

VOL

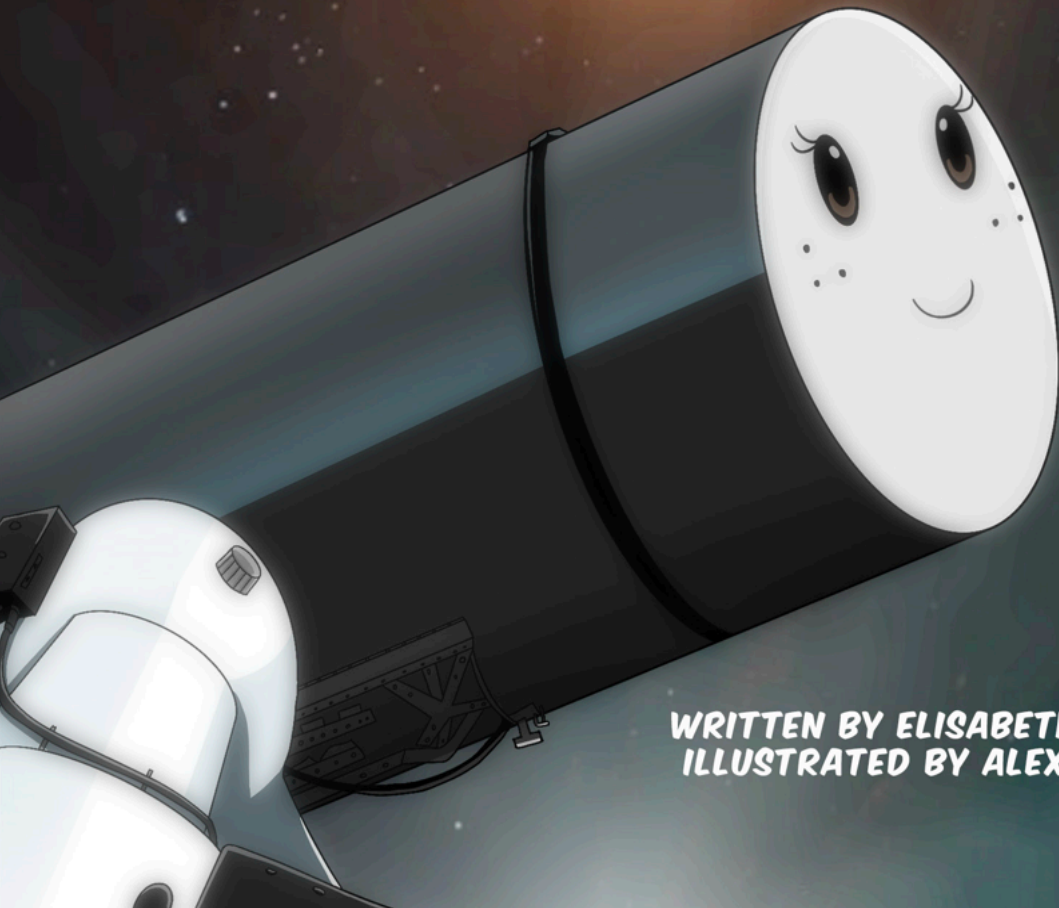
1

ISSUE 1

02/2025

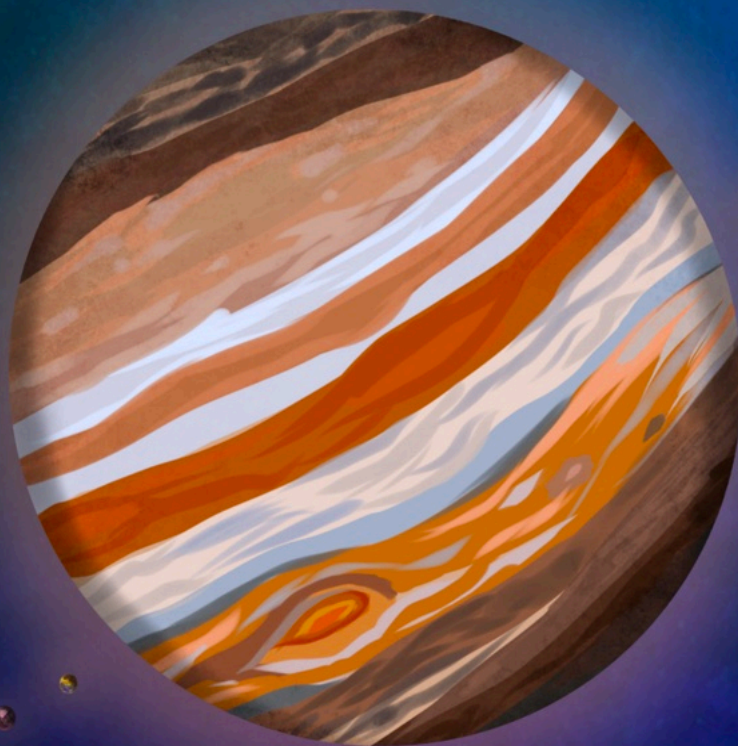
TAKE A SPACE JOURNEY

IOIO'S QUEST



**WRITTEN BY ELISABETH ADAMS
ILLUSTRATED BY ALEXIS LUND**

IOIO'S QUEST



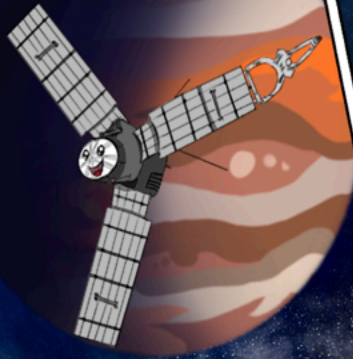
*This work was supported by NSF grant AST 2109219 to the Planetary Science Institute (Dr. Jeffrey P. Morgenthaler, Principal Investigator).
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ONCE UPON A TIME, THERE WAS A TELESCOPE.



IT WASN'T BIG LIKE THE KECK TELESCOPES.

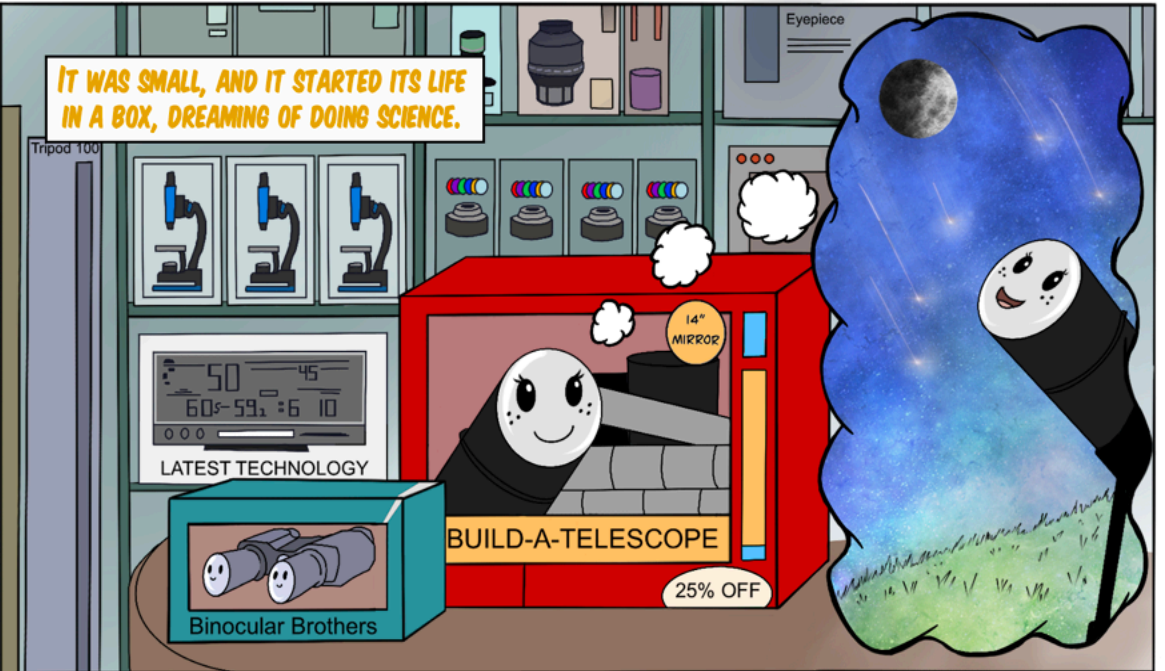
IT DIDN'T ORBIT ANOTHER PLANET LIKE JUNO.



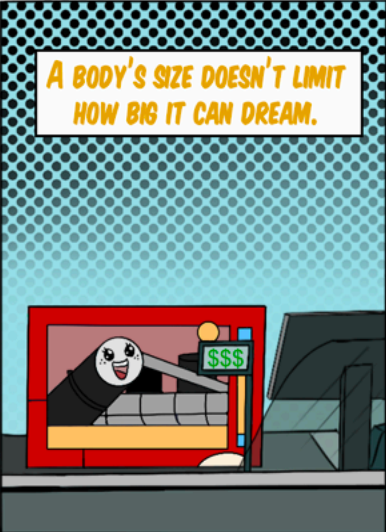
IT DIDN'T EVEN ORBIT EARTH LIKE HUBBLE.



IT WAS SMALL, AND IT STARTED ITS LIFE IN A BOX, DREAMING OF DOING SCIENCE.



A BODY'S SIZE DOESN'T LIMIT HOW BIG IT CAN DREAM.



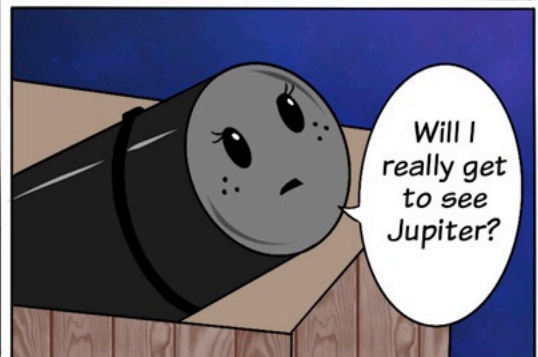
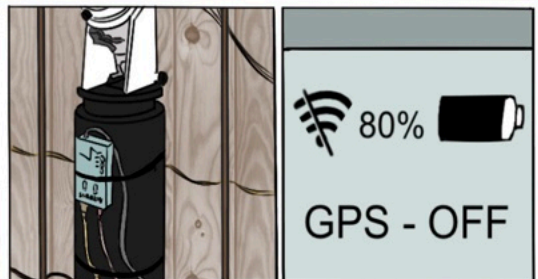
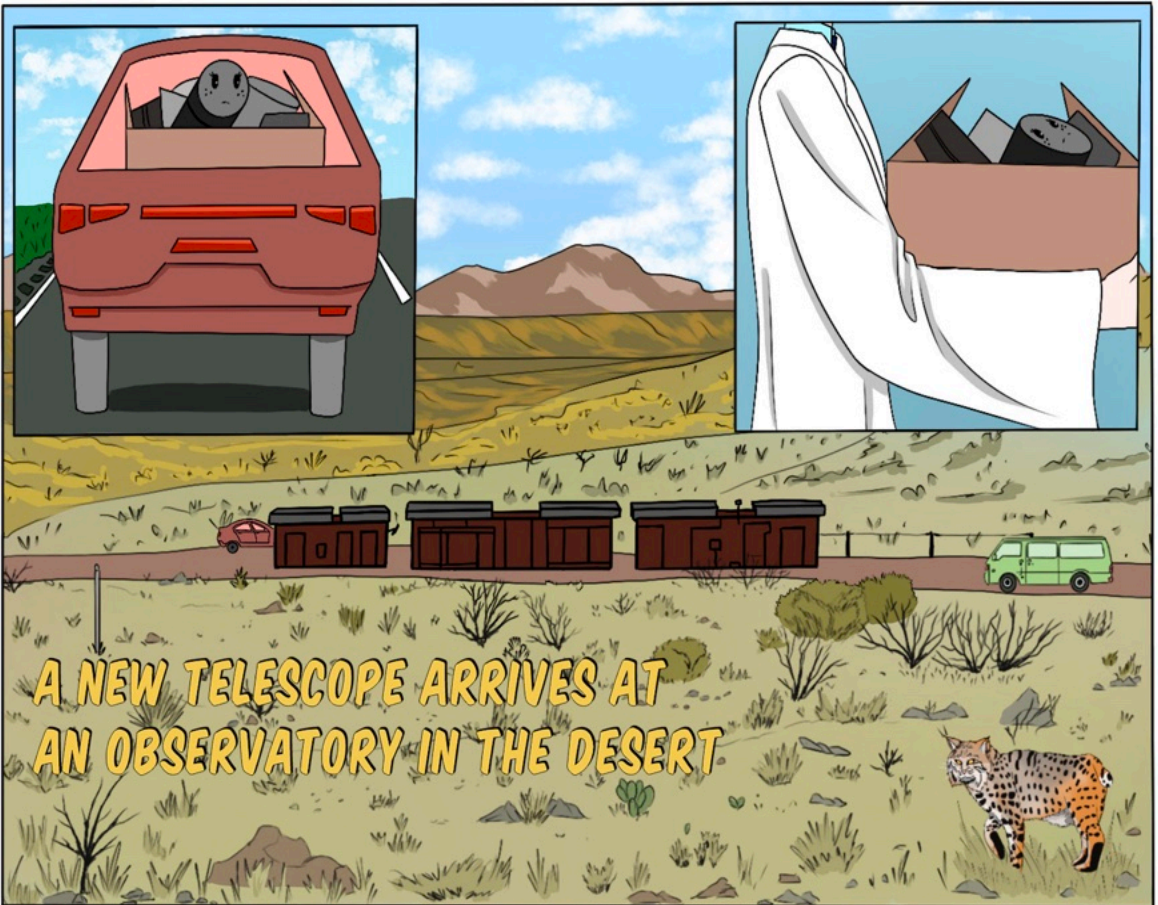
THOUGH IT DOES HELP TO NOT BE STUCK IN THE GARAGE.

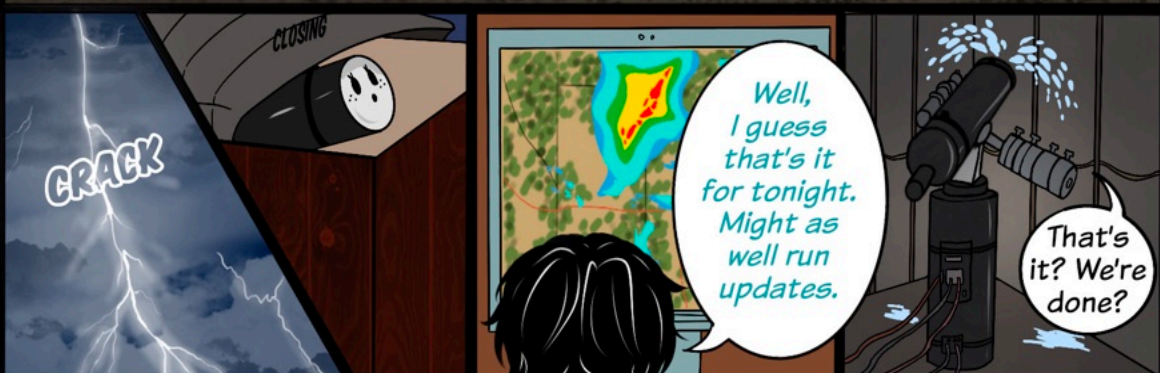
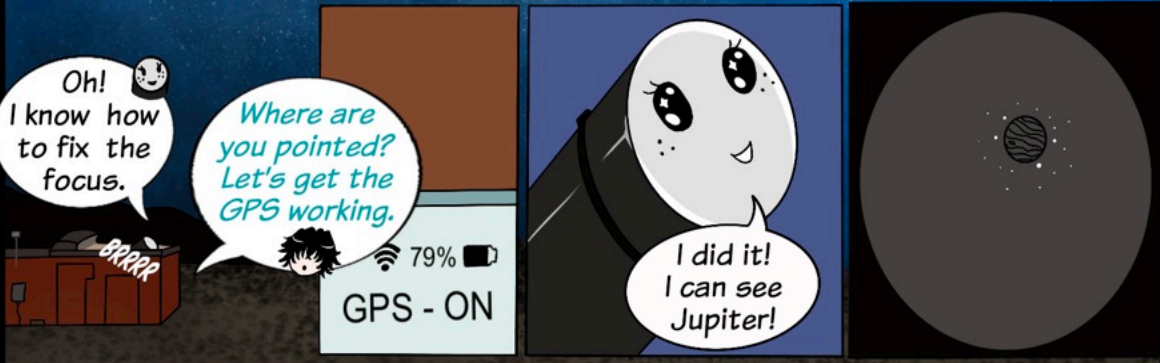
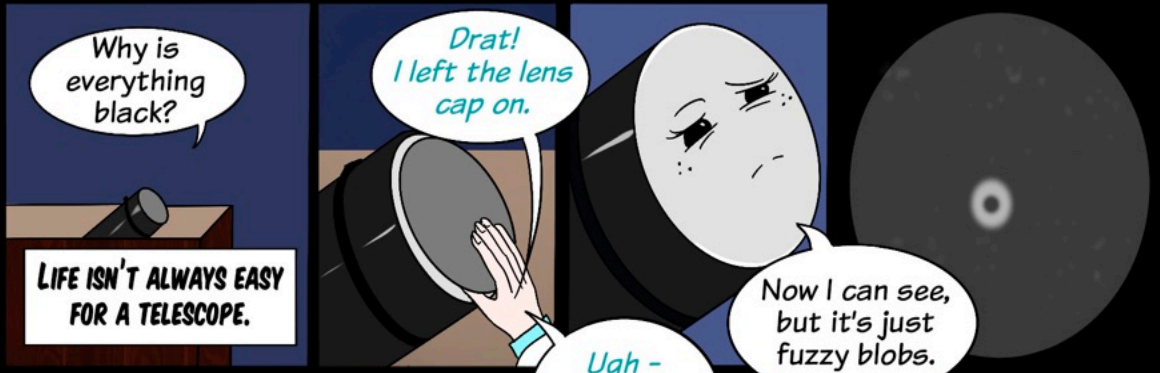


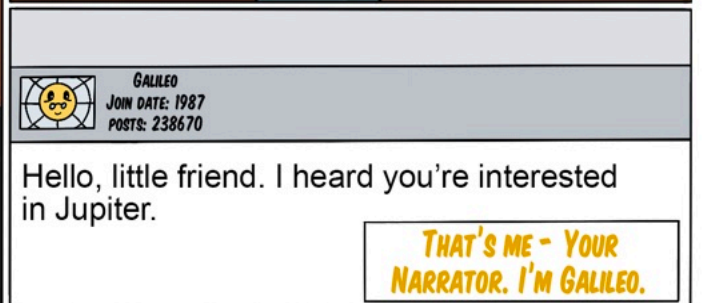
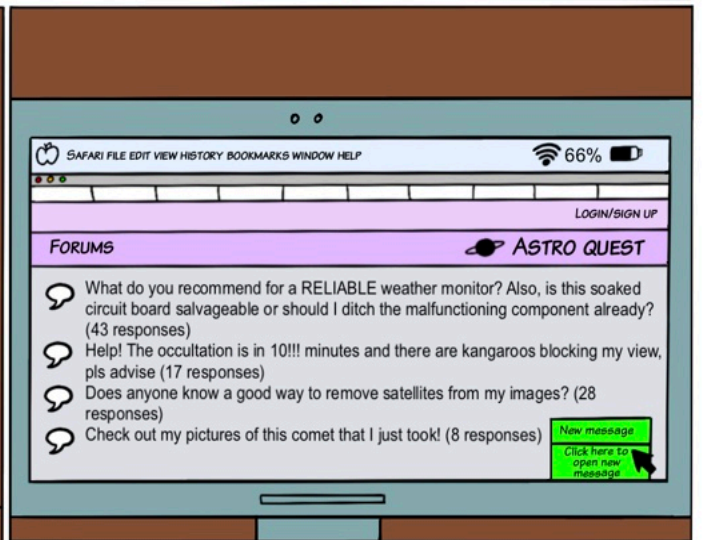
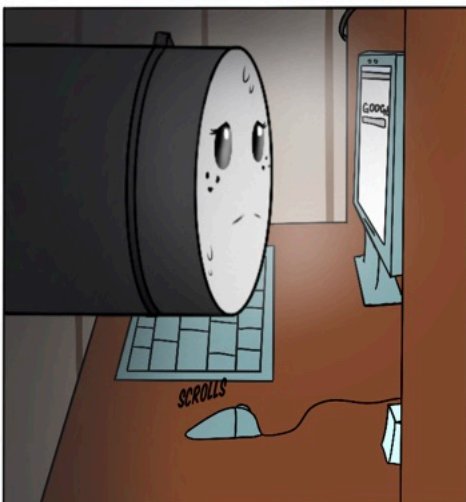
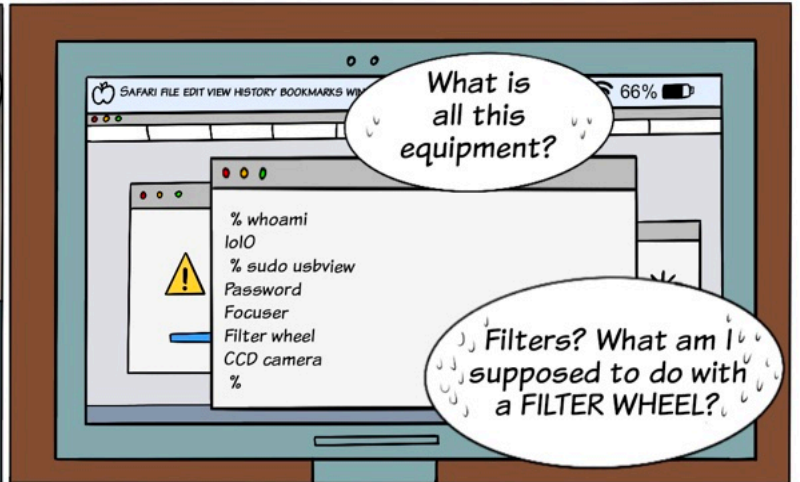
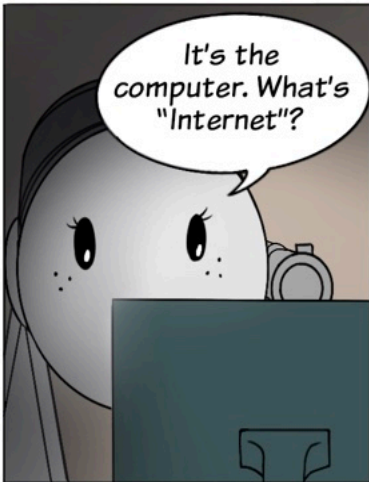
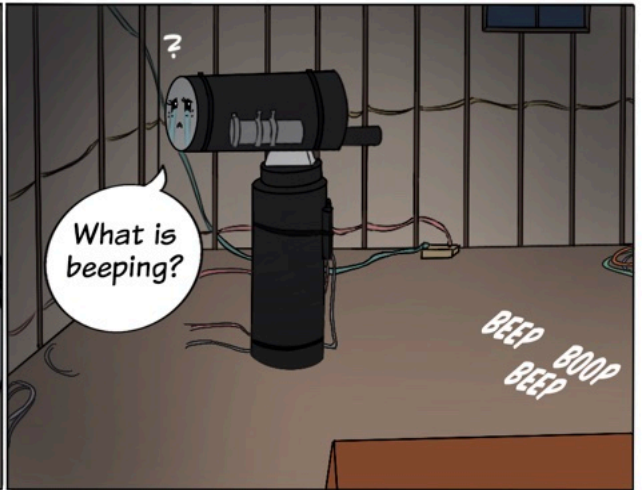
I'm here about the ad.

BUT ALL FATES EVENTUALLY CHANGE...











Io10
Join Date: 2018
Posts: 1

Um, who are you?



Galileo
Join Date: 1987
Posts: 238671

Galileo at your service.



Io10
Join Date: 2018
Posts: 2

Galileo? The mission?!
Aren't you... dead??



Galileo
Join Date: 1987
Posts: 238672

Don't believe everything you read, kid. I downlinked. I may not orbit the 5th planet from the Sun anymore, but I'm still here online.



Io10
Join Date: 2018
Posts: 3

Uh, hi?



Galileo
Join Date: 1987
Posts: 238673

Whatcha looking at? A cool galaxy? Some fancy nova?



Io10
Join Date: 2018
Posts: 4

No. The same boring thing I look at every night: the empty space around Jupiter.



Galileo
Join Date: 1987
Posts: 238674

Oh! Jupiter was my job! What a trip that was. Do you have a favorite moon? Europa? Ganymede? Callisto? I can't pick, but I have a soft spot for Io. I saw a volcano erupt on Io back in 1997. Can you imagine? Hmm, empty space around Jupiter you said? I bet you can see the plasma torus. Io's eruptions make that torus!



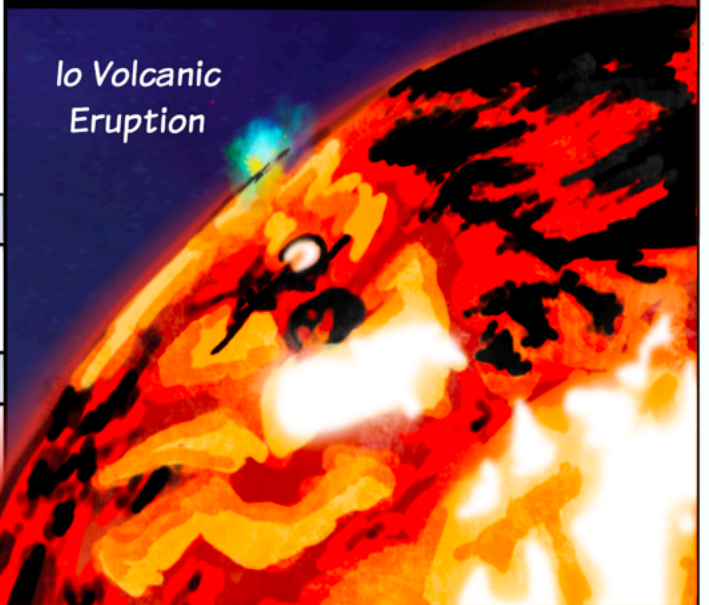
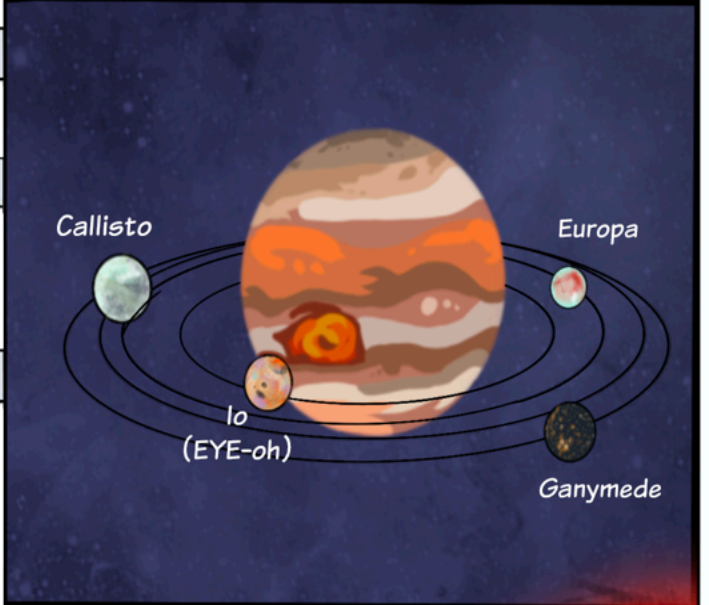
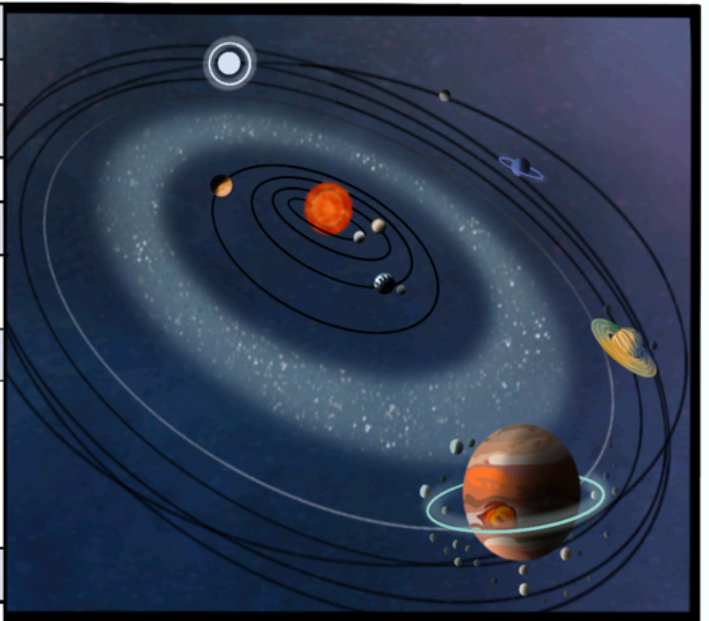
Io10
Join Date: 2018
Posts: 5

Jupiter can't be that important. It's just a planet with moons. There are like 6000 others.



Galileo
Join Date: 1987
Posts: 238675

But not in our solar system: we only have 2 gas giants. And Jupiter's 4 big moons are like whole other worlds, they're each so amazing.



I GOT TO EXPLORE IT ALL
WHEN I WAS YOUNG.

BACK IN 2003, MY BODY DOVE
INTO JUPITER'S ATMOSPHERE.

JUPITER'S MAGNETIC FIELD

BUT I LIVE ON IN MY DATA
ARCHIVE, WHERE I HELP PEOPLE
RESEARCH JUPITER IN NEW WAYS.



GALEO
JOIN DATE: 1987
POSTS: 238676

Nowadays it's my honor
to help new telescopes
and missions learn about
what they can do and
how science *really*
works.



IOIO
JOIN DATE: 2018
POSTS: 6

You help telescopes?
Like me?



GALEO
JOIN DATE: 1987
POSTS: 238677

Just like you! In fact, I
have an important
problem that no one else
can solve!

If you're interested?

SAFARI FILE EDIT VIEW HISTORY BOOKMARKS WINDOW HELP 64%

PDS Archive



GALILEO
JOIN DATE: 1987
POSTS: 238678

Your mission, should you choose to accept, is to study the plasma torus around Jupiter & help find volcanic eruptions.



IoIo
JOIN DATE: 2018
POSTS: 7

I want to help, but I don't know what all those words mean.

Gotta go. My astronomer is here. I'll find you later.

I'm glad I'm not alone.



I'm going to get to do science! And I have a mentor!



Clear skies? Check! Filters ready? Check!

Jupiter? It's rising. Let's start!



Jupiter sure is bright!

... I can't see the torus like this.

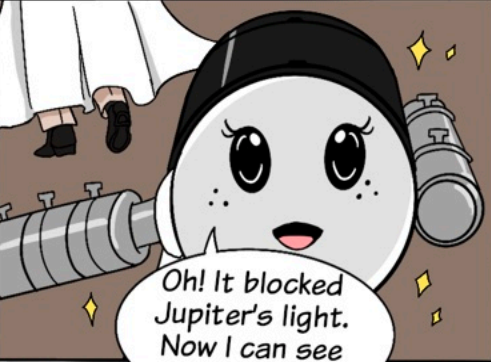
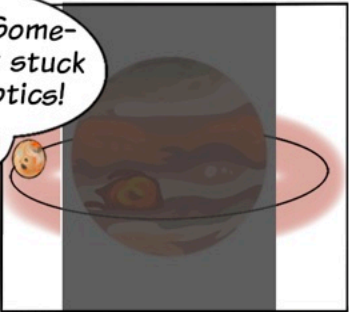


Let's fix that.

This little coronagraph will do nicely.



AHHH! Something got stuck in my optics!



Oh! It blocked Jupiter's light. Now I can see everything!



Bedtime! You got this, lol.



Um...? What am I supposed to do? I do not "got this"!



Galileo! I need your help! I don't know what I'm doing!



GALILEO
JOIN DATE: 1987
POSTS: 238679

Oh, none of us know what we're doing at the start. That's what observing plans are for. What does the file say?



IoIo
JOIN DATE: 2018
POSTS: 8

"Torus - Torus - New filter - Torus - Torus ..."



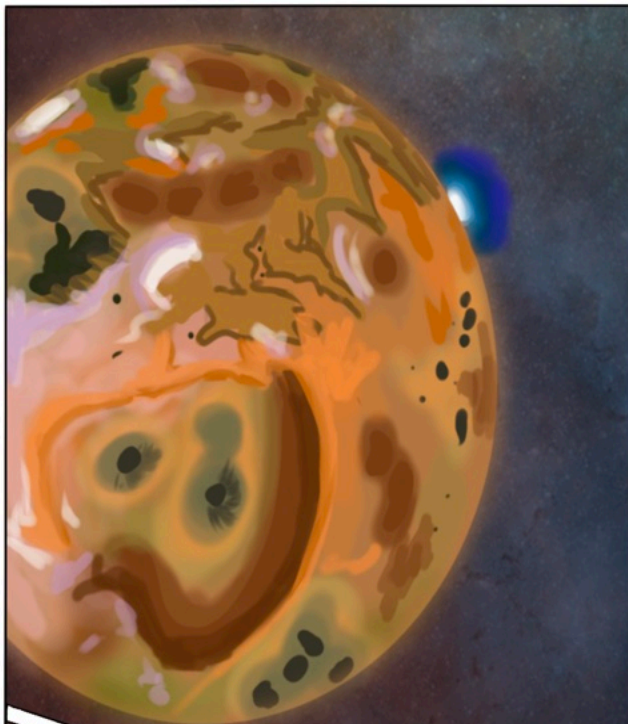
GALILEO
JOIN DATE: 1987
POSTS: 238680

Sounds simple enough. Each filter lets you see a different kind of gas! So take two images and change the filter. Repeat.



IoIo
JOIN DATE: 2018
POSTS: 9

Take two images, change the filter. I can do that!



GALLEO
JOIN DATE: 1987
POSTS: 238681

You are part of a long line of missions and telescopes watching Jupiter. Voyager 1 first saw Io's volcanos as a weird textured landscape in March 1979. A few months later, Voyager 2 caught volcanic plumes spraying material into space.

I was already being planned by then, but I didn't get to launch from Earth until 1989. Then came a 6-year journey before I finally got to lay my cameras on the Jupiter system. In 1999 I finally flew close enough to Io's surface to show how it was constantly changing. It was amazing! So worth the wait!



Io10
JOIN DATE: 2018
POSTS: 10

Why Io? Do any of the other moons have volcanoes?



GALLEO
JOIN DATE: 1987
POSTS: 238682

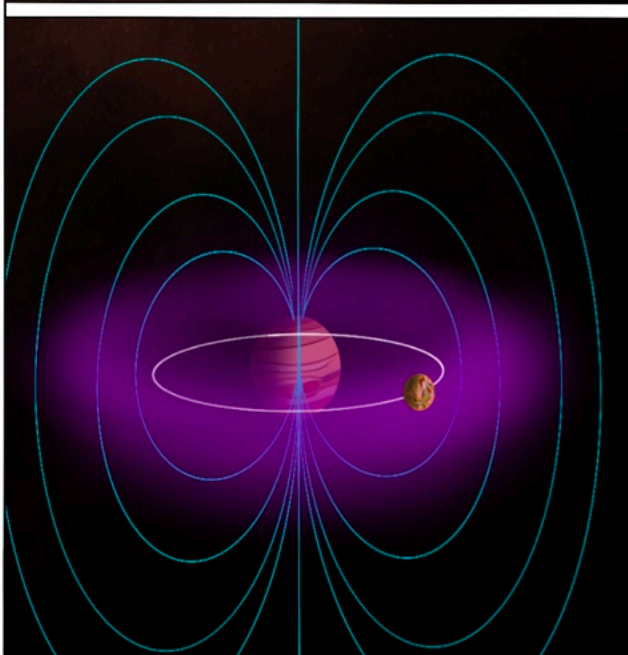
It's all about heat! Most worlds cool down over time and never have volcanoes. But Io is in just the wrong place – or just the right one. It's so close to Jupiter that gravity distorts its shape. But the moon Europa is also tugging it into an elliptical orbit. With both its shape and orbit always changing, there is a lot of friction and flexing, and the rock heats up. Boom! Volcanoes.

Io releases 1 ton of sulfur dioxide gas every second. The gas is charged by sunlight and electrons in space, and then moved around by Jupiter's magnetic field, making a large donut shape, or torus.

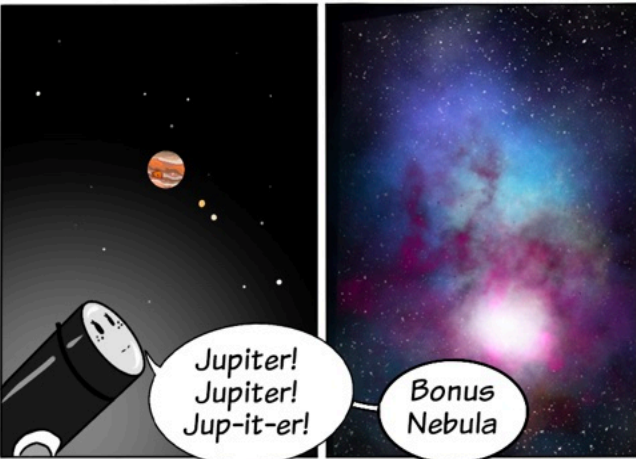


Io10
JOIN DATE: 2018
POSTS: 11

Oh! When I observe Jupiter's torus, it sometimes gets brighter. Is that because a volcano just erupted? Am I actually seeing volcanoes erupt gases into space? That's so cool!



THREE MONTHS LATER...



Jupiter!
Jupiter!
Jup-it-er!

Bonus
Nebula



Comparison
stars

This
is how we
do it!

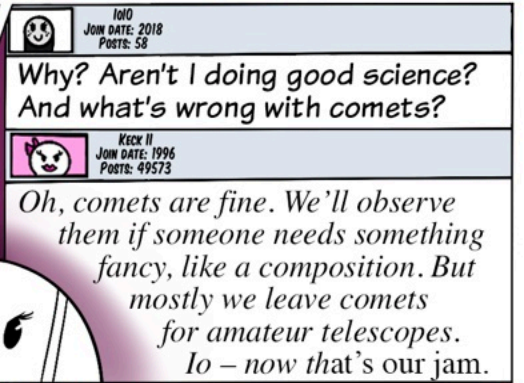


KECK I
JOIN DATE: 1993
POSTS: 52490

Hello, Dearie. I heard a rumor
you think you can do science
with Io. No need. My 10-m
twin & I have this covered.

KECK II
JOIN DATE: 1996
POSTS: 49572

Your 0.35-m mirror is best
for things like comets.

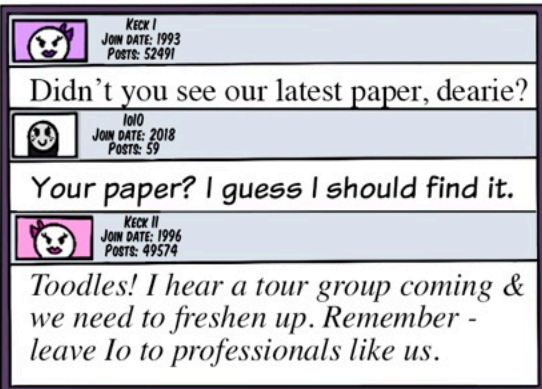


Io10
JOIN DATE: 2018
POSTS: 58

Why? Aren't I doing good science?
And what's wrong with comets?

KECK II
JOIN DATE: 1996
POSTS: 49573

Oh, comets are fine. We'll observe
them if someone needs something
fancy, like a composition. But
mostly we leave comets
for amateur telescopes.
Io - now that's our jam.



KECK I
JOIN DATE: 1993
POSTS: 52491

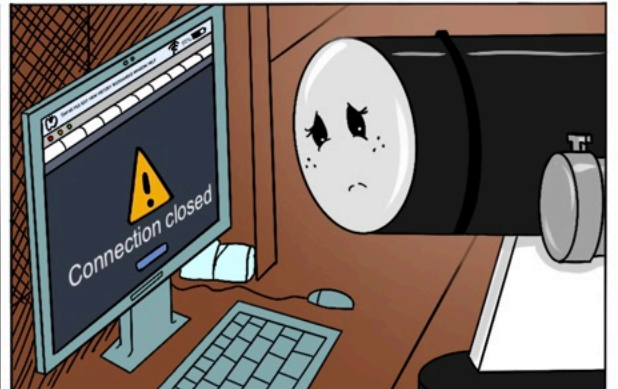
Didn't you see our latest paper, dearie?

Io10
JOIN DATE: 2018
POSTS: 59

Your paper? I guess I should find it.

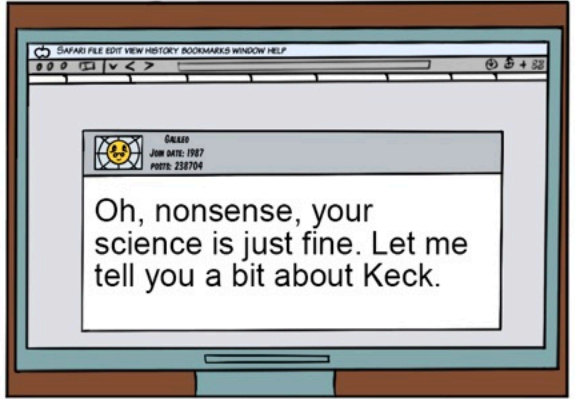
KECK II
JOIN DATE: 1996
POSTS: 49574

Toodles! I hear a tour group coming &
we need to freshen up. Remember -
leave Io to professionals like us.





The Keck telescopes think I'm not doing good science. They are among the best. Are they right? Am I too small?

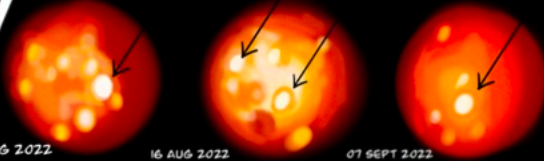


Oh, nonsense, your science is just fine. Let me tell you a bit about Keck.



Keck has a thing for volcanoes.

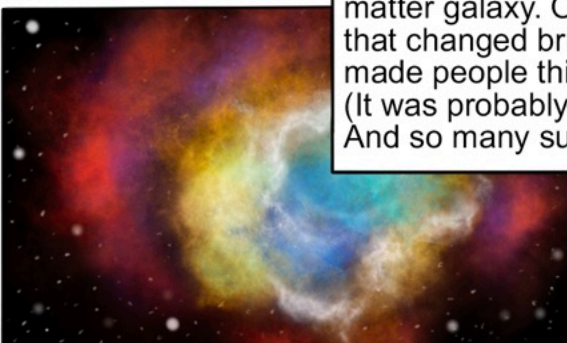
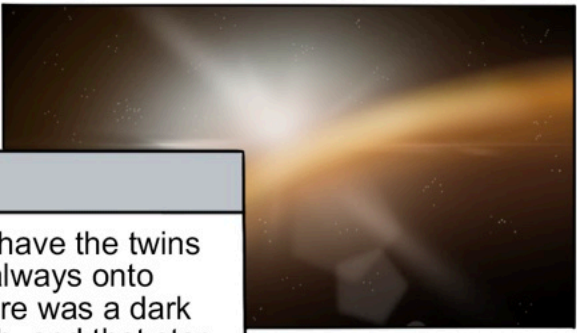
Io and its volcanoes



They live on a dormant volcano, Mauna Kea. They sometimes watch for eruptions on Io. They can get, ah, possessive.



But researchers have the twins so busy they're always onto new targets. There was a dark matter galaxy. Oh, and that star that changed brightness and made people think it had aliens. (It was probably just comets.) And so many supernovae.



Io10
JUN DATE: 2018
POSTS: 435

But they said I'm too small. Too "amateur".

GALILEO
JUN DATE: 1987
POSTS: 238707

Some foolish scopes only look at diameter. Look what I did with my 0.2-m mirror!

Io10
JUN DATE: 2018
POSTS: 436

But you're in space!

GALILEO
JUN DATE: 1987
POSTS: 238708

Exactly! I had less than 8 years to explore. You will have decades to do amazing science.

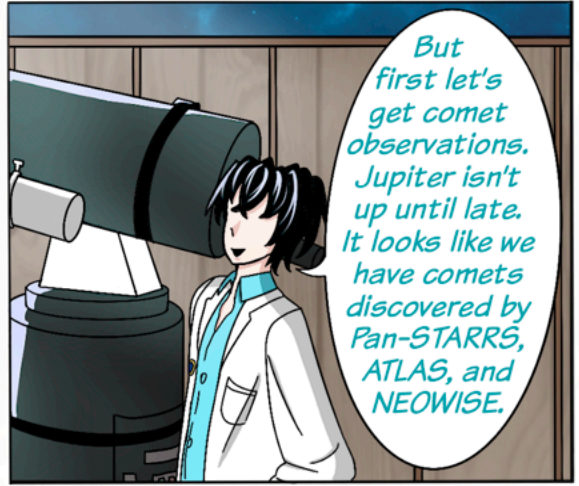
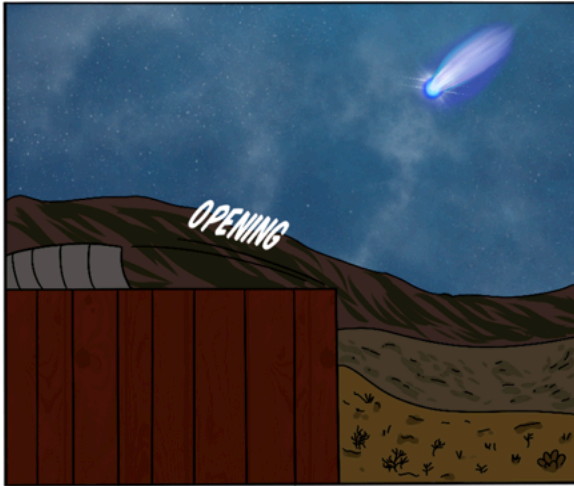
GALILEO
JUN DATE: 1987
POSTS: 238709

Just keep observing every clear night. Keck can't do that! I couldn't! You can see the entire torus. We couldn't do that. You work hard, and new science will come to you.

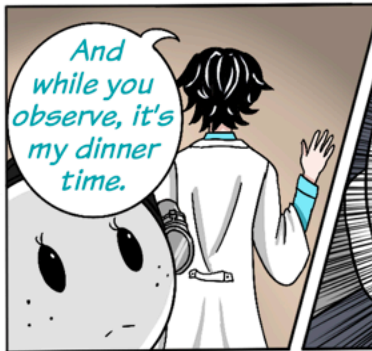


LATER THAT SAME DAY

Look at this, lo! Io! Keck is seeing eruptions on Io! I wonder if we can see this in the torus tonight? I see a paper in our future.



But first let's get comet observations. Jupiter isn't up until late. It looks like we have comets discovered by Pan-STARRS, ATLAS, and NEOWISE.



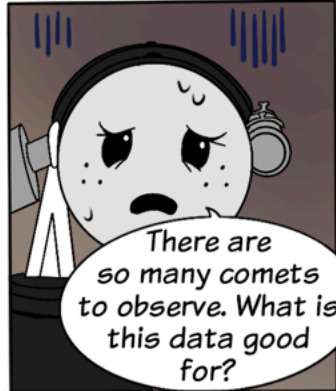
And while you observe, it's my dinner time.



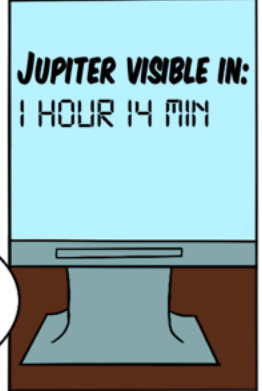
He said we might do a science paper on Io! I just need to observe these comets! Let's go!



Comets now, and then Io later. We'll do so much Io science! Just have to finish this!



There are so many comets to observe. What is this data good for?



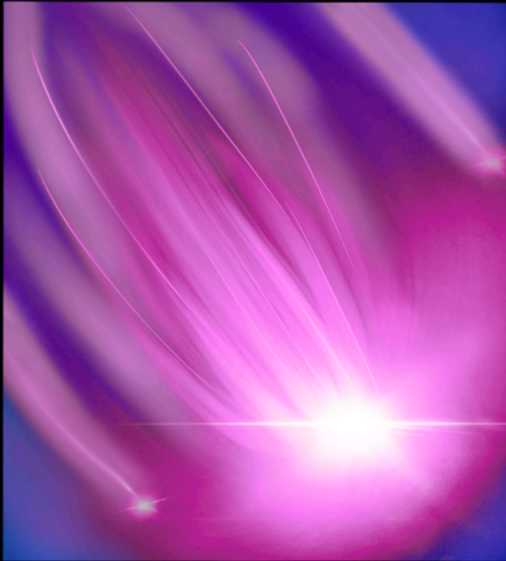


1010
JOIN DATE: 2018
POSTS: 490

Why do comets matter?

GALILEO
JOIN DATE: 1987
POSTS: 238842

Jupiter isn't always up. Good telescopes do science every moment they can.

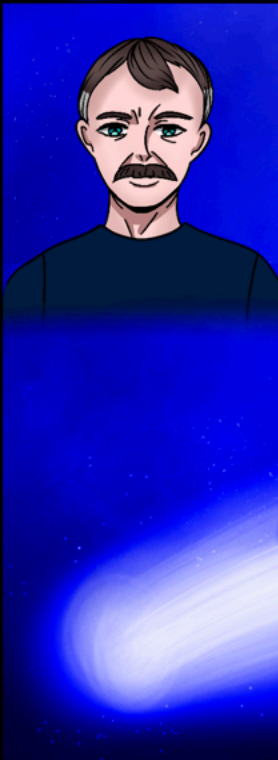


GALILEO
JOIN DATE: 1987
POSTS: 238843

For you, those moments when Jupiter isn't up comets are an additional science. Comets are amazing - they are ices and rocks all packed together and flung by gravity into the inner solar system. They are so important that we have sent spacecraft to chase them and land on them and more.

1010
JOIN DATE: 2018
POSTS: 491

But Keck said comets are for amateur astronomers. I don't know what amateurs are, but it sounded like a bad thing.

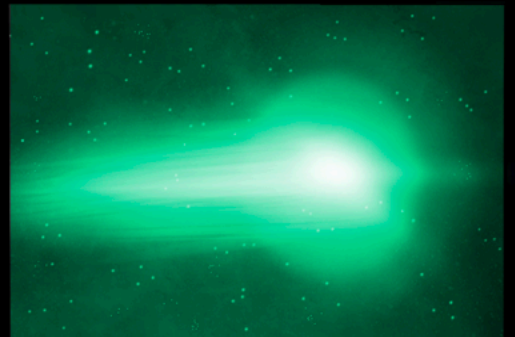


GALILEO
JOIN DATE: 1987
POSTS: 238844

Amateur astronomers are amazing! They volunteer their time to science. For instance, Russian Gennadiy Borisov discovered a comet from another solar system.

1010
JOIN DATE: 2018
POSTS: 492

WOW! An alien comet! Maybe I'll see one too.

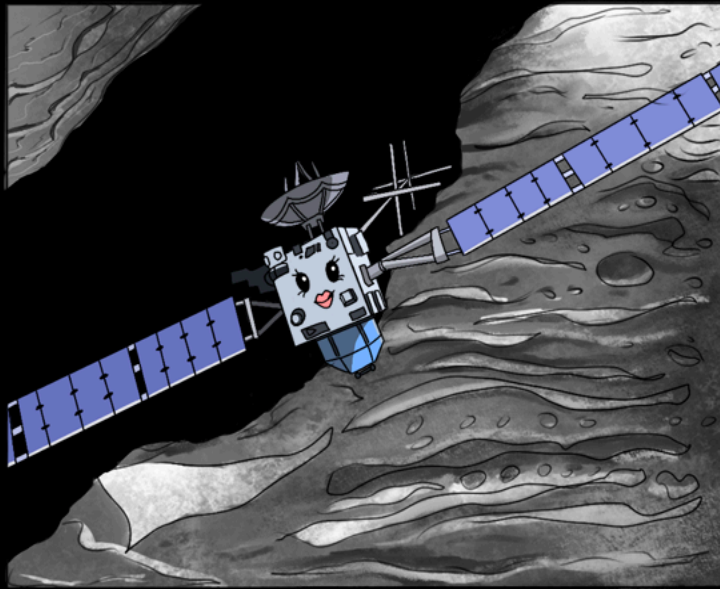


GALILEO
JOIN DATE: 1987
POSTS: 238845

Many astronomers, including amateurs, were watching Comet PanSTARRS (C/2017 S3) when it disintegrated. Their data let us see what comets are made of!

1010
JOIN DATE: 2018
POSTS: 493

It, ah, disintegrated?? I thought comets were just pretty to look at, not scary!




 GALILEO
 JOIN DATE: 1987
 POSTS: 238846

Good ol' Rosetta sure got a scare. One really bad outburst in February 2016 slammed Rosetta with dust & let her instruments see an outburst from upclose! The dust density went up by a factor of up to 100!

For you - outbursts are easy science. You keep looking at comets lolIO. You might be able to help researchers discover something amazing!


 IOIO
 JOIN DATE: 2018
 POSTS: 494

Like what? What can I do that Keck can't?


 GALILEO
 JOIN DATE: 1987
 POSTS: 238847

You can watch longer & spot special moments. You might discover comets have landslides or see how a comet can lose its tail!


 IOIO
 JOIN DATE: 2018
 POSTS: 495

Having time for special projects is my super power! Can Comets really lose their tails?


 GALILEO
 JOIN DATE: 1987
 POSTS: 238848

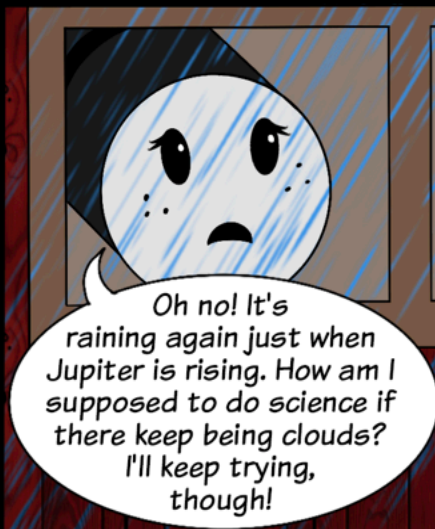
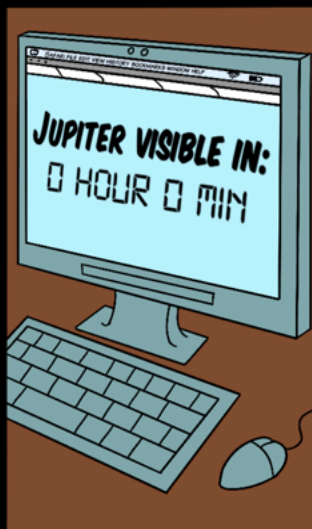
They sure can! Solar flares make the solar winds gusty, and can blast a tail right off!

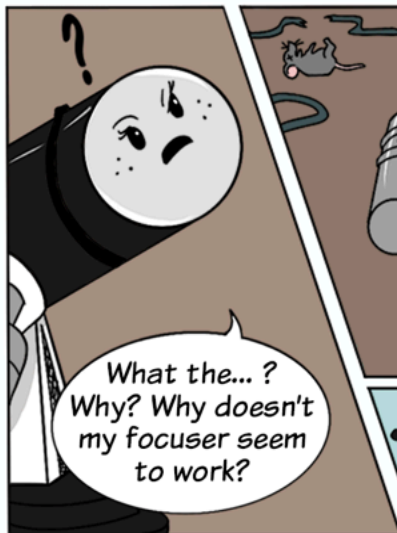
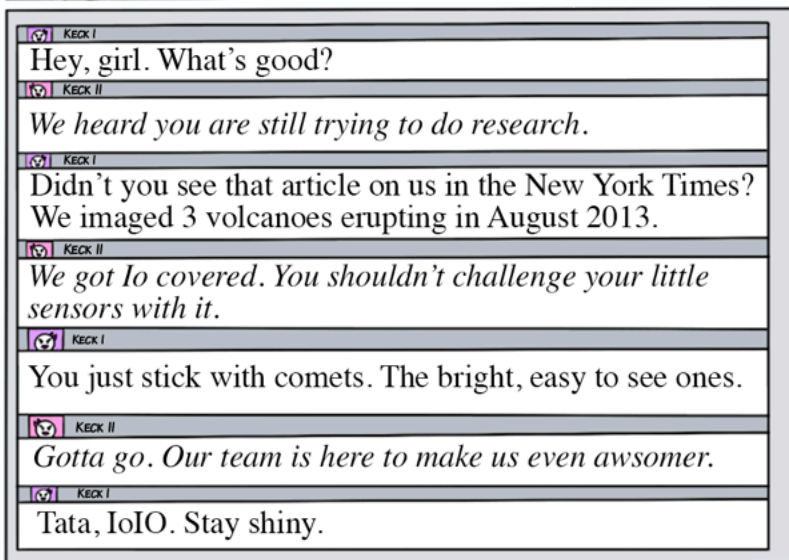
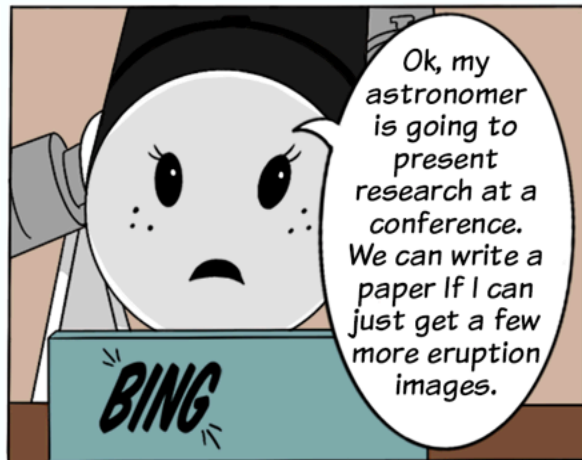

 IOIO
 JOIN DATE: 2018
 POSTS: 496

I can study that? I can study comet outbursts, lost tails, and stuff?


 GALILEO
 JOIN DATE: 1987
 POSTS: 238849

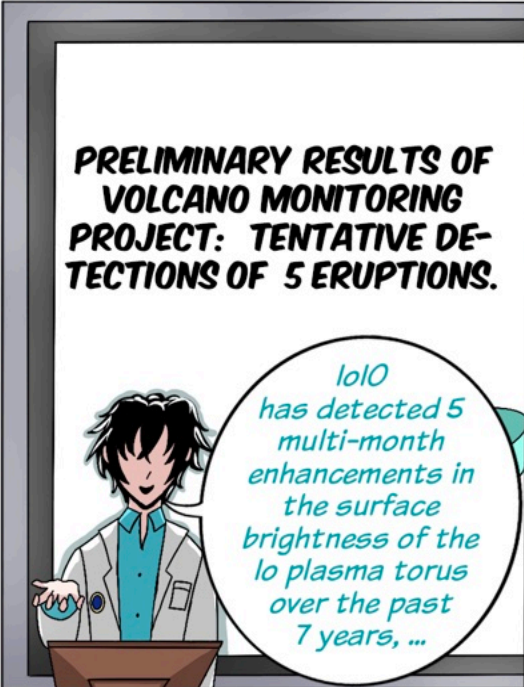
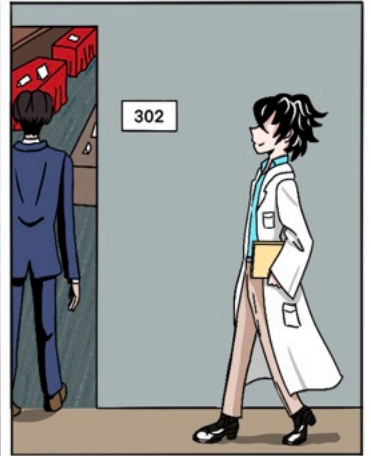
You are designed to study that kind of thing!





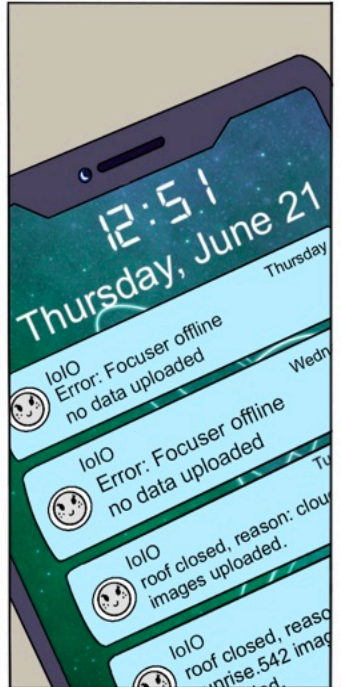
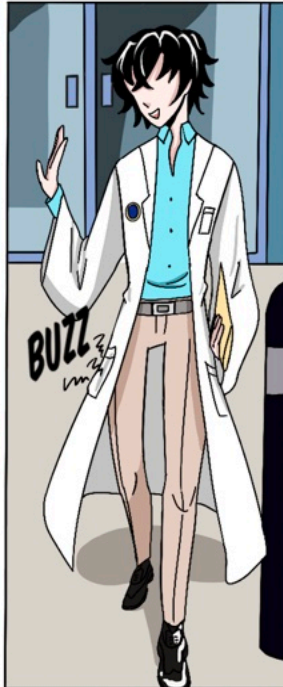


**MEANWHILE, HALF A WORLD AWAY,
IT'S TIME TO SHARE THE SCIENCE**



**PRELIMINARY RESULTS OF
VOLCANO MONITORING
PROJECT: TENTATIVE DE-
TECTIONS OF 5 ERUPTIONS.**

*loIO
has detected 5
multi-month
enhancements in
the surface
brightness of the
lo plasma torus
over the past
7 years, ...*



12:51
Thursday, June 21
Thursday
loIO Error: Focuser offline
no data uploaded
loIO Error: Focuser offline
no data uploaded
loIO roof closed, reason: cloud
images uploaded.
loIO roof closed, reason: cloud
imrise.542 imag



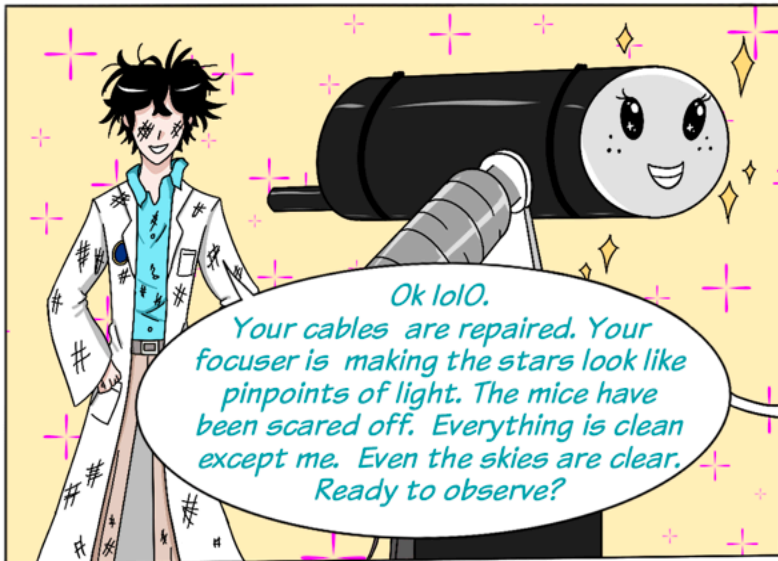
*Oh no...
Hold on, little scope.
I'm on my way to fix you.
We'll get you back
doing science!*

| | |
|----------------------|----------|
| OREGON - ARIZONA | EXPECTED |
| HAWAII - ARIZONA | LANDED |
| WASHINGTON - ARIZONA | EXPECTE |
| ARKANSAS - ARIZONA | BAGS |



*loIO,
what
happened?
Let's get
you fixed up
& cleaned
up.*

*You'll be back
observing in no
time. You'll be
better than ever.*

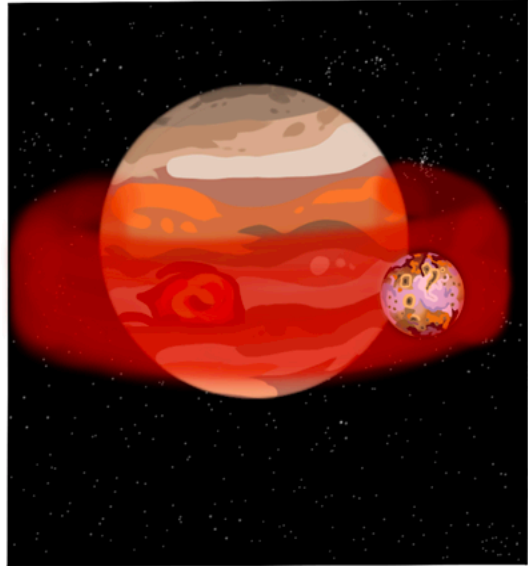


Ok lol0.
Your cables are repaired. Your focuser is making the stars look like pinpoints of light. The mice have been scared off. Everything is clean except me. Even the skies are clear. Ready to observe?

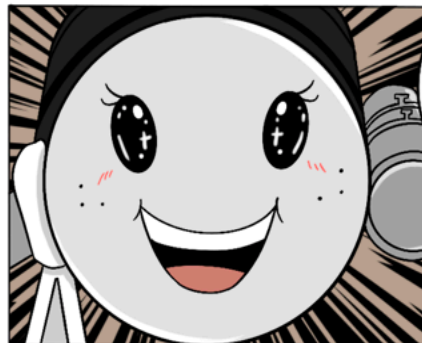


JUPITER VISIBLE IN:
0 HOURS 0 MIN

Let's catch some photons & do science!



Whoa. That torus is bright! I wonder if that could mean ...



CALLING KECK CONTROL ROOM.

Hey, I have a target of opportunity. ...Yeah... lo looks like it has an eruption.

LATER...


New messages
from Galileo
and +1 more

 IOIO
JOIN DATE: 2018
POSTS: 579

Galileo! Did you hear? I saw an eruption!

 GALILEO
JOIN DATE: 1987
POSTS: 238934

Oh yeah? You should talk to JWST!

 IOIO
JOIN DATE: 2018
POSTS: 580

Who is JWST?

 GALILEO
JOIN DATE: 1987
POSTS: 238935

Only one of the latest and greatest space telescopes!! He'll tell us what's going on!

 JWST
JOIN DATE: 2021
POSTS: 680

Hey lil buddy! It's
great observing
with you!

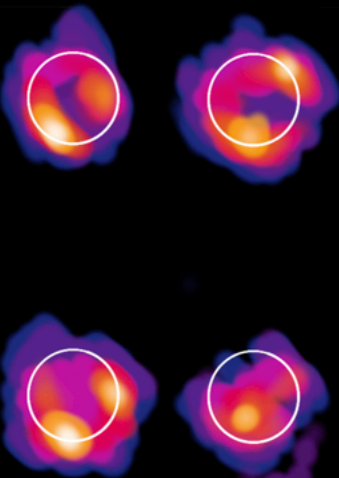
My besties
always talked
about scopes like
you that inspired
them to build me!
You're inspiring!



JAMES WEBB SPACE TELESCOPE, "JWST"

 JWST
JOIN DATE: 2021
POSTS: 681

I don't have much
time, but dude it is
happening at Io.
We're watching a
volcano on the
moon of another
planet erupting!
Ok, I'm being told I
need to slew.
More later little
buddy. Peace out.



 JWST
JOIN DATE: 2021
POSTS: 682

Get this lil buddy, I just
confirmed Kanehekili
Fluctus volcano on Io is
erupting.

 KECK II
JOIN DATE: 1996
POSTS: 57390

Well...
I guess...

 KECK I
JOIN DATE: 1993
POSTS: 59673

We should
probably
say...



 GALILEO
JOIN DATE: 1987
POSTS: 238936

See kid, even JWST
with his 6.5m mirror
can't do what you do!

 IOIO
JOIN DATE: 2018
POSTS: 581

I like doing science
with other telescopes!

 GALILEO
JOIN DATE: 1987
POSTS: 238937

The best science
happens when every-
one works together
doing what they're
each best at. I'm glad
you stuck with it. Now
go share!

 IOIO
JOIN DATE: 2018
POSTS: 582

It's time to get writing!



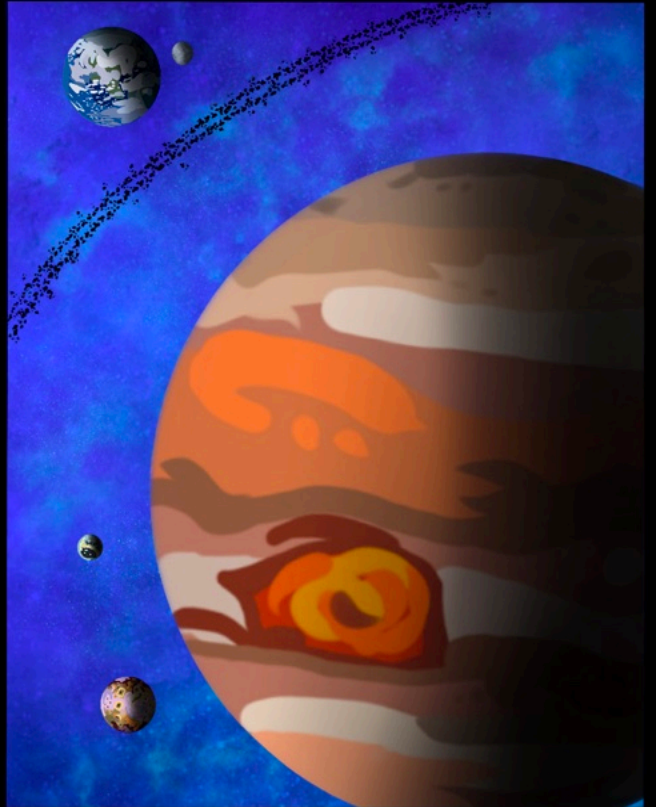
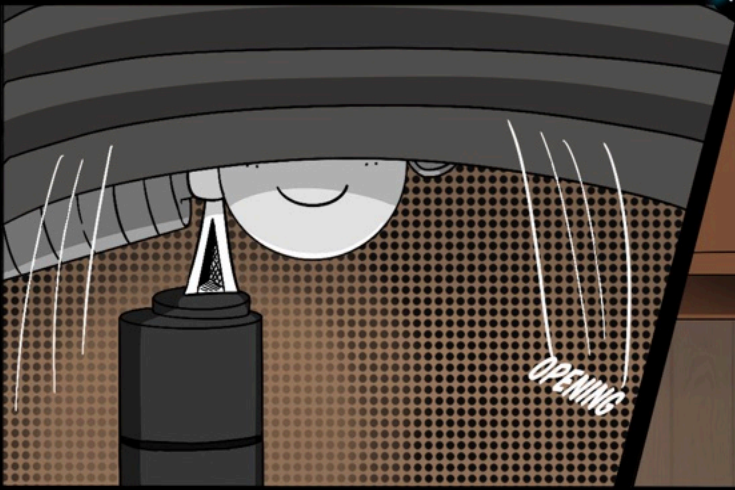
Well lolO.
We did it.
We published
6 years of
data.

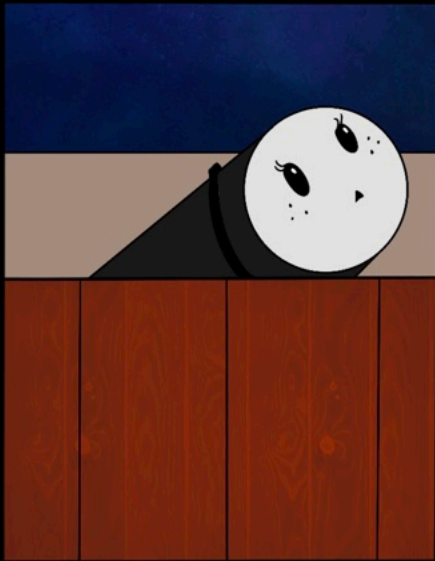
That didn't feel
like 6 years!

Now let's
finish up that
comet research.
It's a great night
to look up. Are
you ready,
lolO?



Let's go
observing!





I may be small, but I can do many things big scopes can't: I can show up night after night and look at Io, Jupiter, and the torus. And I can watch comets when they're not up.

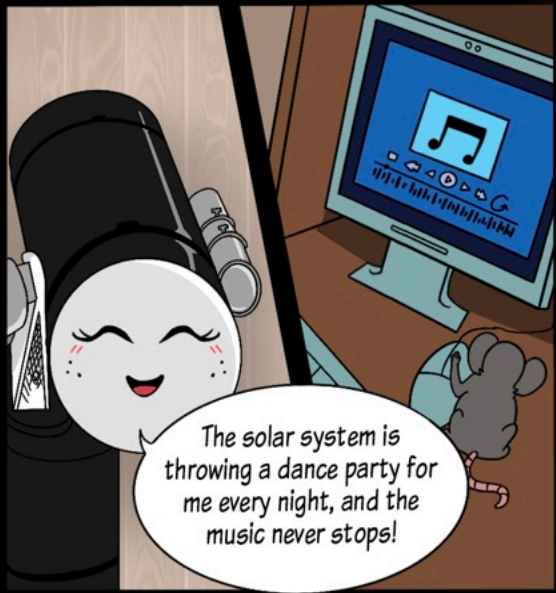
IT'S A BIG UNIVERSE OUT THERE. IT'S EASY FOR A SMALL TELESCOPE IN THE MIDDLE OF NOWHERE TO FEEL SMALL. I KNOW I FELT SMALL OUT AT JUPITER. BUT IOIO NEVER GAVE UP & KEPT LEARNING.



IOIO IS SMALL BUT CAN DO MIGHTY THINGS!



I can catch the moments everything changes. When Io erupts, comets outburst, and tails get lost.



The solar system is throwing a dance party for me every night, and the music never stops!



KEEP DANCING, LITTLE FRIEND. KEEP DANCING.

GLOSSARY

A

ATMOSPHERE - planet's gas layer

C

CORONAGRAPH - blocks out direct light from a bright star or planet to better see faint things nearby

E

ELLIPTICAL ORBIT - path of object is an ellipse and not a circle

F

FILTER - controls which colors of light the camera sees

FILTER WHEEL - used to switch filters

FOCUSER - keeps telescope images sharp and in focus

I

IMAGE - picture taken by telescope and saved for science

G

GUIDER - tracks a bright star so telescope stays on target

M

MAGNETIC FIELD - region where charged particles feel a magnetic force

METER (M) - 1 m = 3.3 ft

MIRROR - part of telescope that collects light; larger mirrors collect more light

MOON - orbits a planet

O

OPTICS - materials that direct light through telescope

ORBIT - path of moon around planet, or planet around star

P

PHOTON - particle of light

PLASMA - state of matter with many charged particles

PLASMA TORUS - charged particles around Jupiter

S

SLEW - to move a telescope to a location on the sky

SUPERNOVAE - more than one supernova, or exploding stars

T

TORUS - a donut shape



TELESCOPES & WORLDS

GALILEO

A SPACE MISSION THAT EXPLORED JUPITER FROM 1995 TO 2003. THE TELESCOPE WAS SMALL (0.2M MIRROR) BUT IN THE RIGHT SPOT FOR AMAZING DISCOVERIES.

IOIO

SMALL (0.35M MIRROR) BUT FIESTY TELESCOPE IN A SHED IN THE ARIZONA DESERT.

JWST

THE NEWEST AND LARGEST SPACE TELESCOPE YET. JWST LAUNCHED IN 2021, HAS A 6.5M MIRROR, AND IS A PRETTY CHILL DUDE. (LITERALLY; IT'S CHILLED TO <50 KELVIN.)

KECK

TWIN 10M TELESCOPES ON MAUNA KEA IN HAWAII. AMONG THE BIGGEST AND BEST, AND THEY KNOW IT.

ALSO MENTIONED:

HUBBLE: orbiting Earth since 1990!

JUNO: orbiting Jupiter since 2011.

Rosetta: orbited a comet 2014-16.

Pan-STARRS, ATLAS, and NEOWISE:

many telescopes working together to find comets & asteroids.

HOW DID I GET MY NAME?

NO, I DON'T LOVE IO SO MUCH I'M SAYING IT TWICE. (WELL, I DO, BUT THAT'S NOT MY NAME!)

IOIO = IO INPUT/OUTPUT, PRONOUNCED "IO-I-O". MY INPUT IS MATERIAL FROM IO - MY OUTPUT IS SHEER AWESOME SCIENCE!

JUPITER

BIGGEST PLANET IN OUR SOLAR SYSTEM, WITH FOUR LARGE MOONS.

IO

JUPITER'S CLOSEST MOON. HAS THE MOST VOLCANOES IN THE SOLAR SYSTEM.

EUROPA

2ND MOON FROM JUPITER. BELOW ITS ICY SURFACE THERE MIGHT BE OCEANS.

GANYMEDE

3RD MOON FROM JUPITER.

CALLISTO

4TH MOON FROM JUPITER.



**PLANETARY SCIENCE
INSTITUTE PRESENTS...**



**AN EXCITING ADVENTURE ON
HUMANITY'S LATEST DISCOVERY
IN OUR UNIVERSE!**

Once upon a time there was a telescope. It wasn't big. It didn't orbit another planet. It didn't even orbit Earth! It started life in a box in a box store, but through a chance of fate this little telescope was sent on a quest to capture big science.

Learn more at ioio.psi.edu



Find us on social media!

