Transcript

April 1, 2025, 5:19PM

JR **Jamie Rankin** 0:03

Thanks for the invitation.

I share my screen.

I I saw in the chat that some people are previewing those cards in the Northeast Astronomy Forum this weekend.

Turns out that I will be a speaker.

There are too.

So there you go.

Some of this might be repetitive if you tend not talk.

But anyway.

All right. Does everybody see the display with the main big screen?

KS **Kirk, Michael S. (GSFC-6700)** 0:33

Looks great.

Yeah, looks great.

JR **Jamie Rankin** 0:35

Per.

Alright, so so yeah, I I'm here to just talk about the kinda highlights of the cool science from the Voyager's journeys.

I am focusing on this on the story through the interstellar medium.

Of course, Voyager is known for its planetary science, and that was before my time.

But, but I've been a deputy project scientist for Voyage mission since 2022.

And Ed Stone, who was the head of the Voyager mission, the the chief scientist for the Voyage mission for 50 years. He was my advisor at Caltech.

I was his last graduate student and had a 52 year age difference of great.

Wonderful mentorship.

And anyway, so I when when he retired and his deputy became project scientist.
So I was selected as the deputy, so it's been quite amazing, but I've had a front row seat of seeing this story develop since being a graduate student at Caltech, which was around like 6 days. I arrived at Caltech, started working with Ed Stone.
Six days after Voyager one crossed the heliopause.
So anyway, a lot of this is from first hand experience, so please enjoy.
So First off, I love to talk about like just the context of where are we now.
So this.
Slide is meant to represent.
Basically, we have the Milky Way that's 100,000 light years across and it's about like 2000 light years deep. And our solar system is in this this finger here between these two arms known as the Orion Spur. Although I've been told that Saturdays like the OR.
Arm. Now what? It's called and just the width of this is is something like. 2500 light years wide, which is kind of amazing, and in between some clouds.
In there.
And there's the local interstellar cloud, the gcloud.
It's debated actually.
We don't fully know where we reside. If we're in between clouds or if we're at the edge one cloud.
A lot of research says we're kind of in between like 4 clouds even.
Anyway, within this is our heliosphere and that's our stellar astrosphere.
We see examples of asteroids just remotely on all sorts of.
Wonderful telescopes and.
We have this question ongoing, which is what does our own hewosphere look like and our own astrosphere Helio for the Sun and sphere. It's not really a sphere, but we're doing all sorts of exciting science to understand, basically looking at ourselves from the outside.

NM **Nancy Maryboy** 3:21
Yeah.

JR **Jamie Rankin** 3:25

Inward. And that's a tricky vantage point.
But living next to our star, of course, we know it's really large and it makes up by far most matter.

NM **Nancy Maryboy** 3:32

You.

JR **Jamie Rankin** 3:35

Solar system and even these flares, I mean, I love this image from NASA Solar Dynamic observatory.
There's approximate size of earth when the flare comes out, and it's just a lot of of power whenever some some chrono mass ejection occurs or something. That's something like 100 billion times. There's power consumption that they estimate from these kind of large events and.
The and compared to other stars.
It's it's surprisingly quiet.
So that's kind of an interesting context.
I don't know why that keeps changing and then from here we know that the sun gets heated from its thousands of degrees at surface to millions of degrees at the corona and we're still just barely trying to understand why that is. And so Parker's sort of pro.
Was sent very close to the Sun to investigate this.
I also worked on Parker Solar probe as well.
Still, do science from Parker Solar probe.
I helped build my energetic particle instruments and we know that the the materials from the Sun escapes and streams outward.
It escapes the sun's gravity, forms a supersonic solar wind, and these are two big mysteries we don't fully understand. We've known them for a long time, and we're just barely right now.
Parker Solar Probe is starting to be right.
The history books on our understanding of this and maybe even.
Answer some of these questions.

But we know that the sun propagates outward and it creates this like time varying solar wind and the sun rotates every 27 days.
So it actually, as the magnetized plasma and it flows outward sun and magnetic field are kind of kind of tied together as they're flowing outward, they basically come off in the same direction. And then as the sun rotates, they twist it into the spiral form.
An Archimedean spiral known as the Parker.
Spiral. So we know that as this fills up, our whole entire heel sphere as these winds expand outward, we know that that the shape is sort of our comedian spiral shape of the interplanetary magnetic field. And as these winds expand outward, they eventually lose energy, and then they.
Become subsonic and all this collectively forms.

NM **Nancy Maryboy** 5:55
Move it.

JR **Jamie Rankin** 5:59
Our own astrosphere, which we call the heliosphere.
And so it's made-up of like kind of kind of this region where everything's supersonically radially flowing outward, more or less.

MM **Mariah McNamara** 6:09
I just pulled a screw out of the dishwasher.

JR **Jamie Rankin** 6:12
And then the termination shock is basically where these flows actually start to come out and then bend back.
So the magnetic field becomes a lot more turbulent in this region.
It's known as the Hilo sheath, but all of this is made-up of solar material, solar gases and they are magnetic fields.
There's heated particles.
There's the plasma of the sun itself.
All of this is intermixed within this bubble, and it's a highly magnetized plasma.

And then in the space between stars, the interstellar material, and that's a separate gas and where the voyagers are right now is both of them are outside of this boundary.
It's known as the heliopause, and if this was the plane of the planet right here, just like kind of going across this page. Voyager one is about 35° N of the ecliptic plane, and Voyager 2 is about 35 or so degrees South of ecliptic plane.
So as these winds expand outwardly, they eventually achieve a pressure balance with the surrounding interstellar medium.
And did you know that you can simulate these complicated food dynamics, even though it can be kind of hard to understand?
Consume like these using your own household appliance, which is known as the kitchen sink.
Credit goes to Ed Stone on this description, but you turn on your faucet. And you have this all regularly flowing outward. All this fluid flow and then this right here would be in August to the termination shock where it it's supersonic flow, mostly radio very.
Very well organized material. And then all of a sudden it will slow down, become very bubbly.
Turbulent. That's what we call the hilu sheath.
And then eventually you would just kind of stop, which is the helipase.
And so you know.
So there's some way that this breaks down for the most part, it captures a lot of the critical elements of this fluid dynamics of what forms are he?
M and so we know that the sun gives out all these weather patterns.
And that, you know, it varies from a maximum activity level to minimum activity level every eleven years and it has to do with the Dynamo itself, where it's highly organized field during solar minimum.
This is like this plot here in 2019 and it becomes very disordered during solar maximum time periods. But we also know that there's an overall magnetic polarity reversal, and this this significantly impacts kind of all the materials that we measure from intercellular space.
So all the stuff that we know of that's not from our solar origins gets modified.

By passing through the sun's.
Weather patterns these cycles.
And so there's a lot of modified sun modified measurements that we've been observing for hundreds of years.
Including the we see the sunspot numbers and we see.
We can actually calculate how the North and South pole magnetic fields are separated with this current sheet calculation, and we know that as cosmic rays come in from external sources like killer parsecs away and even further.
Now this radiation from other stars and supernova explosions comes in, and it also has a time variation pattern.
It's known as solar modulation.
Where during the maximum sort of sun activity levels then most of these particles gets blocked out. A lot of it gets reduced anyway, and then during the minimum.
So activity levels a lot more particles from external sources. A lot of these cosmic ray radiation can come in more freely.
And actually, if you'll notice, maybe people who want cosmic ray experts don't know about this.
But it's kind of fun, which is that the cosmic ray pattern actually has the imprint of the 22 year behavior of the solar cycle because.
The IT has a pointy top sort of shape right here.
And it has a flat top.
So everyone alternates between pointy and flat top based off of the polarity of the solar cycle.
And that's because during.
These what we call negative polarity solar cycles.
The particles can come in and out, and they can escape really easily so they can come in along the.
Hue, this current sheet right here.
They just SERP in along there and they can escape.
Very quickly.
Whereas here they're more coming down.
They're they're they're they're coming.

In rapidly, but they're kind of escaping outward through the polls, and that's that's harder for the particles to escape. So. So you can actually see the the effects actually of this 22 year pattern and how the cosmic rays behave. And so in the midst of this, the.
Voyagers launched in 1977, a month apart.
They basically took their planetary tour.
And then starting in 1990, actually is when the Voyager Interstellar mission began, which is pretty incredible.
How visionary nowadays?
And so now, even though it started out as this planetary science sort of tour, it's been an on an interstellar trek.
For many decades, even longer than the the the planetary phase now, and it both missions are both spacecraft are still running.
You're still helping, and they are this mission in 2027 will be 50 years old, which will be.
An incredible milestone.
And anyway, one of the things amongst amongst the things they've measured was these cosmic rays that I described.
So they're coming from sources on our heliosphere, just outside.
Just radiation from the outside, not of solar origins coming in and we measured what that looks like as a function of distance away from the sun.
And so you can see in blue and red what the two voyagers trajectories.
Look like they watched kind of near in time but but Voyager two took the toward down all the outer planets here. And then after Neptune is when it it went on the escape trajectory you can see on Voyager 1.
That was right after Saturn.
So they kind of exited the kilosphere 'cause. They're traveling at different speeds on the escape trajectory.
They ended up exiting the heliosphere at different times.
Voyager one in 2012, Voyager 2 and 2018.
And what we see in this whole story of the cosmic rays is kind of remarkable.
We see that solar cycle effects this bottom plot is just at Earth distance

from the sun. Looking at sunspot numbers.
Cosmic rays that the Voyager saw on both the red is Voyager 1 blue is Voyager 2.
You can see the the rise during a solar minimum time period.
There's a maximum of cosmic rays and you can see the the minimums during solar maximum.
And this right here, this chunk is through the. It is through the up to the termination shock crossing.
So TSX here means termination shock crossing and we saw that these solar cycle effects sort of went away.
It kind of became weaker in the Hulu sheath in the bubbly region, and then all of a sudden, when the two spacecraft crossed the hue pause, she got very quiet.
In fact, people wondered. Did something happen?
Into the instruments.
Or are they actually measuring a signal out there because it's much more quiet than anything that we've ever seen on these whole history of measuring cosmic rays, for example? This is the only type of material of charged material that can come in and interact from the outside there.
Some neutral atoms that can come in as well.
They're rare.
And there are other missions that measure that neutral gas, like the upcoming IMAP mission, will do that.
But the cool story here.
Is that we see just if you take the ratio of what happened basically here onward is interstellar space for Voyager 1. Here onward interstellar space for Voyager 2 you can see that about 95 eighty 85% or so of the radiation is shielded so our he.
Protects us from about 85% out radiation from.
Nearby stars.
So it's really interesting question.
About whether or not life would exist without that amount of kinda shooting that our heel sphere provides for us.
And so that was a really huge result from the Voyagers to be able to see

where those boundaries are and to to know roughly, kind of in these two trajectories anyway.
Where? What's the nature of the magnetic field? The plasma?
The energetic particles in each of these environments.
And so Voyager one for example.
Example it it is now.
Actually this number is out of date.
It's now pretty close to 24 wide hours away, so almost a whole light day away.
And it's cool because the other thing that we see is we see the interactions of the interstellar magnetic field Nitro and how it basically shapes itself around our entire heliosphere.
So for example, we know from these measurements and some other remote observations.
Did the magnetic field kind of drapes itself around the heel of sphere?
In fact, this picture is not quite correct in in how it draws these fill lines.
There's basically more squished in materials from from the South.
More highly draped magnetic field and it actually causes the heliosphere to be offset a little bit.
And so we see that we saw that when voyagers crossed, we saw that the magnetic field strength was very different between the two spacecraft, because it's just a much more compressed.
Magnetic field here.
And we saw we took measurements of the plasma density out there and also the cosmic rays.
So there's some pretty incredible measurements in these materials that most of which never even make it inside our heel sphere. And so the story about which which measurement capabilities does voyagers have?
This is just kind of a summary of that.
There's cosmic rays and low energy particles.
There's two.
Two instruments here.
Unfortunately, these were recently turned off, one on each spacecraft was turned off, even just within the past month. Couple days ago, on this

lacp instrument. On board the two to save power, the cosmic ray subsystem on Voyager one turned off about a month ago to save power. But.
All these measurements that I'm showing you here have are from all of these instruments.
There's a plasma instrument.
It was turned off.
In 2024, but took a lot of long measurements on Wager 2.
The magnetometer.
Both magnetometers on both spacecraft are working, and there's a radio instrument that is working on both spacecraft as well.
So those are both currently operating. And then there's at least one particle instrument on each spacecraft operating at this time.
But all the data I'm going to show you is from these particles, the radio, the plasma magnetometer.
Measurements. And so how do we know that we arrived in interstellar space?
Well, the first giveaway was these cosmic rays that I described. So the materials.
Of galactic origin, all of a sudden jumped up and they reached their flat levels, whereas other materials.
Of solar origin heated up materials caused by our sun just dropped out, so that's what these blue lines represent here.
And so that was one really abrupt change that occurred occurred in less than a day on Voyager.
One surprise to people, there was also a change in the plasma density, and there's a change in the magnitude of magnetic field as well, but not the direction.
So when the Voyager's arrived.
When both spacecraft arrived, there's this big question of how far.
Outward would the cosmic rays be affected?
And it turned out the cosmic rays were just very unaffected as a function of distance from the helipads, so there was no change in the overall magnitude of cosmic rays, unlike what we saw in the plot I showed

through the heel of sphere and the other incredible part.
Is that the two spacecraft? Oops. They agreed.
Really, really well on these very low energy helium.
Proton electron measurements.
This is just intensity here on this axis.
Who lose void or two Reds? Voyager one. These are energies. This low energy part of the cosmic rays.
Is a lot of these materials cannot even make it into one AU at this low energy.
But it it actually was the first time people have tried model cosmic rays through the heliosphere, but they never had the source spectrum in the models to constrain it.
So this is the first time of seeing.
What that looks like out there, and it actually helped advance a lot of the modeling because it put constraints on all the possibilities.
And here here examples where they were connecting to AMS and some other higher energy measurements in the inner heel sphere.
So we saw the lowest energy galactic cosmic rays ever observed.
We saw that it doesn't seem like these are affected by the sun too much anymore. Once we cross the Hulu pause.
The the spectrum of cosmic rays remains unchanged.
That was seen by the cosmic ray subsystem.
And then there's other measurements made by this lecp instrument. Low energy charged particle experiment that is on a stepper motor platform.
And so it takes these 45° steps and when they are stepping they noticed that when the telescopes were looking along the magnetic field line, which is this, this this diagram right here the circle diagram.
They the there was kind of maybe a few bumps and wiggles.
Here, but not much change when they're 45° with their respective magnet field.
Not much change.
But then what?
We were very surprised that there were these small but small percentage, but long lived events and structures out there. Only when

the telescope oops looked 90° with respect to the magnetic field perpendicular.
Any sort of anisotropy and cosmic rays is very exciting.
And this was totally unexpected and I actually ended up writing my thesis on the topic and we confirmed that in some telescopes on the cosmos subsystem we have some counters that see the whole entire sky. We we match these features, but our other telescopes, Bobby fixed were more.
Like this here and so we saw a few few interesting.
Signatures of these jump ups and we saw some dips right here.
That I'll talk about, but for the most part, we saw that in very certain directions. The cosmic rays can be changed in this time bearing way, which is surprising.
We didn't expect it.
And then magnetic fields showed similar strange changes. There were shocks observed out there.
There's these things that were termed pressure fronts, which were just structures, prolonged structures in magnetic field.
This is the plot for Voyager 1.
And it's plot for Voyager.
Two similar types of structures.
Seen by both spacecraft.
And when they're the two spacecraft, when they crossed into the interstellar medium.
It didn't seem like the magnetic field change direction and it still doesn't look like the magnetic field has changed direction. We don't fully understand that except that somehow the interstellar magnetic field is highly influenced by the presence of the heelosphere at the location that the voyagers are at.
But but we saw these shocks.
We saw shocks out there that lasted weeks to months and they were very different than shocks in the they were in August but different in their time and strength compared to what we see in the solar system when an interplanetary shock occurs. They're also very thick a th.

Times thicker than their solar system counterparts, and we also found these beams of radio waves that would emit every so often, and they would.
The precursors to the shocks, and this is the spectrogram, the radio frequencies seen by Voyager one in the wide band receiver. For the two.
We view that with a 16 channel Spectrum analyzer and we see little spiky things.
This would be kind of equivalent to one of these events and and they seem to kind of be correlated with these shocks.
So we're putting to putting out putting together this picture, trying to understand what does this all mean.
And it turns out.
That when you wind up all these events I've described, it looks like it's related to these shocks. It looks like these disturbances, these jump ups in the cosmic rays that we see are kind of like particles that get accelerated from the shock as a particle encounters shock it.
Can get energized and when Voyager is approaching a shock.
The particles, the highest energy particles.
Will stream back first.
And then the lower energy particles and then all of a sudden we'll cross the shock.
That's exactly what we see.
We see these before every shock. Here is an example.
These FRF and R.
This is magnetic field through the kind of four reverse shocks that that we think were out there.
Before each one of these is a spike in the energetic particles, the protons in this case, and then we see these lower energy, much lower energy electron plasma.
And then we see the shock migrate here. Here, here, here.
And then we typically see these structures right here in the cosmic rays.
And so we think that all these signatures are pointing to an interesting story in how that environment responds to shocks out there.
And this is Voyager 2's picture as well.

It sees similar things.
It was very quiet.
We we saw kind of a few shocks like maybe 2.
In when Voyager first crossing the paws?
And then it got really quiet.
And now the activity is kind of ramping up a little more.
But there there hasn't been as much activity out there as that Voyager as there was for Voyager 1.
So what is happening?
The basic story is that we can have these coronal mass ejections. Oops.
They can put off the the slow the the slow speed, sort of a weak one, and then you can have very strong ones that blast off, then overtake those and these can actually combine these sorts of structures from the sun and corotating interaction regions.
They can actually merge and instead of completely dissolving away.
These can survive.
They can survive through the hemisphere.
They can create plasma.
My disturbances that get combined.
This is the paper done in 2003 where they took some of the solar wind measurements at one AU seen by wind.
And they had a simple model that propagated it out to guess at which which distance would it arrive at Voyager 2, there's the model prediction in this line.
There's the actual rival in this data.
It's pretty incredible they could track that.
So we've seen it in the supersonic solar wind in the.
Before the termination shock, we've seen it in the Hulu she bubbly region.
We saw even the effects of a global merged interaction region.
That's what the steamers is.
Disturbed Voyager 2 cosmic rays in the Hulu sheath and then it pushed out a wave into the interstellar medium.
And that's what caused this 90° pitch angle event.

At Voyager 1.
And so we know that these sorts of things from the sun can combine.
They can survive all the way out there.
They can cause all those structures that we saw and so they can eventually collide with the edge of the heliosphere.
So here's an example from Voyager 2 and of all sorts of little pressure waves that it saw from the sun. These sorts of events as a signature and plasma.
And people have even traced these sorts of events when Voyager two was in the heli sheet.
Out to those events that I showed, the shocks that I showed in interstellar space.
So each one of these has a precursor that that was seen by a Voyager 2 and it is the results of these events from the sun that coalesce and they merge and they they propagate through the heel sphere.
And the important point, though, is that they're not necessarily intermixing materials, they're just pushing.
And they're sending waves, and those waves propagate through the plasma.
And form these shocks to disturb the plasma in interesting ways.
And so we actually use this particular event to show how much of the pressure balance occurs.
And that was actually an unknown quantity, but because we knew the speeds between these two events, we could actually derive what the well, that's interesting.
I don't know why I did that.
There's a news week article where it derived what these.
How much pressure is out there? And it turns out that that outer area is about 300 femto pascals and pressure that inflates this region here.
And that was previously unknown.
And what are we doing now?
Well, right now we've seen the strangest event yet, and we're puzzling over that because like I described, we have all these events.
We have these shocks here.

We have these things we call pressure.
Up front we have these in addition to those radio bursts that we saw, there's actually a continuous plasma line where we can also get the plasma density from it.
So this is because Voyager 1 doesn't the the plasma instrument stop working in 2007, so we can actually use the radio instrument to do plasma measurements.
But very recently we saw.
In mid 2020, we saw this sudden jump up.
Just a large jump up. We haven't seen anything this large since we originally crossed the Hulu.
Pause, jump up in magnetic field and we saw a jump up in plasma density and it formed this what we call pressure front 2.
We really just kind of made-up the name Len Berlaga had pressure front one and he said, well, maybe this is a pressure front too. We saw this jump up, but we saw an increase in the magnetic field, which we've never seen. Most of these events have Dec.
Afterward, this was like an increase.
So what could cause that?
And then actually these levels that, that, that they arrived at which?
Is considerably larger than where it was before, where the magnetic field was.
And the plasma jumped up about the same percentage that's just been sustained even to this day.
So we don't know what this means.
It's really puzzling that that 14 billion miles from the sun is when this started.
Now we're a light day away.
These these levels are at a totally new level and we don't understand what exactly happened, so we're investigating this event.
It's it's not. Not much has changed.
This is still to this day very kind of flat at that level on both instruments.
But we're trying to to investigate now.
Is this a region that's due to some solar cycle effect?

And the sun's lingering influence on what's outside and the pressure balance between our heel sphere and the interstellar medium.
Or is this something that's happening in the interstellar medium itself?
So that's a really big topic of research, and every day of receiving observations of Voyager one, we're very, very grateful for seeing this.
And I'll note that the Voyager one has now been out there for a whole solar cycle.
So the longer that we get these measurements, we can see if there's any patterns within the 11 year we're starting to gain overlap on how does the sun influence the interstellar medium?
Over the course of its solar cycle.
And we have these big trending questions basically to just sum it up of how far can these events travel?
What's our heel spheres, 3D size and shape? That's a bigger question than the community is looking at with IMAP. In addition to coming online in fall of this year, it will launch in September late September.
What caused this new strain event at Voyager 1?
How does the interstellar medium itself influence our sun and solar system?
But how does the sun influence the interstellar surroundings?
So it goes two ways, and then this bigger question of without our heliosphere, would life even exist?
So. So that's kind of a summary of big bird's eye view of some some science highlights from the Voyagers.

KS **Kirk, Michael S. (GSFC-6700)** 33:22
Thank you so much. That is amazing.
I you know, Voyager has, you know, been around as long as I've been alive. And so it's really neat to hear the the latest updates. And so this, this is fantastic.
Are there questions for Jamie?

JR **Jamie Rankin** 33:47
There's some nice statements in the chat.

There's one that says. Do you think we went into a new arm of the Milky Way?
And we do know it has arms of higher density.
You know, it's interesting we we assume that the interstellar medium that we are in is just unchanging compared to how the sun changes.
But it's it's true.
We, we we could be wrong in those assumptions.
And so actually, yeah, it's a good question.
Is it something related to the material of the interstellar medium?
It's a very good question.
We don't know yet.

KS **Kirk, Michael S. (GSFC-6700)** 34:29
So I'll ask a question.
So there's a couple instruments that you refer to that were turned off recently for to save power and and, you know, lengthen the the mission forward.
Are there?
Are there science questions that are going to be harder to address without those instruments or with this existing suite you can sort of interpolate over what they saw because of redundancies or or correlations or something like that.

JR **Jamie Rankin** 34:53
It's a.
It's a great it's a great question.
There is redundancy.
There was redundancy and now we're using it.
So. So the two cosmic ray instruments.
We kept one on each spacecraft and they see things from different perspectives, but we we they've kind of been inner calibrated.
So we know.
You know how to infer what's going on, but it's at this point any future.
Instruments being turned off would be losing that capability. So we are at

that time in the mission and I'll point out that.
Point out that people thought that the Voyagers would end, and I remember as a kid reading in a textbook about the voyages for the first time.
So at the end of mission would be in 2010 and then it said it would be in like 2015 and even before that they thought the mission, they thought the voyagers were old in 1990.
After when it started its interstellar mission.
And so it's pretty incredible that here we are in 2025 and we haven't yet lost our capabilities of measurements. But we are kind of now at the very margins of everything including temperature and power and all that.

KS **Kirk, Michael S. (GSFC-6700)** 36:15
Yeah, it's, it's fantastic.
So a couple more questions in the chat.
So how? How far can they go, assuming that that the spacecraft remains healthy with communications?
I mean like you are now. What, a 48 hour round trip to send the signal and get something confirmation back?
So how? How far can they go?

JR **Jamie Rankin** 36:37
Yeah, so so to answer this question if there, how long does it take for data to return? You just said it, it's takes one day to send the the data up there and one day back.
So it's a 2 day round trip flight time and they're travelling 1,000,000 miles a day. Voyager one is at about 165 astronomical units.
It travels like 3 astronomical units a day.
So.
So and we're not sure.
We're just not sure at this point if.
We have all sorts of estimations about how long the spacecraft might last, but there can also be just hardware failures like happened in November of 2023.

There was a chip that just went belly up and we kind of lost ability to it lost ability to communicate with us. We could communicate with Voyager 1.
It's in the news and they found out in a very clever way.
Exactly what happened and rerouted around the memory.
So it's kind of like we're, we're not sure, but we are thankful for every single day that we get and it's making history.
So it's pretty amazing.
OK.
Yep, go ahead.

KS **Kirk, Michael S. (GSFC-6700)** 37:55
Yeah, I was gonna say more questions from the chat just to read them out. Let's see here.
Pat, following up on your your previous comments and about the one seeing only the the perpendicular component of the the magnetic field and and sort of the implications of that and then a separate question about CME travel time from the Sun to Voyager.

JR **Jamie Rankin** 38:17
Oh, that's great questions.
So yeah, the that one is stepping and it's stepper motor.

KS **Kirk, Michael S. (GSFC-6700)** 38:22
OK.

JR **Jamie Rankin** 38:25
Stepping.
It it does.
It is the one that knows that it's 90°.
But we also know from the other cosmic ray instrument that it just has body fixed telescopes and it does have ones that that look, you know, on the off directions. And so by comparing that, those are steady.
And then our all sky direction one shows the same features.

We can infer that that's same 90° drop out and so there is some redundancy.
There is not ideal, but we can tell and we can also tell when the spacecraft rolls during calibration maneuvers that that those dropouts anytime long time changes.
We can just probe those and we can tell during those roles as well that there's dropouts.
And then CME.
How long does it take to travel from the sun to Voyager? That's an.
Excellent question.
Takes about.
Four years or so, maybe 2:00 to 4:00. There's a kind of a range of speeds.
From the sun out to the Hulu pause and then the distance out to the Voyager actually really depends on which spacecraft.
And that's kind of it's, it's bizarre to think about because these events, they, they might be travelling. So wind is traveling at 400 kilometers per second.
These shocks are often travelling faster than that.
But when they hit the interstellar medium, they slow down a lot.
They're traveling only 60 kilometers per second and the voids are spacecraft are traveling at 17 kilometers per second.
So.
These shocks are overtaking the spacecraft, but it takes a long time, so 17 kilometers per second.
Translates to three AU per year, so maybe these shocks travel like 10 AU per year.
And Voyager one is now.
45 astronomical units past the hue pause, so it take like five years for shock to hit the hue, pause and then travel out to Voyager 1.
Voyager 2 is maybe about 10 astronomical units, so I would say maybe five years from the Sun.
Out to Voyager 2.

KS **Kirk, Michael S. (GSFC-6700)** 40:55
So we're we're at time or at the top of the hour, but one last thing before you go.
You mentioned a major anniversary coming up in a couple of years.

JR **Jamie Rankin** 41:00
Very good.

KS **Kirk, Michael S. (GSFC-6700)** 41:04
Do you have plans for that already?

JR **Jamie Rankin** 41:07
Oh yeah, that's a great question.
We are starting to be in the planning phases about that and we would totally love to partner with.
Going back into the archives, pulling up all the fun Voyager stuff, there's so many fun aspects of the voyages, especially the technology that had to develop over the whole on Earth compared to like the technology of the spacecraft being unchanging.
There's all sorts of amazing.
History.
Be an educational outreach opportunities and we're actually right now just looking at thinking about who to partner with.
So if there are people interested.
In participating in planning, I'm sure JPL will host a big event on the 50th.
Where we're working to get.
A whole like big literature. Big papers out that.
Kind of describe the whole history of this 50 year mission.
So there's there's definitely campaigns to make sure all the data sets are, you know, ready to go for anybody to use it, and that the legacy gets preserved for future generations.
But yeah, we are.

We are open to suggestions as well because we wanna plan a big party but but.
Yeah, 50 years since 1977 to 202750.

KS **Kirk, Michael S. (GSFC-6700)** 42:32
Hello.
It.

JR **Jamie Rankin** 42:38
But anyway.

KS **Kirk, Michael S. (GSFC-6700)** 42:38
Yep.

JR **Jamie Rankin** 42:40
We're looking for partners to help us plan that, I would say.

KS **Kirk, Michael S. (GSFC-6700)** 42:42
All right.
Well, we'll certainly be in touch and maybe you'll come back to this group in in a couple of years of telling us all about the exciting plans you have for for the 50th.

JR **Jamie Rankin** 42:55
Yep.

KS **Kirk, Michael S. (GSFC-6700)** 42:57
Alright. Well thank you so much, Jamie.
I really appreciate it.
I certainly learned something.
I hope everybody else did too.
And yeah, and of course, Jamie, you're always welcome back if you want to just attend and learn about other cool missions, not just your own, but that that'd be amazing.

JR **Jamie Rankin** 43:09
Yeah.
Thank you.
Thank you very much.

KS **Kirk, Michael S. (GSFC-6700)** 43:13
All right. Thanks a lot.
We'll see everybody next time.

Ng, Carolyn Y. (GSFC-670.0)[ADNET SYSTEMS INC] stopped transcription