations to be able to make predictions about what is going to happen in any given situation. Since we have never experienced the conditions at the beginning of the Universe, we have not had much of a chance to make and test physical equations that govern those conditions.

Prof. Heidi Jo Newberg

How can a universe worth of matter and space come out of nothing?

liberty4u2

Travis here: I'm not sure if it did or not. I think the scientific consensus is still out on that one.

I have always wondered, the current image that we teach with, is that an actual rendering of what we believe the milky way looks like based on measurements or is it another spiral galaxy that we use and call it the milky way?

Sunflier

I have see both. I don't know which one you have.

Prof. Heidi Jo Newberg

What all was the defining moment you wanted to pursue astronomy?

Beemow

After my first year of graduate school I got a summer job working on the Berkeley Automated Supernova Search. I showed up on the first day and said, "Great, what's a supernova?" And the rest is history.

Prof. Heidi Jo Newberg

Hey guys, love your professions and the studies you guys do, one question though. What's your favorite star and/or solar system?

smallfri321

My favorite star is probably Albireo. This is a binary star that is located in the constellation of Cygnus. The reason I like it so much is that the two stars have different colors (one blue and one red) that can be seen when viewed through a telescope. There are only a few stars that don't look white when viewed through a telescope. -CM

Hey guys, love your professions and the studies you guys do, one question though. What's your favorite star and/or solar system?

smallfri321

I would definitely have to say our own for the single reason that we would not be here without it. But, I also find binary and tertiary star systems to be completely awesome.

-sid

Hey guys, love your professions and the studies you guys do, one question though. What's your favorite star and/or solar system?

smallfri321

Travis here: probably the Pleiades just because they make for so many fun ancient aliens episodes. :P

Have you been able to discover if there are pools of vicious liquids on Uranus?

eatabagofdickz

No, but we certainly see lumps of dark matter! -ss

Will there be a GPS like network to guide space travelers journeying throughout our galaxy?

aulnet

Will there be a GPS like network to guide space travelers journeying throughout our galaxy?

Travis: Yes! ... unless our civilization dies out first.