the WINNOWER

REDDIT

Hi Reddit! We discovered “Steve,” a mysterious purple light in the sky related to auroras. We’re space and citizen scientists participating in an initiative called Aurorasaurus and working with NASA. Ask us anything!

NASASUNEARTH R/SCIENCE

EDIT 4:35 pm ET: Thank you all for your excellent questions. It's been a lot of fun sharing our science with you. We're signing off now.

We have just published a study detailing “Steve,” an aurora-related dancing purple light first spotted – and named! – by amateur photographers. This new information about Steve comes from analyzing satellite data, all-sky cameras and additional citizen-scientist photographs. Steve’s scientific name is now Strong Thermal Emission Velocity Enhancement (which can still be shortened to STEVE).

STEVE appears as a faint purple ribbon of light in the sky and is often accompanied by a short-lived,green, picket fence structure. It looks much like an aurora but occurs at lower latitudes closer to the equator.

After analyzing satellite data, we learned that STEVE is the visible side of something we were already familiar with: sub auroral ion drift (SAID), a fast moving stream of extremely hot particles. SAIDs appear in areas closer to the equator (like southern Canada) than where most auroras appear. Until now, we never knew SAIDs had a visual component! Studying STEVE can help us paint a better picture of how Earth's magnetic fields function and interact with charged particles in space.

You can help us learn more about STEVE by submitting your photographs and sightings of the phenomenon to a citizen science project called Aurorasaurus (online at aurorasaurus.org or on your device as iOS and Android apps). Check here for more details about how to spot STEVE.

Answering your questions today are:

Liz MacDonald, space scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and founder of Aurorasaurus

Chris Ratzlaff, citizen scientist who first named Steve; runs the Alberta Aurora Chasers Facebook group

Burcu Kosar, space scientist at NASA Goddard

Matt Heavner, space scientist at the New Mexico Consortium, Los Alamos, New Mexico

Bea Gallardo-Lacourt, space physicist at the University of Calgary, Canada

Bill Archer, space scientist at the University of Saskatchewan, Saskatoon, Canada

Megan Gillies, space scientist at the University of Calgary, Canada

We are now live. @NASASun on Twitter

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WRITE A REVIEW

CORRESPONDENCE:

DATE RECEIVED:
March 16, 2018

DOI:
10.15200/winn.152111.18240

I'm curious about the finer details of the emission spectra, it looks like a fluorescent green at the end, what electronic transitions determine the color? Are there particular elements involved? (I know, I'm such a chemist about this, asking about the chemical compositions!)

nate

(B.K.): The green emission typically seen in aurora (557.7 nm) is due to the transition of an electron from the excited state of the atomic oxygen to the ground state. We think this is what is seen with

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STEVE in the “picket fence” structures as well. The purple is whole different chemical ball of wax… so to speak, and we’ll address that in another question here.

Can you predict STEVE as you might predict an aurora?

adenovato

(MG+BGL) Unfortunately, we can not currently predict when we will see STEVE. Currently, we can not 100% predict when and where the aurora will occur either. For aurora in general, tools like Aurorasaurus.org help our understanding of where it is visible, especially in real-time. If you want a general heads up a few days ahead of time, websites like spaceweather.com and @tamithaskov’s forecasts on Twitter are really helpful.

For STEVE, we are still learning. We do know that STEVE is seen when the aurora is active, but sometimes for large storms and sometimes for smaller events. We currently don’t have enough information about STEVE to predict where and when it will occur. We are still in the beginning phases of understanding why and how STEVE occurs...really ‘What’ STEVE is.

For more information about how to use Aurorasaurus, this video is a good place to start: https://www.youtube.com/watch?v=opkLAoRdbHA

What's important about STEVE? What would you tell a person on the street about why this is important?

sciencereader3455

CR - From a citizen scientist’s perspective, this research shows us that anyone can follow their passions and participate in important scientific discoveries. We can reach out to scientists, ask question, share our observations, and help gather fundamental data.

What's important about STEVE? What would you tell a person on the street about why this is important?

sciencereader3455

BGL - STEVE occurs in a very interesting region of the magnetosphere. Here the magnetic field topology changes from stretch magnetic field lines to dipolar magnetic field. We are still trying to understand how these two different regions are coupled and interact.

What's important about STEVE? What would you tell a person on the street about why this is important?

sciencereader3455

[EM] We don’t want to toot our own horn too much, so I’ll quote UCLA Prof. Larry Lyons, a senior physicist in this field, who told the Atlantic “It is truly exciting, to us as aurora scientists, that there is a group of amateurs out there who enjoy the aurora so much that they could put together something that is this new to us. That’s just unbelievably cool.” “I’ve never seen something this new discovered by citizen scientists in the aurora before." "Finding something you can identify as a new structure in the aurora is relatively unusual. The last major thing was poleward boundary intensification, and you can find that name used back over 20 years ago.” More here:

https://www.theatlantic.com/amp/article/555491/?utm_source=twb&__twitter_impression=true

How do the particles get heated in the upper atmosphere to cause a STEVE? Is it just a matter of particles accelerated by the reconnecting magnetic fields impacting the atmosphere? I was under the impression that STEVE is a very high altitude phenomenon, above meaningful atmosphere altitudes.

AtlantisCodFishing

(MH+BA): There are two different answers to your question, as ions and electrons are heated by different processes around STEVE. For electrons, most heating is caused by hot (fast) particles traveling along Earth’s magnetic field lines. As they come closer to Earth, they enter denser atmosphere and are more likely to collide with particles in the atmosphere. These collisions result in the glow of traditional aurora. In the case of subauroral ion drifts (and likely STEVE), even though the particles are not precipitating, they still heat the electron gas.

In contrast, ions are frictionally heated around STEVE as large electric fields drag them through the neutral atmosphere.

How does STEVE interact with other space weather events, or even interact with the Van Allen belt radiation.

MisterPulley

(BA+BGL+MG): We still do not understand how STEVE is produced and how other regions in the magnetosphere contribute or interact in the formation of the phenomenon. What we know is that there is a strong connection between STEVE and subauroral ion drifts (fast and narrow channel of westward moving particles below the auroral oval - subauroral). Subauroral ion drifts occur during more active (or substorm) conditions, and this is an active area of research.

Do the colors of the auroras have significance?

Is there a possibility that there's something about Steve that is related human activity? That Steve is closer to Earth and unique made me first think this must be something humans have done to the atmosphere.

BurgundieM

Answer (BK+BGL): The charged particles coming from the near Earth space environment can precipitate into Earth’s upper atmosphere and interact with different types of atmospheric constituents such as Oxygen and Nitrogen. The collisions between incoming particles and atmospheric atoms and molecules cause the later to get excited and as they go back to their original state (de-excitation), they emit light. The altitude that the incoming particle will reach depends on their energy. This altitude will determine what atom or molecule the incoming particle will interact with and this will determine the color of the emitted light. For example, atomic oxygen is responsible for green and red emissions while molecular nitrogen gives off red and blue colors. More information on the colors here: https://aurorasaurus.desk.com/customer/en/portal/articles/2127021-download-aurorasaurus-infographics

Nothing suggests that STEVE is related to human activity. We have clues about its origins by analyzing the data collected by the satellites orbiting around the Earth. This data suggests that the processes taking place within the Earth’s magnetosphere and upper atmosphere are responsible for

the formation of STEVE.

Why is STEVE purple?

sciencereader3455

(B.K.): This is also a very good question. We don’t know yet and need an instrument called a spectrograph to learn more. This instrument will help us map the emission spectrum of STEVE. Knowing the exact spectral lines (or wavelengths) appearing will allow us to identify the type of glowing gas responsible for that particular emission line. However, we hypothesize in the paper that the cause of purple emission might be associated with unusual atmospheric compounds (such as Nitric Oxide [NO]) that may exist in this region of the atmosphere due to the strong flow, decrease in density and collisional processes taking place within the arc.

How do citizen scientists help you in this regard? Why do you need more pictures of STEVE?

scienceaccount103040

(B.K.): Citizen scientists reporting their observations to projects like Aurorasaurus (aurorasaurus.org) can help us create a catalog of these events. Citizen science reports collected on the ground frequently contain information on the location and time of STEVE events. These valuable pieces of information allow us to check possible conjunctions with various scientific observations made from space and ground. Thus, it will lead to better understanding of the physical processes responsible for the formation of STEVE. Not only that, most of the citizen science reports include phenomenal photographs! Images taken from different locations on the ground within a close time period can help us deduce information about their altitude of formation via a technique called triangulation.

How do citizen scientists help you in this regard? Why do you need more pictures of STEVE?

scienceaccount103040

BGL+MG - For STEVE in particular, the phenomenon was discovered by citizen scientists and they brought it to our attention. They were the key to link a phenomenon that has been known to the citizen science community for a while with the scientific community.

We need more pictures of STEVE because more information helps us to better understand the physics that is playing a role in the formation of STEVE.

Will I be able to see STEVE at the 50th latitude north (in Germany)

EpicEric33

BK: Yes, you might be able to see STEVE at the 50 N latitudes since we have frequent sightings from Alberta, Canada which also sits around the same geographic latitude. But it does have to be in a place with a dark sky.

Hi guys! Christian here. Which brand of tin foil do you recommend to protect my brain from the alien mind control signals coming from STEVE?

Okay, no, seriously.

STEVE has been seen to appear far south from the Aurora oval, with only that it seems as if it's existence may not be very common at polar latitudes.

I spoke with an Aurora photographer, Tracey Mendenhall Porreca from Delta Junction, Alaska about a structure she captured in photographs that strongly resembled STEVE. She mentioned that she was able to watch it morph from the tall red and white structure to a typical corona you'd normally see.

The photos with comments and times can be seen here. Photos and comments posted with her permission. Note: The 4th photo is facing due WEST not east. Same direction as the third photo.

Looking at the stats (taking into account travel time from L1 to the magnetopause) before these photos start, Bz was sitting in positive numbers, then took a dive to around -10nT with ~650km/s for an hour. So this series can be seen as the enhancing of activity to major storm levels (G3/Kp7).

My question then, given the evolution in the photos of Steve into a corona, could the appearance of Steve at polar latitudes be taken as a visual indicator of increased activity to come?

nuviremus

EM: Things do get very complicated during very large events. We have not seen that behavior of STEVE changing into active corona aurora before and would need to look into it further. Tracey’s post is very helpful in that the times and orientations of the photos are clearly marked. To get to the answer of your exact question though, yes it is definitely possible the appearance of STEVE is linked to enhanced auroral activity, and this is an active area of research.

Is 'Steve' related in any way to the very light equatorial band that circles the planet?

KingMob4313

BK: Could you please clarify your question further? What do you mean by “very light equatorial band”?

Who named it Steve?

GreenDog3

[EM] Our citizen scientist Chris Ratzlaff! He is the administrator of the Facebook group called Alberta Aurora Chasers and one of the paper's co-authors! You can listen to this TEDx talk by another one of our co-authors Eric Donovan who discusses the discovery. https://www.youtube.com/watch?v=n6liyhbQJeE

What kind of accuracy do you get predicting auroras in general and do you imagine you'll be able to predict future instances of STEVE with the same level of confidence?

invisiblhospitalhell

EM: STEVE is currently quite small (in terms of a feature size) and not well enough understood to be predicted by our models. Prediction of specific auroral forms is also very limited at this time, but both are areas of future research.

What kind of accuracy do you get predicting auroras in general and do you imagine you'll be able to predict future instances of STEVE with the same level of confidence?

invisiblhospitalhell

BK: I think we are in the very beginning phase of understanding the processes responsible for the occurrence of this phenomena. The ability to predict when and where STEVE can occur is possibly a future step. However, even detailed understanding of it does not necessarily mean that we can effectively and accurately predict it. The region of the atmosphere where STEVE occurs is highly dynamic and the coupling between the Earth’s atmosphere and magnetosphere makes this system complex, therefore making accurate predictions very challenging.

What had STEVE SAID about taking pictures of his new green fence? Surely he wasn't pleased.

scienceaccount103040

What had STEVE SAID about taking pictures of his new green fence? Surely he wasn't pleased.

Answer (B.K.): I would like to think that he must be absolutely thrilled to get this amount of attention in a matter of months that instantly upgraded him to “celebrity” status. :)

Has Steve been hypothesized and now first confirmed? Or has this been a known occurrence but hasn't been seen yet?

Juice-drinker

(B.K.): Great question! Actually STEVE has previously been seen and captured by the amateur photographers but misidentified as a “proton aurora”, which is a different type of phenomena. Recently, we have confirmed that STEVE is not a proton aurora but a completely new type of arc forming south of the traditional auroral oval. This type of arc has not been identified in the scientific literature before. So, while STEVE was previously observed from the ground, the association with a subauroral ion drift is new, and was not hypothesized previously.