

Hi Reddit, I'm Mike Liemohn, a Professor in the Department of Climate and Space Sciences and Engineering at the University of Michigan, here to talk about the many ways space can kill you (or satellites, electricity), AMA!

AmGeophysicalU-AMA ¹ and r/Science AMAs¹

¹Affiliation not available

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Abstract

I'm Mike Liemohn, a Professor in the Department of Climate and Space Sciences and Engineering (<http://clasp.engin.umich.edu/>) at the University of Michigan (umich.edu). You've probably seen Gravity, The Martian, or The Fantastic Four, so you know that outer space is a dangerous place. But isn't outer space a vacuum of nothingness? Beyond no air to breathe, what else could possibly hurt you? It turns out... lots! I investigate the physics at work in the almost-nothingness of our solar system. I am also the Editor in Chief of the Journal of Geophysical Research – Space Physics(2169-9402/) a leading journal in this field of understanding the Sun, solar eruptions, magnetic storms, the radiation belts, and the aurora at Earth and other planets. I am also currently teaching a very fun course at U-M called SPACE 101: Intro to Rocket Science. I hope to have an engaging discussion with you about the fascinating physics happening in the near-emptiness of outer space, and explore the many ways that space might pose a danger to astronauts, to satellites, or even to power grids here on Earth. I'll be back at 12 pm ET to answer your questions, Ask Me Anything! The AGU AMA series is conducted by the Sharing Science (sharingscience.org) program. Sharing Science: By scientists, for everyone. More at sharingscience.agu.org.

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many ways space can kill you

What is the protocol for astronauts if a colleague dies up there?

[Ungodlydemon](#)

There is a UN agreement that says that you cannot "litter in space," so the body cannot be put into the airlock and sent off from the spaceship. I am not exactly sure what the NASA protocol is for this situation, but with this UN mandate, my guess is that they have to bring the body back. Luckily, this has not happened on the International Space Station.

Thanks for coming to talk with us! I'm curious about radiation exposure for people in space. How much do astronauts on the ISS get and how long is it safe to stay up there, from a radiation perspective? What about on a trip to mars? Has materials work to shield astronauts gotten better? How much worse is a space walk than being in the station?

[asbruckman](#)

(or satellites, electricity), AMA!,
The Winnower
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You are pretty safe inside the ISS. The energetic photons, like EUV X-ray radiation, are stopped. So are nearly all of the energetic electrons and protons in the Earth's Van Allen radiation belts. So, very little radiation gets through the walls, except for the really energetic particles, like galactic cosmic rays (from beyond our solar system) and solar energetic particles (from the Sun). The Earth's magnetic field helps with these particles, so the exposure is less than if you were on a trip to Mars. So, 6 months on the ISS is relatively safe. The danger is when you are outside of the spacecraft, with just the spacesuit as protection. Your time outside is limited to hours, and even shorter if there is an intense space storm.

Hi and thanks for joining us today!

From what I understand fluid shear in micro gravity can increase both virulence and antimicrobial resistance of pathogens. If say on Earth we reach a point where AMR restricts almost all treatments, would space flight still be possible given the many opportunistic pathogens we harbor?

[PHealthy](#)

This is a great question but, sorry, beyond my expertise. I hope that those contemplating long-duration space flight, especially interplanetary travel, consider this issue in their planning.

1)Does your blood boil or freeze at space? 2)What kills an astronaut faster? Boiling/freezing blood, over pressure ,etc.

[poyrazogluyigit](#)

An astronaut exposed to the vacuum of space will suffocate first. You will have ~15 seconds of consciousness and perhaps a minute or two of life.

Because it's a hard vacuum, heat transfer is very slow, so the astronaut will not freeze very quickly. The pressure difference will cause bodily liquids to vaporize, but your blood is well contained and won't boil away. Your tongue, however, will start to boil. I have read that it feels like an effervescent bubbliness. The other thing that happens is that the air in your lungs will expand. It can be pushed too rapidly into the neighboring cells and cause damage. If you want to live the full 1-2 minutes, then exhale. Counterintuitive, yes, but apparently it prevents this damage in your lungs and makes your time in space less painful.

Do you still have to wipe in space after a number 2? Like does poop still stick to your butt in space or how does that work?

[haywood-jablomi](#)

Yes, you have to wipe in space. In fact, on Earth's surface, gravity usually helps to pull away the "number 2" from the body. In orbit, everything (you, the spaceship, the air in the ship) is in free-fall and appears weightless, so...yeah.

With all that can go wrong out there, do you think that the idea of interplanetary colonization is feasible/something worth pursuing?

[evdog_music](#)

Yes, because humans like to explore and go where they have never gone before. I think that it is worth it purely for the worldwide communal experience of watching a human go to another planet.

To actually do something there...no. We can do whatever it is with robots, in a faster, better, cheaper way. It's very expensive to keep humans alive in outer space, and very expensive to move all of the support equipment/materials with those humans from Earth to another planet.

What, in your opinion, is the biggest threat our world faces from space?

[5meterhammer](#)

Human malfeasance. As we become more reliant on satellites in space or ground-based systems susceptible to space weather effects, we also face a big risk of human error or intentional acts causing serious problems for life and society.

Take, for instance, the Chinese testing their anti-satellite technology a few years ago. They shot a missile at a defunct satellite, and hit it! Now there is a thin layer with thousands of bits of space junk that is essentially unusable for new orbits because of the relatively high risk of your new satellite being hit by one of these pieces from the satellite. Satellites can cross through this altitude without much danger, but they shouldn't linger there.

In the 1960s, the US and USSR tested several nuclear weapons in upper atmosphere. The result was many satellites going dead and a new radiation belt that lasted at a dangerously intense level for several years.

On a more naturally-caused threat from space, I also worry about a big space storm causing such intense space currents in the auroral zone that the geomagnetically induced currents in power lines on the ground cause massive blackouts across the world.

Hi Dr. Liemohn thanks for having this. When I was just a child I watched the movie Mission to Mars and to this day I still remember one of the main characters having to remove his helmet to save the rest of the crew and he dies immediately.

Is there truth behind this? What would happen if an astronaut removed part of their suit while in space?

[chezloafy](#)

The astronaut would have about 15 seconds of consciousness as the body used up the oxygen in the blood and cells. Then the person would lose consciousness but still be alive for another minute or two. Our body's outer shell is pretty tough, so there would be no exploding skin or eyes. Because there is essentially no oxygen in deep space, your body would not decay.

Thanks for the AMA!

Do we have the technology now to build a plausible spaceship (see below) that will protect human astronauts from all the dangers you mentioned, assuming this ship is going to travel between the planets (so a multi-year trip outside the Earth's protective magnetic shield)?

By "plausible spaceship", I mean one that can (for example) withstand those dangers without needing such a thick hull it'll never get off the ground.

[Senior0422](#)

The short answer is no. The two biggest threats to astronauts in terms of radiation damage are galactic cosmic rays (extremely energetic particles from beyond our solar system) and solar energetic particles

(from solar flares and interplanetary "shock fronts" in the electrified, magnetized gas from the sun called the solar wind). These two types of particles require a really thick shield to stop both the initial energetic particle and the secondary particle/X-ray spray created when the initial particle smashes through the material. For GCRs, which are everywhere in space, you pretty much have to live with the radiation dose. Luckily, this is relatively small and won't cause a "prompt radiation sickness" in the astronauts. The cumulative effect, though, of being in deep space for several years could be bad on the people. For SEPs, we can monitor the Sun and see when we expect (or actually detect) these particles to be emitted from a solar active region. The take about 30 minutes for the fastest SEPs to get from the Sun to Earth (remember that light takes 8 minutes, so these are really fast particles), so if you are on a trip to Mars, you might have a few minutes warning. The best defense would be to get behind a big small region of really thick shielding. This could be done several ways, like getting in a chamber embedded in a fuel tank, or turning the spacecraft to put the whole length (and mass) between you and the incoming SEPs, or just having a small wall somewhere in the ship.

Why are people obsessed with leaving this planet? The cost to do so is so extreme, wouldn't it be better to improve our own planet before abandoning it? Why spend billions of dollars on going to mars, when there is such limited benefits?

IMHO, there are so many unique special places on the planet we are already on, and so many people here that can be helped. Taking our engineering talent and our rare resources to shoot a few people into space to eventually die is just an ego trip.

[whitedsepdvine](#)

We look up at night and see the moon, planets, and stars, and our human imagination takes us there. I don't think that we will ever stop our curiosity from contemplating space travel and dreaming up the technology to tackle this problem. Plus, humans going to a new place where no humans have gone before captures the attention of others, often the whole world. Why are we obsessed? Because we see the night sky and want to go there. You bring up a great point, though, about exploring our current planet and making it better. I love our home planet and have very little desire to go to outer space myself. I am fully satisfied with a calm walk through the woods or along a beach. And yes, I fully agree with you: for the adventurer who is the first to go somewhere, it is a big ego trip. They know that their name will be known around the world, at least for the day if not for many years to come. I like to think, though, that the engineering talent and resources spent on space travel is justified because it is relatively small (only 0.5% of the US federal budget goes to NASA, so <0.1% of US GDP), and that this effort is not wasted but leads to breakthroughs with far reaching relevance. Plus, space travel ignites the imagination of young people around the world and encourages them to pursue big dreams, whatever those are. Overall, for me, the good outweighs the bad, I am glad that we support human spaceflight and that there are companies pursuing space tourism.

Hi Dr. Liemohn, thanks for taking the time to share your work with us, even though it's somewhat horrifying to think about.

When you watch movies about how dangerous space is, do you enjoy it or get upset that Hollywood gets it so wrong? Is there any portrayal in modern media that you particularly like, either for it's accuracy or sheer ridiculousness?

Would you ever go into space if given the opportunity? Why or why not?

Also, how many "It's not rocket science" jokes do you make on a daily basis?

[PapaNachos](#)

Surprisingly, the rocket science jokes are not an everyday experience for me. It usually comes up when someone first discovers what I do. To your first question: I have to watch sci-fi movies for the action, story, and visual effects, not the science. Usually, there is some tiny piece of scientific truth in the plot line, which the producers have exaggerated into something horrific. I don't try to get hung up on the bad science; I just laugh at it to myself. Would I go into space? Not yet. I don't think I am needed for space science experiments in space (robots can usually do it much better than humans), and I am not yet ready to be a space tourist. We're still in the adventurer/explorer stage of space travel, and I don't need to be one of them.

Has there been any progress in creating a magnetic field around a satellite or spacecraft to shield the electronics/occupants from radiation?

[NeverBob](#)

People have worked on this, yes, not only for protection but also for propulsion, using the created magnetic bubble as a big sail in the electrified, magnetized solar wind streaming from the sun. I don't think it is practical, yet. You need a massive magnetic field to offer any real protection from the damaging particles at the high-energy-end of the spectrum. Plus, you then either have a giant permanent magnetic in the spaceship, making metal objects hard to use and playing havoc with electronics, or it would take a big power source, and power is usually at a premium on spacecraft.

Professor L,

Is it feasible to use an artificial radiation source, such as a magnetron, in LEO to irradiate a precise target on Earth? What factors would prevent such a device from working? From what I understand, with a precise enough waveguide and a high enough wattage, it should be possible. Thank you!

P.S. Alternatively, could a weapon system such as this be used to destroy hostile alien space ships?

[Skydronaut](#)

Yes, I think a magnetron could work in space, but it would then be on a satellite flying at the 7 or 8 km/s speed to be in LEO. You'd have to constantly redirect it to focus on your target. Beam spread would also be a huge obstacle to overcome. I think that microwaves from a magnetron are too high-frequency to be guided along the Earth's magnetic field, so some other beam-controlling technology would be needed.

Welcome Dr. Liemohn,

On the power grid, how well-protected is the infrastructure and what should we be doing differently?

What is the most inaccurate death by exposure to outer space you've ever seen depicted in a movie?

[adenovato](#)

We can overcome the threat to the power grid with both software and hardware upgrades. The first would be controlling the flow of current and diverting away from regions beneath intense aurora and near-Earth space currents. The second would be in better switches to prevent damaging levels of current from reaching sensitive equipment, and better transformer design to prevent damage from spikes of excessive current. The most inaccurate death is, off the top of my head, probably the non-death of Arnold Schwarzenegger in "Total Recall."

If offered to be one of the first people on a manned mission to mars, would you go?

[CodingComedy](#)

No, I like my life here on Earth. I do not wish for the slow cancerous death of long-term. low-level radiation poisoning that would get from the journey, and I do not need to have my name immortalized as one of those doomed souls on the first journey across the void to the Red Planet.

Hi Dr. Liemohn, thank you for doing this AMA!

Regarding bacteria, could some actually survive in space for a long time (if so, for how long?) and reactivate when put in a favorable environment? How dangerous would they be? And what would be the mechanism behind their survival in space?

Otherwise, on the subject of radiations, what would a dose received in deep space for a given amount of time, beyond Earth's magnetic field, compare to what we can receive on the ground? How deadly would be such a dose?

Edit : another question : how powerful would a solar storm need to be in order to 1) significantly damage satellites, 2) have a non-negligible effect on ground infrastructure?

[Haforin](#)

We know that most bacteria can go dormant survive in extreme conditions for long intervals. From what I know of bacteria, they shut down and their tiny body essentially crystallizes. A few molecules remain active and, when conditions are better, uncrystallize the bacteria's "body." About dose: beyond Earth's magnetic field, astronauts would be exposed to a continual bath of galactic cosmic rays (energetic particles from beyond our solar system). Luckily, this dose is below anything that causes a prompt response, like immediate sickness. What is unknown is how well our bodies replace and repair the damaged cells from such a continual bombardment from GCRs. After even a few months in space, the astronaut will definitely have a higher risk of cancer later in life. So, a long journey (~1 year to Mars, many years to other planets) will not be that bad in terms of being sick in flight, but most likely will be bad for long-term health. The last question on how powerful a storm needs to be needs a multi-part answer. -- Surface charging: even during relatively quiet times, satellites are bathed in hot particles that can build up static electricity charge on the outer surfaces. If there are parts of the satellite with different materials, or are electrically isolated from each other, then this can lead to "differential charging" and the possibility of an electric discharge. That is, a spark, like when you zap your hand on a doorknob after walking across carpet in your socks. Satellite designers have to be very careful to avoid this issue, because it will arise as a problem quickly if not designed right. -- Internal charging: the more energetic particles, like those of the Van Allen radiation belts, can make it through the surface layers and penetrate into material deeper within the satellite. If they stop in an electric insulator, they are stuck! If enough stop there, though, again a static electricity buildup occurs and eventually there is catastrophic release, usually ruining that component. This is a slow and cumulative effect, and the damage often happens at seemingly random times, but a storm that pumps up the radiation belts could push this buildup over the tipping point. -- Internal bit flips: those same very energetic particles can also zip through wires or chips and flip a one to a zero, screwing up packets of information. Redundancy has to be built in to the electronic systems to mitigate these single event upsets. -- Ground infrastructure: this is most affected by a phenomenon we call "substorms." Basically, if the aurora is really bright and curtain-like above you, then there are intense currents flowing in and near them which can cause geomagnetic induced currents in "long conductors" on the ground, like power grids and pipelines. Like surface charging, even moderate activity can lead to an intense moment of GICs. However, really big magnetic storms usually have many short substorms during the day-long storm

event, any one of which could cause GICs that push the power line over some current limit, blowing a transformer or damaging other equipment.

Greetings, Dr. Liemohn.

You state you work with "understanding the sun." I don't belittle man's influence about the weather, but doesn't the sun control almost all of what happens on the earth (and all planets) weather- and climate-wise?

Thank you for your answers and insight!

[english](#)

The short answer is yes, the Sun is a primary energy source for the Earth's atmosphere. But the weather would probably be pretty stable and predictable without the oceans, land masses, lakes, forests, and mountain ranges perturbing it. It is the local features of Earth that make weather and climate so interesting. Humans also have an influence, as we create urban heat islands, change the vegetation across vast swaths of land, and alter the chemical composition of the air. For space weather and climate, humans have only managed a few experiments with only temporary changes to the space environment. There, the changes happen more rapidly but the influence is cleared away relatively quickly.

What is your favorite Sci-fi/space movie and why?

[czr79](#)

Off the top of my head, any movie with one (or maybe a few) aliens fighting humans for survival. Like "The Thing," specifically the 1980s version with Kurt Russell, or the first "Alien" movie, or "Predator." Then I don't have to worry about the space science being wrong and I can enjoy the struggle and action.

Will the first human on Mars be known to the public, or will only the second?

Assuming the possible negative public reaction, fear, and other factors that could occur if the mission was a failure, will the first few attempts be a secret? Thus, only providing the public with good press for the country or company, when they are absolutely sure they have figured out all the issues.

[whitedsepdvine](#)

I don't know but my guess is that it would very hard to keep a mission to Mars secret, especially in today's media-rich culture.

Thank you for this! What are causes of death the average person doesn't know about or not seen in movies?

[djmjuegos1](#)

There are enough very fast particles, mostly electrons and protons, that pose a serious radiation risk. In near-Earth space, the biggest threat are the Van Allen radiation belts, two torus-shaped rings around the magnetic equator of the Earth (one close in and another a few Earth radii out from the planet). After a magnetic storm, during which the aurora would be brightly lit up and perhaps shifted equatorward

over the USA, these Van Allen belts are often intensified with additional particles, some times 100 times stronger than during quiet times. If you were in a space suit, outside of your ship, in the heart of these enhanced radiation belts, you would be exposed to damaging levels of particles in a matter of an hour or two...death in a day or two. Even inside your ship, you don't want to linger in these belts when they are enhanced like that.

Another issue are geomagnetically induced currents. These are from the currents flowing in the auroral region, 100-200 km altitude. When the aurora are lit up brightly in spectacular sheets of green, red, and purple, this means that those space currents are strong as well. They can "induce" currents in really long (many miles) conducting loops here on the ground, like power lines and pipelines. Pipelines absorb this by having an extra add-on called a "sacrificial anode", which we have to replace occasionally. Power lines, however, suffer through the extra current. If a grid were operating at nearly 100% current capacity and then a space storm added a few percent more in GIC current to the grid, it could damage equipment. In 1989, the province of Quebec went black due to a GIC surge that blew out one of the really big transformers, setting off a chain reaction of outage across the region. They got it back on line ~12 hours later. If several such transformers blew out simultaneously, then it could be really bad. These transformers are very expensive and there is not a big inventory on hand. Power could be out for weeks or even months. Not a direct death but, we are so dependent on power for essentials of life, it could threaten many lives during a prolonged blackout.