



CINDY

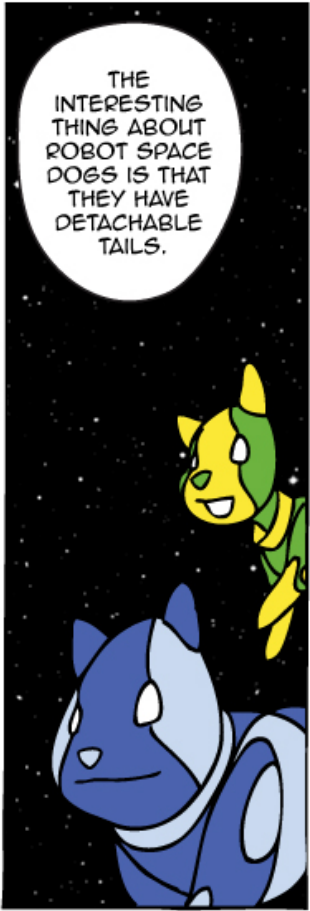
IN THE ELECTRIC ATMOSPHERE



HI!
WELCOME
BACK! MY
NAME'S
CINDI AND
THESE ARE
MY SPACE
DOGS.

IF YOU
SAW ME IN
MY LAST BOOK*
YOU ALREADY
KNOW THAT I'M
AN ANDROID
SPACE GIRL AND
THESE ARE MY
ROBOT DOGS,
TEKS AND
TAKS.

THERE
ARE A LOT
OF ROBOT
DOGS UP
HERE IN
SPACE.



THE
INTERESTING
THING ABOUT
ROBOT SPACE
DOGS IS THAT
THEY HAVE
DETACHABLE
TAILS.



IF ONE
OF THEM
HAPPENS
TO EAT A
CERTAIN
TYPE OF
ENERGY
BISCUIT...



...THEN
THEY
LOSE
THEIR
TAIL!

*YOU CAN READ CINDI'S FIRST BOOK, CINDI IN SPACE, AT [HTTP://CINDISPACE.UTDALLAS.EDU/EDUCATION/CINDI_COMIC.HTML](http://cindispace.utdallas.edu/education/cindi_comic.html)

OF COURSE THEY DON'T STAY LIKE THAT FOR LONG. THERE ARE ENOUGH LOOSE TAILS FLOATING AROUND THAT THEY GET ONE BACK VERY QUICKLY.



LAST TIME WE EXPLAINED ALL ABOUT THE TAILS, BUT WE NEVER DID EXPLAIN WHERE THE ENERGY BISCUITS THEY LIKE TO EAT COME FROM.



SO... WHERE DO THE ENERGY BISCUITS COME FROM?



THEY COME FROM THE SUN!



THE SUN IS THE SOURCE OF ALMOST ALL ENERGY FOR THE EARTH, SO THE ENERGY BISCUITS COME FROM THE SUN TOO.



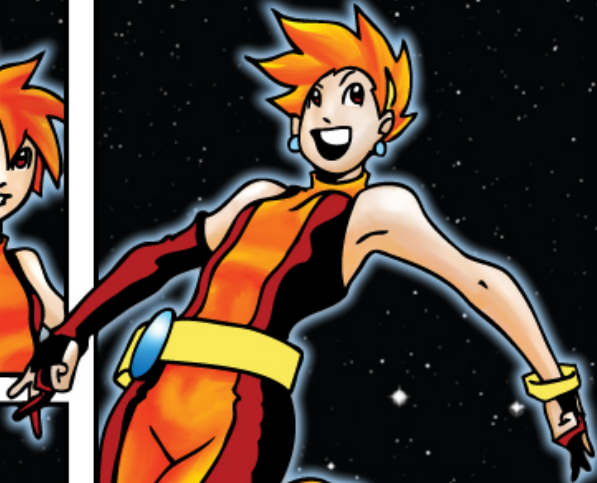
SPACE DOGS ONLY EAT CERTAIN TYPES OF TASTY ENERGY BISCUITS, THE ONES HERE THAT LOOK REALLY PURPLE. BUT THOSE PURPLE ONES ARE TYPES YOU ALMOST NEVER SEE DOWN ON THE SURFACE OF THE EARTH. SO WHY IS THAT?



THE REASON IS THAT THE SPACE DOGS UP HERE EAT ALMOST ALL OF THOSE TYPES BEFORE THEY CAN REACH THE SURFACE.



FOR NOW ON WE'RE JUST GOING TO FOCUS ON THE TYPE OF PURPLE ENERGY BISCUITS THE DOGS LIKE TO EAT. (THIS SAVES OUR ARTIST FROM DOING ALL THE WORK TO FILL UP THE BACKGROUND WITH ALL THE OTHER TYPES OF BISCUITS TOO!)

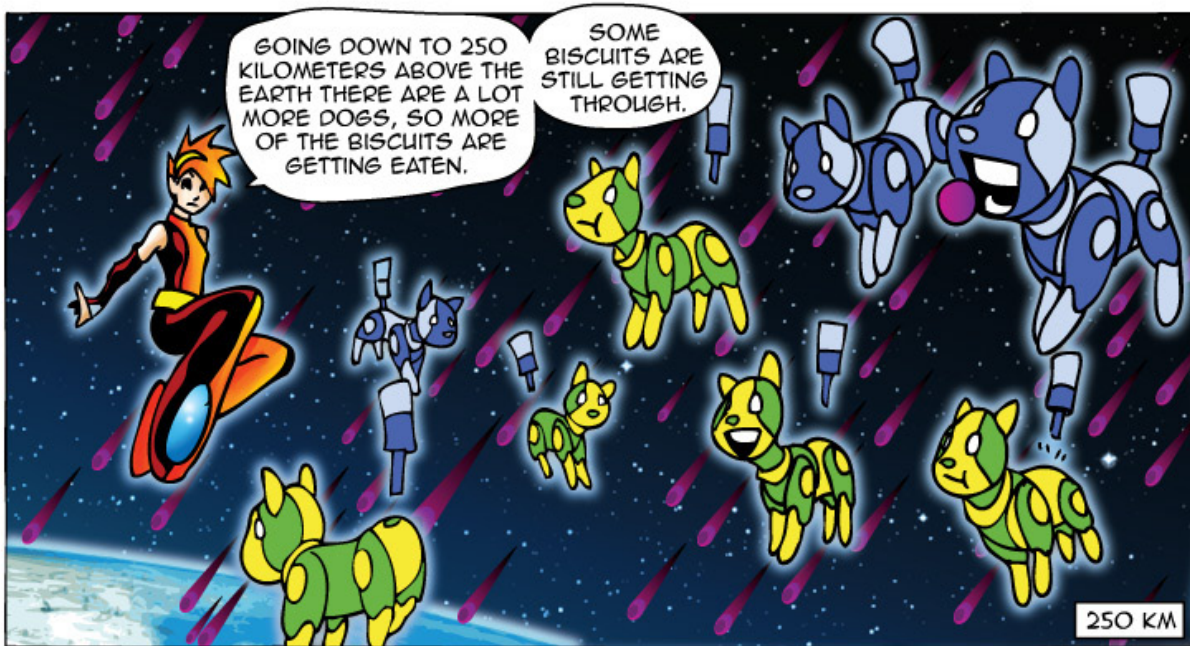
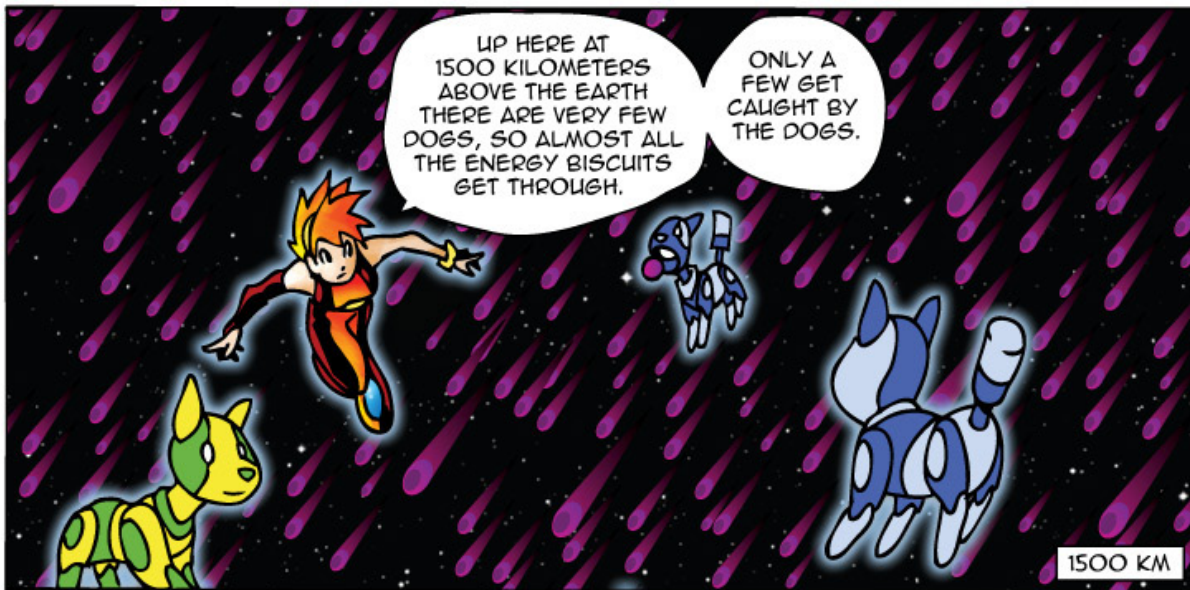


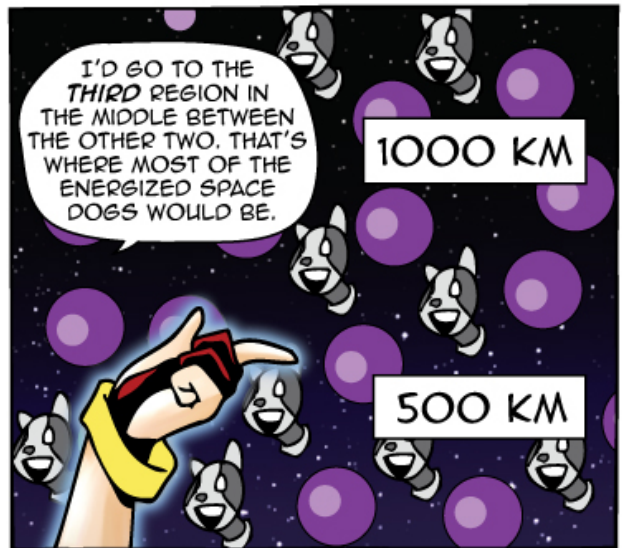
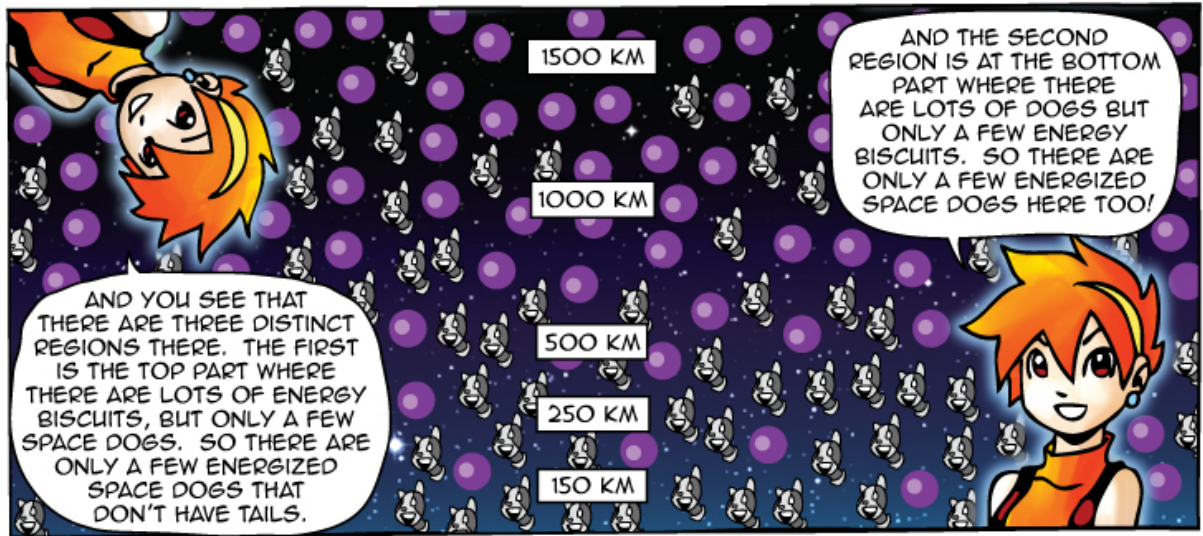
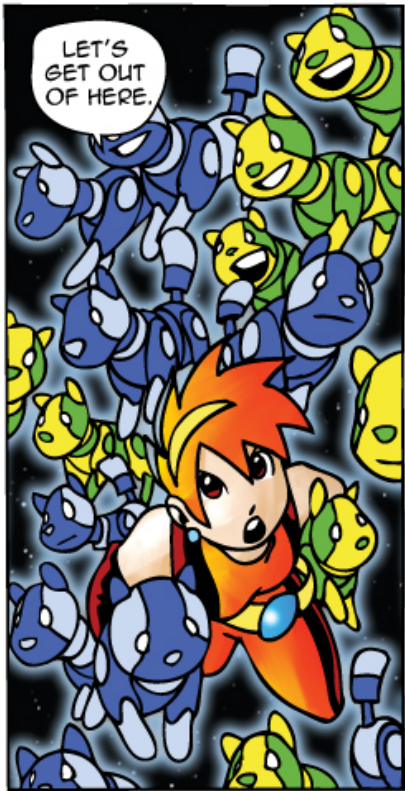
FOLLOW ME AND I'LL SHOW YOU HOW THIS HAPPENS!



WHEW!







WHY THERE? BECAUSE THERE WE HAVE THE RIGHT BALANCE BETWEEN THE NUMBER OF BISCUITS AND THE NUMBER OF SPACE DOGS. WE HAVE JUST ENOUGH DOGS TO EAT MOST OF THE BISCUITS THERE.



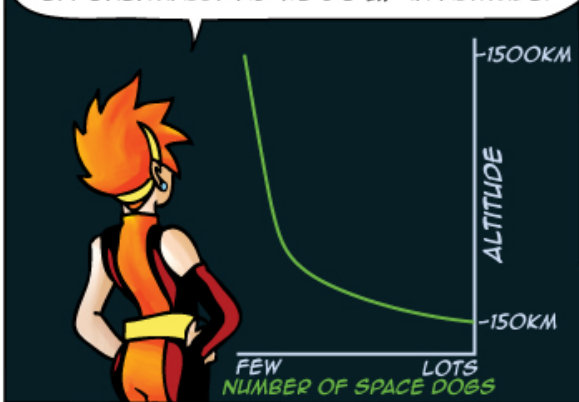
SEE, AT THE TOP THERE ARE NOT ENOUGH SPACE DOGS AND AT THE BOTTOM THERE ARE NOT ENOUGH ENERGY BISCUITS. BUT SOMEWHERE IN THE MIDDLE IS A PLACE WHERE THERE ARE STILL ENOUGH ENERGY BISCUITS AND ENOUGH SPACE DOGS THAT WE GET LOTS OF ENERGIZED SPACE DOGS.



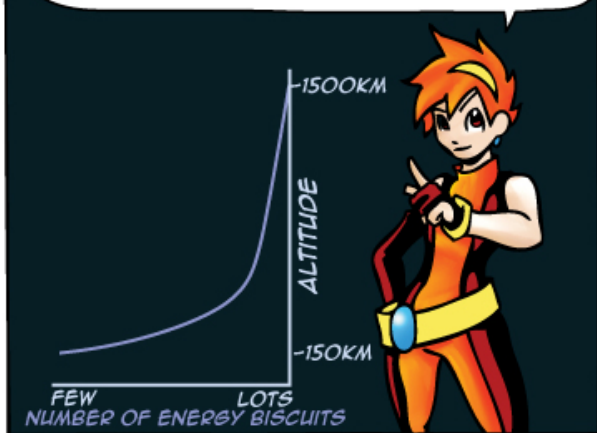
SO HOW WOULD I KNOW WHERE IN THE MIDDLE REGION TO LOOK? WELL, I COULD MAKE A GRAPH.



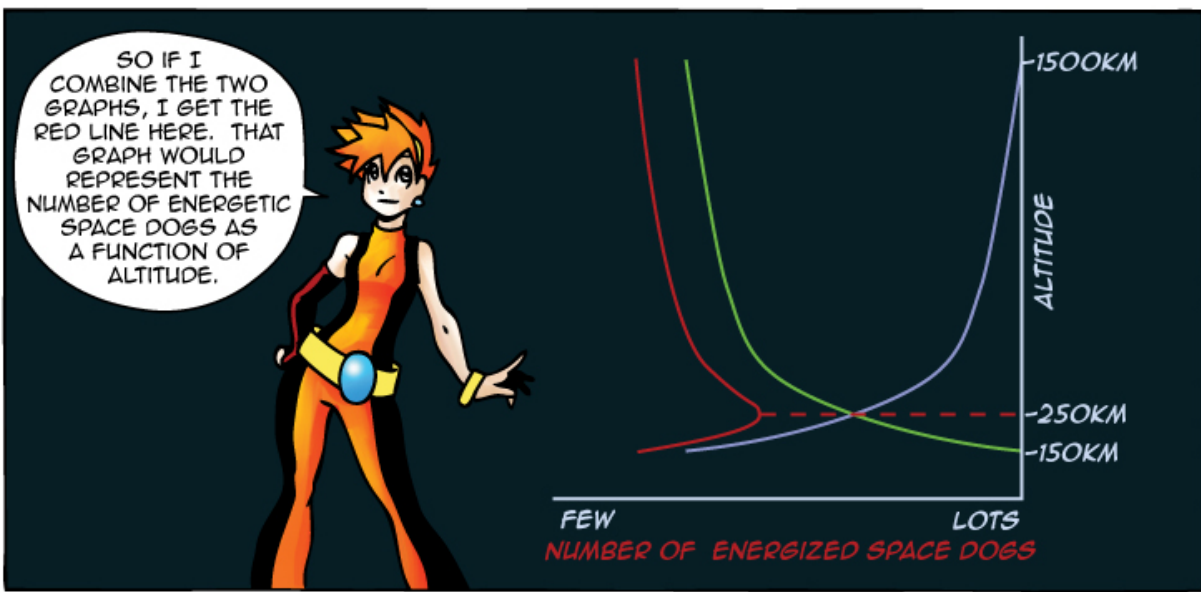
IF I PLOT THE NUMBER OF DOGS AT DIFFERENT ALTITUDES, IT LOOKS LIKE THIS! GOING UP FROM THE GROUND THE NUMBER OF DOGS DECREASES VERY FAST AT FIRST, THEN SLOWS DOWN AS WE GO UP TO HIGHER ALTITUDES AWAY FROM THE EARTH. THIS TYPE OF CURVE IS CALLED AN "EXPONENTIAL CURVE" SO WE SAY THE NUMBER OF SPACE DOGS DECREASES EXPONENTIALLY AS WE GO UP IN ALTITUDE.



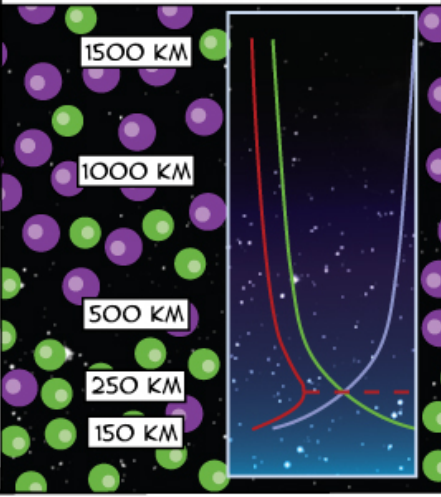
BUT IF I PLOT THE NUMBER OF PURPLE ENERGY BISCUITS AT DIFFERENT ALTITUDES, IT LOOKS LIKE THIS! THIS IS ANOTHER TYPE OF EXPONENTIAL CURVE WHERE THE NUMBER OF BISCUITS DOESN'T CHANGE VERY MUCH AT HIGH ALTITUDES, BUT THEN DECREASES VERY QUICKLY AS WE GO DOWN IN ALTITUDE GETTING CLOSER TO THE EARTH.



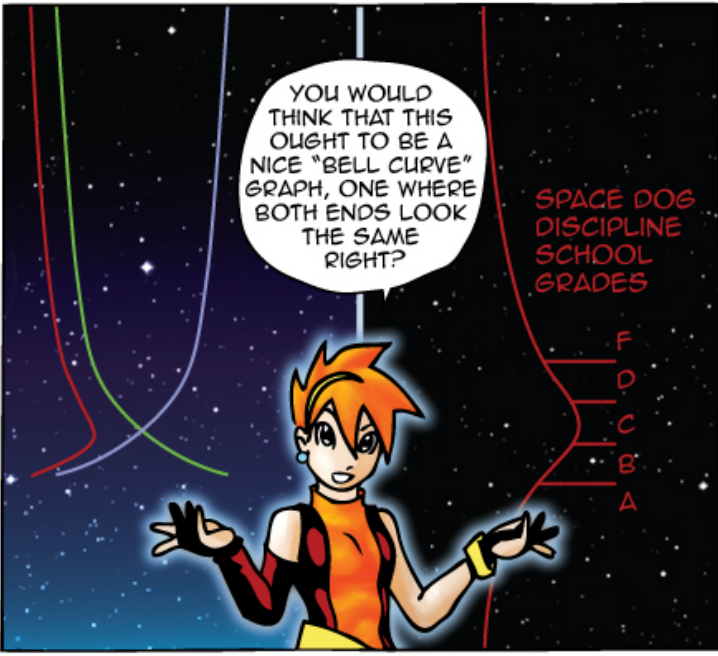
SO IF I COMBINE THE TWO GRAPHS, I GET THE RED LINE HERE. THAT GRAPH WOULD REPRESENT THE NUMBER OF ENERGETIC SPACE DOGS AS A FUNCTION OF ALTITUDE.



SEE? DEPENDING ON THE NUMBER OF SPACE DOGS AND THE NUMBER OF ENERGY BISCUITS, THERE IS ALWAYS GOING TO BE **SOME** ALTITUDE WHERE WE GET THE **MOST** ENERGETIC SPACE DOGS IN ONE PLACE.



YOU WOULD THINK THAT THIS OUGHT TO BE A NICE "BELL CURVE" GRAPH, ONE WHERE BOTH ENDS LOOK THE SAME RIGHT?



BUT COMBINING THESE TWO CURVES GIVES US ONE WHERE THE TWO ENDS LOOK DIFFERENT. THE BOTTOM PART CLOSEST TO THE GROUND (THE BOTTOMSIDE) DECREASES TO ZERO VERY QUICKLY, WHILE THE TOP PART GOING UP TO SPACE (THE TOPSIDE) TAPERS OFF TO ZERO VERY SLOWLY. IN OTHER WORDS, THE NUMBER OF ENERGETIC SPACE DOGS DROPS OFF RATHER ABRUPTLY AS YOU GET CLOSER TO THE EARTH, BUT CHANGES MUCH MORE SLOWLY AS YOU GO UP TO REALLY HIGH ALTITUDES.



BY NOW YOU'RE PROBABLY WONDERING, SO WHAT DOES ALL THIS HAVE TO DO WITH THE "ELECTRIC ATMOSPHERE"? I MEAN, THAT **IS** THE **NAME** OF THIS COMIC BOOK AND ALL...



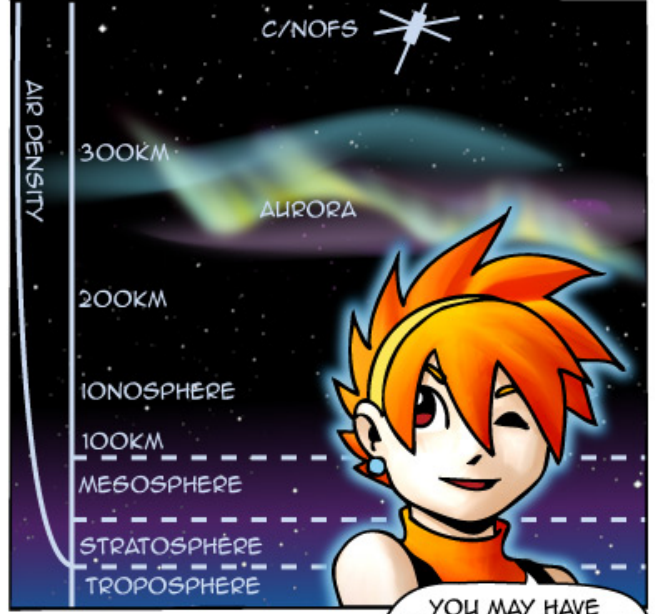
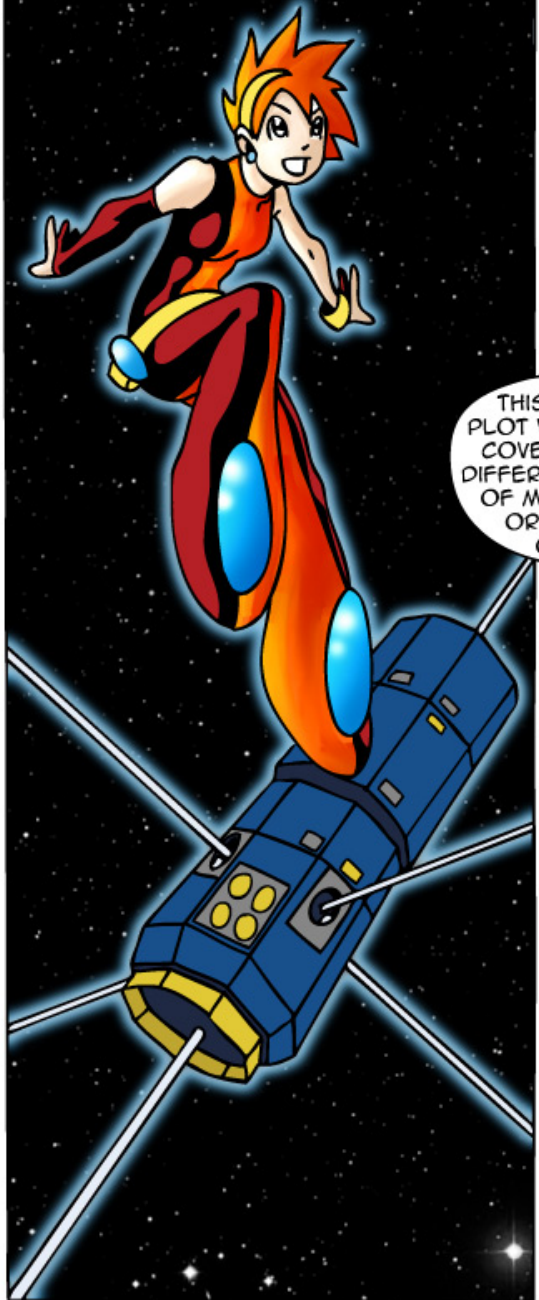
REMEMBER IN THE LAST BOOK* I TOLD YOU ABOUT THE REAL CINDI, THE INSTRUMENTS FLYING ON THE C/NOFS RESEARCH SATELLITE?



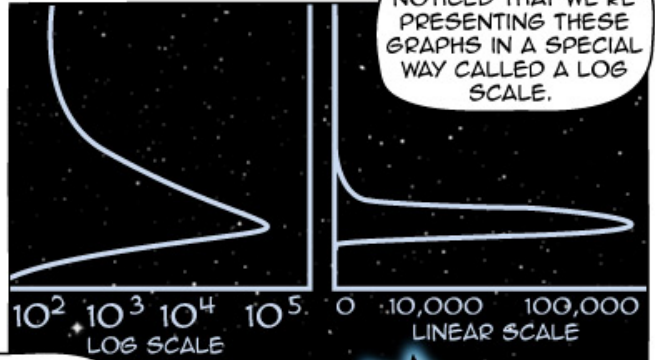
*THE COMIC BOOK I TOLD YOU ABOUT BACK ON PAGE 2. REALLY, YOU OUGHT TO GO READ IT. IT'S VERY GOOD!

CINDI IS THE SET OF THE INSTRUMENTS ONBOARD THAT MEASURE THE NEUTRAL AND CHARGED PARTICLES IN THE REGION OF THE EARTH'S ATMOSPHERE UP HERE IN SPACE CALLED THE IONOSPHERE.

REMEMBER THAT THE ATMOSPHERE NEVER REALLY "STOPS," IT JUST GETS LESS AND LESS DENSE AS YOU GO UP IN ALTITUDE. THERE ARE STILL AIR MOLECULES AND ATOMS UP WHERE SATELLITES ARE IN ORBIT, THERE ARE JUST A BILLION-BILLIONTH FEWER OF THEM HERE THAN DOWN WHERE YOU ARE.



YOU MAY HAVE NOTICED THAT WE'RE PRESENTING THESE GRAPHS IN A SPECIAL WAY CALLED A LOG SCALE.



THIS LETS US PLOT VALUES THAT COVER SEVERAL DIFFERENT ORDERS OF MAGNITUDES OR POWERS OF TEN.

MOST OF THE GRAPHS YOU NORMALLY SEE PRESENT THE VALUES LINEARLY, BUT IF WE GRAPHED THIS LINEARLY (LIKE ON THE RIGHT PLOT) WE WOULD ONLY SEE THE VERY HIGHEST VALUES AND NOTHING ELSE.

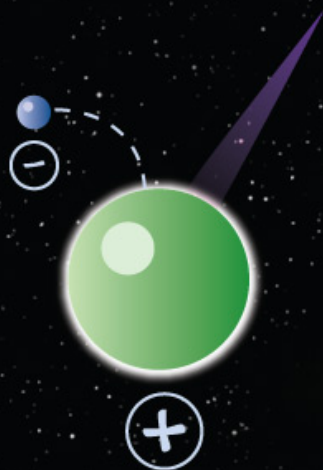


UP IN SPACE WE GET LOTS OF ULTRAVIOLET LIGHT FROM THE SUN THAT YOU NEVER SEE ON THE GROUND. WHY?

BECAUSE THE ULTRAVIOLET LIGHT THAT WE CALL THE "FAR ULTRAVIOLET LIGHT" IS SO POWERFUL THAT WHEN A SINGLE PHOTON OF IT HITS AN ATOM (OR MOLECULE) OF GAS UP HERE...



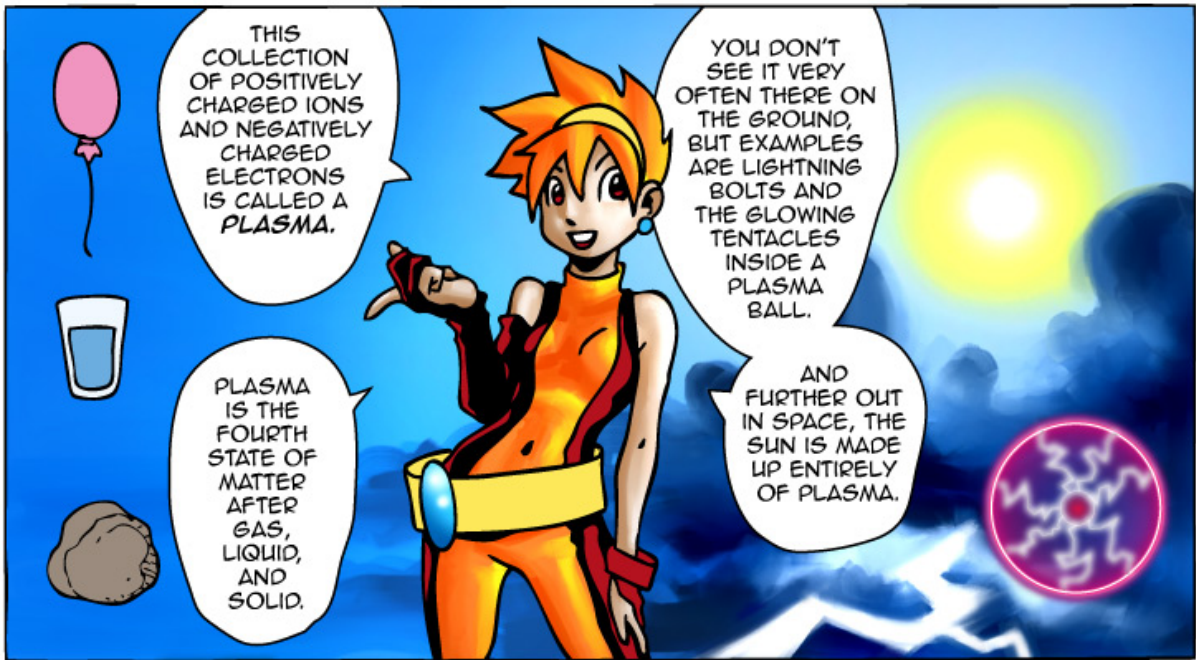
...THE PHOTON IS ABSORBED BY ONE OF THE ATOM'S (OR MOLECULE'S) ELECTRONS CAUSING THE ELECTRON TO GET KNOCKED OFF. THE FREE ELECTRON HAS A NEGATIVE CHARGE AND THE LEFTOVER ATOM OR MOLECULE NOW HAS A NET POSITIVE CHARGE, AND IT'S CALLED AN "ION."



SO UP HERE IN SPACE AND THE UPPER ATMOSPHERE, WE HAVE THIS INVISIBLE REGION WHERE THERE ARE A LOT OF FREE ELECTRONS AND IONS FLOATING AROUND. I'M IN THE MIDDLE OF AN ELECTRIFIED GAS, IN OTHER WORDS, AN **ELECTRIC ATMOSPHERE!** AND THIS PART OF SPACE IS CALLED THE **IONOSPHERE.**



YEAH, IT'S EXACTLY LIKE THE SPACE DOGS EATING THE PURPLE ENERGY BISCUITS AND HAVING THEIR TAILS FLY OFF.

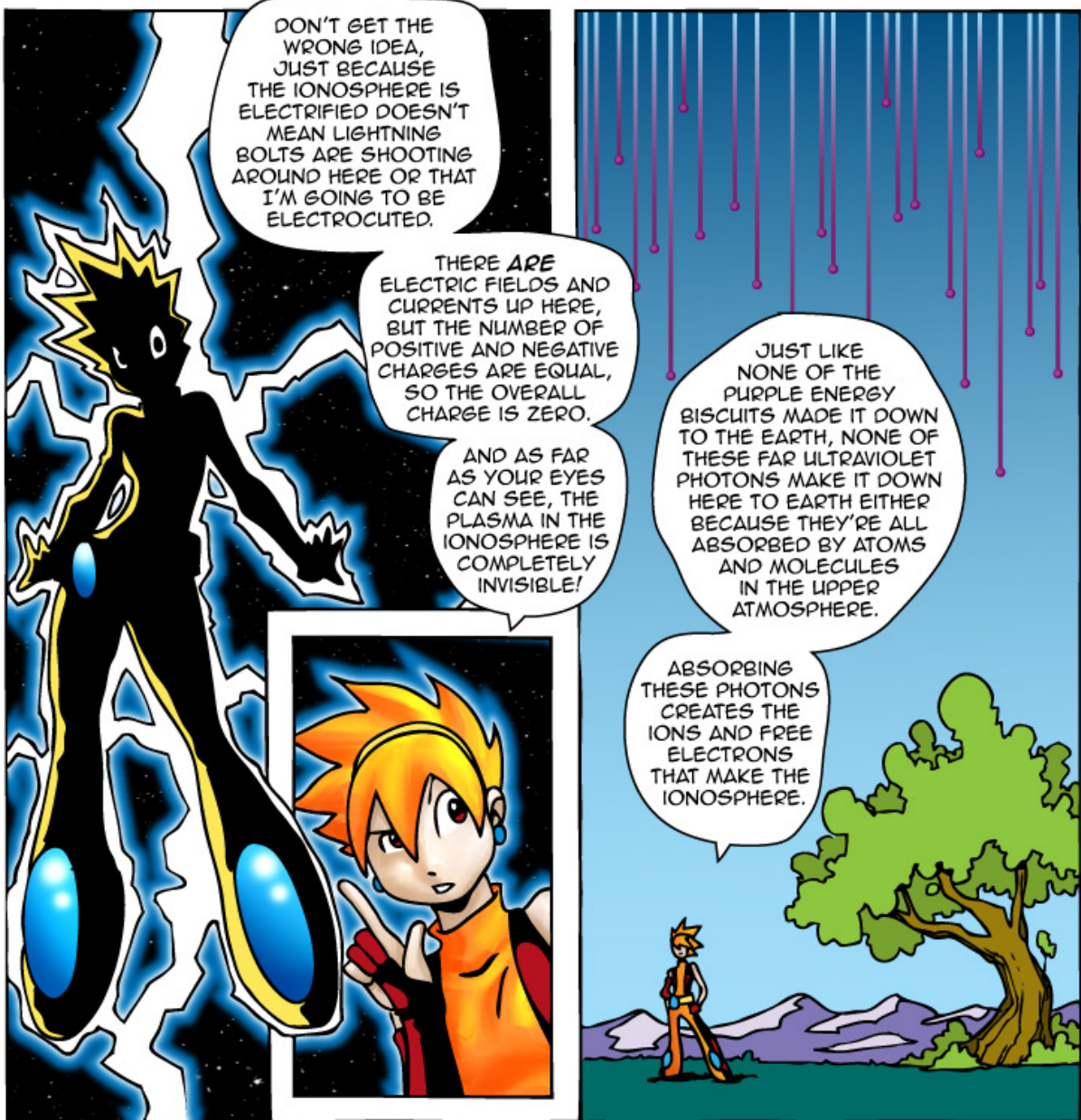


THIS COLLECTION OF POSITIVELY CHARGED IONS AND NEGATIVELY CHARGED ELECTRONS IS CALLED A PLASMA.

YOU DON'T SEE IT VERY OFTEN THERE ON THE GROUND, BUT EXAMPLES ARE LIGHTNING BOLTS AND THE GLOWING TENTACLES INSIDE A PLASMA BALL.

PLASMA IS THE FOURTH STATE OF MATTER AFTER GAS, LIQUID, AND SOLID.

AND FURTHER OUT IN SPACE, THE SUN IS MADE UP ENTIRELY OF PLASMA.



DON'T GET THE WRONG IDEA, JUST BECAUSE THE IONOSPHERE IS ELECTRIFIED DOESN'T MEAN LIGHTNING BOLTS ARE SHOOTING AROUND HERE OR THAT I'M GOING TO BE ELECTROCUTED.

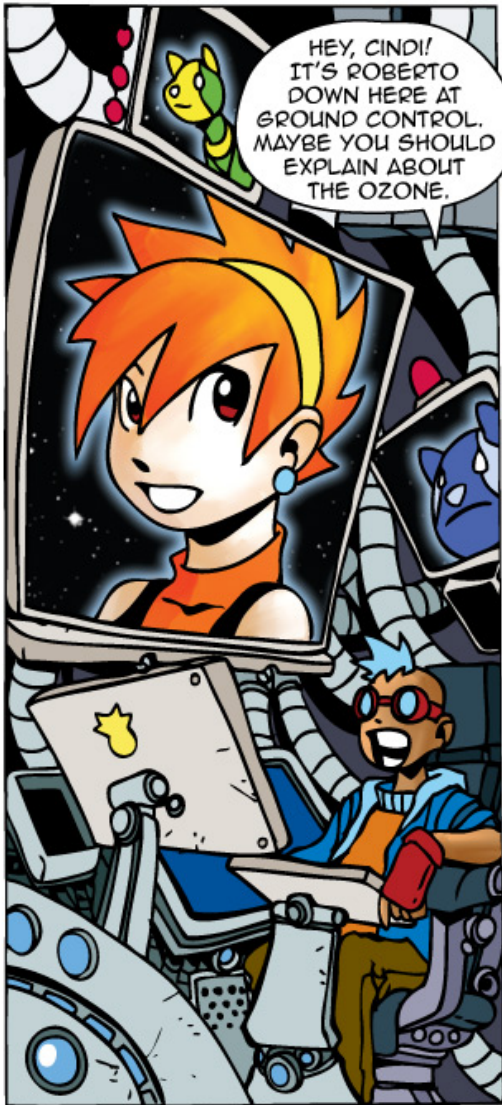
THERE ARE ELECTRIC FIELDS AND CURRENTS UP HERE, BUT THE NUMBER OF POSITIVE AND NEGATIVE CHARGES ARE EQUAL, SO THE OVERALL CHARGE IS ZERO.

AND AS FAR AS YOUR EYES CAN SEE, THE PLASMA IN THE IONOSPHERE IS COMPLETELY INVISIBLE!

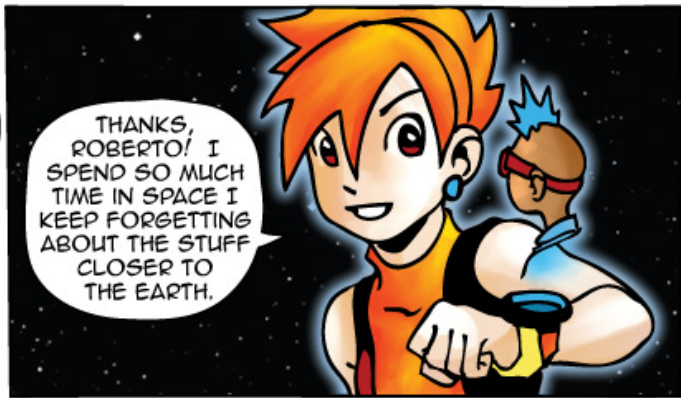
JUST LIKE NONE OF THE PURPLE ENERGY BISCUITS MADE IT DOWN TO THE EARTH, NONE OF THESE FAR ULTRAVIOLET PHOTONS MAKE IT DOWN HERE TO EARTH EITHER BECAUSE THEY'RE ALL ABSORBED BY ATOMS AND MOLECULES IN THE UPPER ATMOSPHERE.

ABSORBING THESE PHOTONS CREATES THE IONS AND FREE ELECTRONS THAT MAKE THE IONOSPHERE.





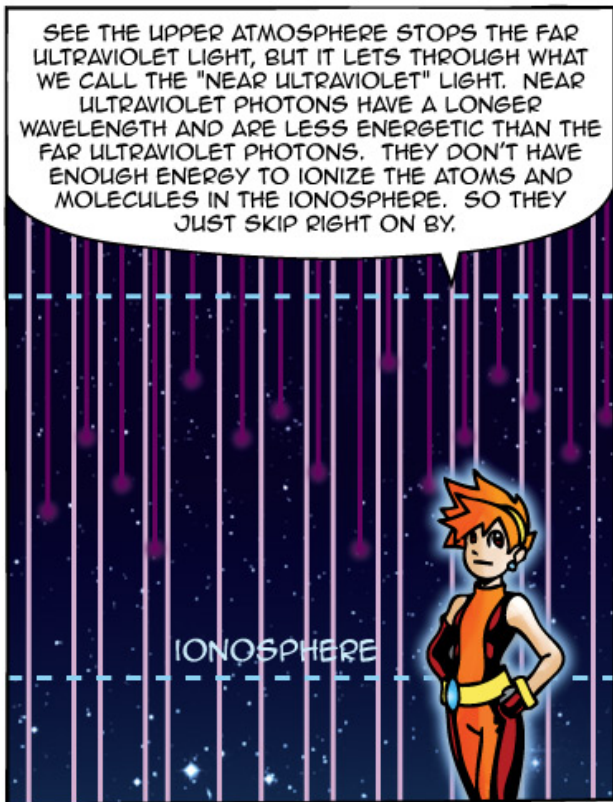
HEY, CINDI!
IT'S ROBERTO
DOWN HERE AT
GROUND CONTROL.
MAYBE YOU SHOULD
EXPLAIN ABOUT
THE OZONE.



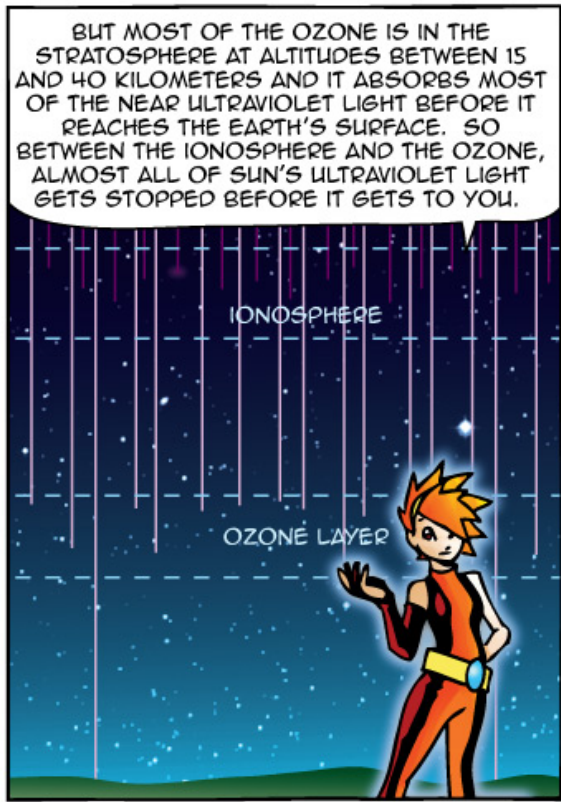
THANKS,
ROBERTO! I
SPEND SO MUCH
TIME IN SPACE I
KEEP FORGETTING
ABOUT THE STUFF
CLOSER TO
THE EARTH.



NOW SOME OF
YOU MAY BE THINKING
"WAIT! I THOUGHT THE
OZONE IN THE ATMOSPHERE
WAS PROTECTING US FROM
THE ULTRAVIOLET LIGHT
OF THE SUN?" WELL,
ACTUALLY IT'S BOTH.



SEE THE UPPER ATMOSPHERE STOPS THE FAR
ULTRAVIOLET LIGHT, BUT IT LETS THROUGH WHAT
WE CALL THE "NEAR ULTRAVIOLET" LIGHT. NEAR
ULTRAVIOLET PHOTONS HAVE A LONGER
WAVELENGTH AND ARE LESS ENERGETIC THAN THE
FAR ULTRAVIOLET PHOTONS. THEY DON'T HAVE
ENOUGH ENERGY TO IONIZE THE ATOMS AND
MOLECULES IN THE IONOSPHERE. SO THEY
JUST SKIP RIGHT ON BY.

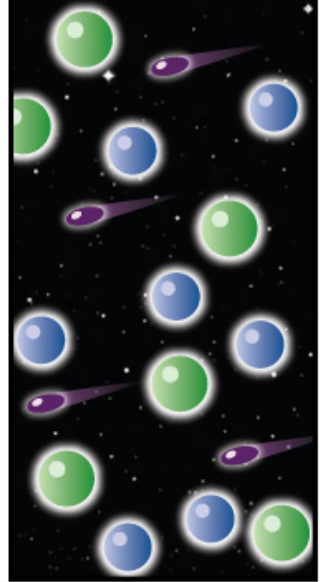


BUT MOST OF THE OZONE IS IN THE
STRATOSPHERE AT ALTITUDES BETWEEN 15
AND 40 KILOMETERS AND IT ABSORBS MOST
OF THE NEAR ULTRAVIOLET LIGHT BEFORE IT
REACHES THE EARTH'S SURFACE. SO
BETWEEN THE IONOSPHERE AND THE OZONE,
ALMOST ALL OF SUN'S ULTRAVIOLET LIGHT
GETS STOPPED BEFORE IT GETS TO YOU.

NOW WHAT'S LEFT OVER IS STILL ENOUGH TO GIVE YOU A SUNBURN IF YOU'RE OUTSIDE WITHOUT PROTECTION FOR TOO LONG. BUT JUST THINK ABOUT HOW FAST YOU WOULD GET A REALLY BAD SUNBURN (AND WORSE!) IF WE DIDN'T HAVE AN IONOSPHERE AND OZONE LAYER!



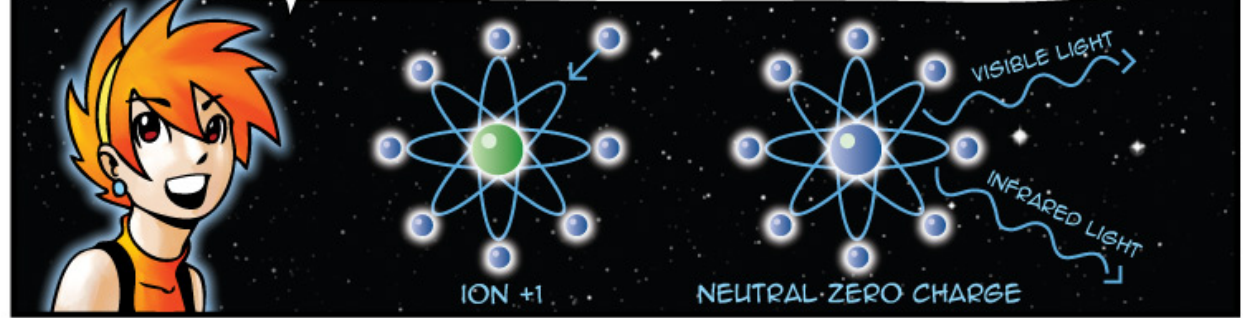
YOU MAY BE WONDERING IF THE UV PHOTONS IONIZE ALL THE ATOMS AND NEUTRALS IN THE IONOSPHERE? IS THE WHOLE ATMOSPHERE UP HERE ELECTRIFIED?



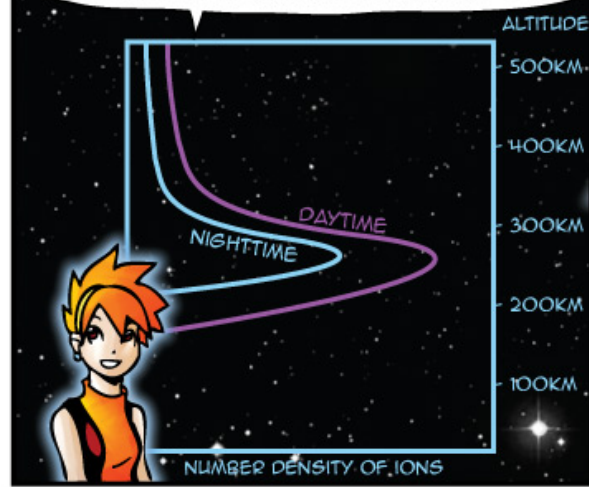
NO, FOR EACH ION IN THE IONOSPHERE, THERE ARE 100 TO 100,000 NEUTRAL ATOMS AND MOLECULES AROUND. AND WHILE THE SUNLIGHT IS CREATING MORE IONS, SOME OF THEM ARE TURNING BACK INTO NEUTRAL PARTICLES.



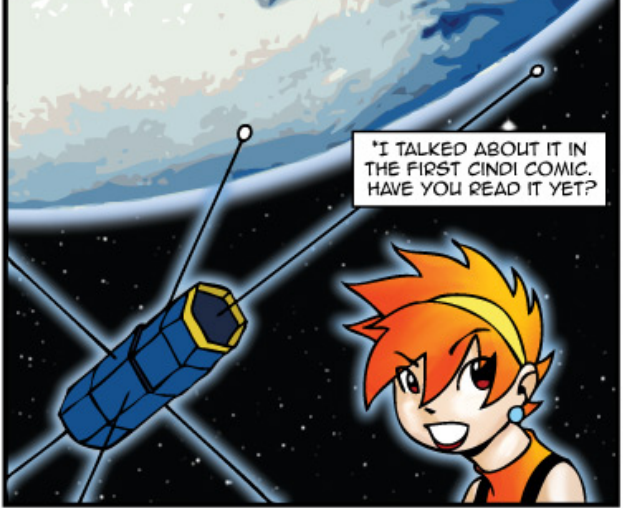
WHEN AN ION COLLIDES WITH A FREE ELECTRON THEY SOMETIME RECOMBINE SO THE ION BECOMES A NEUTRAL PARTICLE AGAIN. WHEN THIS HAPPENS THE ATOM OR MOLECULE RELEASES BACK THE ENERGY IT GAINED WHEN IT WAS IONIZED. HOWEVER INSTEAD OF RELEASING AN ULTRAVIOLET PHOTON, IT USUALLY RELEASES TWO OR THREE PHOTONS OF VISIBLE LIGHT OR INFRARED LIGHT.



SO ON THE DAYSIDE, THE IONOSPHERE BUILDS UP TO A MORE OR LESS STEADY STATE OF ION DENSITIES. BUT ONCE THE SUN SETS THEN NO NEW IONS ARE CREATED AND THE ONES ALREADY THERE ARE SLOWLY TURNING BACK INTO NEUTRALS. SO DURING THE NIGHT, THE ION DENSITY IN THE IONOSPHERE DROPS BY A FACTOR OF 10 TO 100. THEN THE SUN RISES AND THE CYCLE STARTS ALL OVER AGAIN.



THAT'S WHY WE LAUNCHED THE CINDI INSTRUMENTS ON THE C/N/OFS SATELLITE.* THOSE INSTRUMENTS TELL US WHAT THE IONOSPHERE IS DOING BY MEASURING THE IONS AND THE NEUTRAL PARTICLES AS THE SATELLITE FLIES THROUGH THEM IN ITS ORBIT BETWEEN 400 AND 840 KM





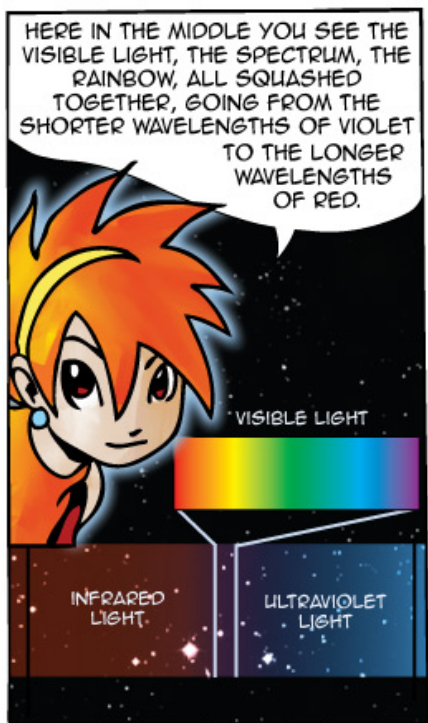
SO WHY DO WE CARE WHAT THE IONOSPHERE IS DOING? WHY DO WE PUT SATELLITES UP HERE TO STUDY THE IONS AND NEUTRAL PARTICLES?



PART OF IT IS PURE CURIOSITY. WE WANT TO UNDERSTAND HOW THE WORLD AROUND US WORKS. BUT PART OF IT IS THAT THE IONOSPHERE AFFECTS LIGHT.



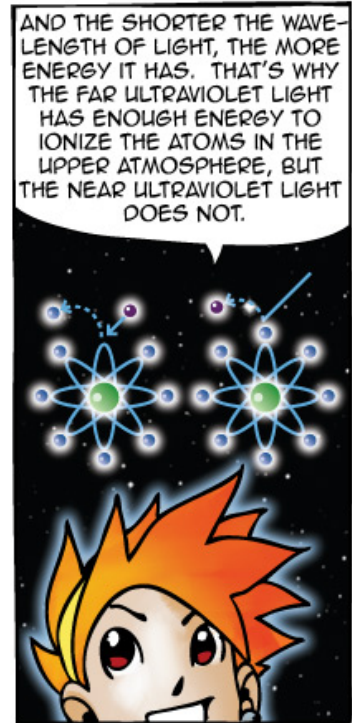
LET ME EXPLAIN ABOUT LIGHT. WHEN YOU SAY "LIGHT" MOST PEOPLE ONLY THINK ABOUT THE LIGHT WE SEE WITH OUR EYES. WE CALL THAT "VISIBLE LIGHT," BUT THAT'S JUST PART OF LIGHT, OR WHAT SCIENTISTS CALL THE "ELECTROMAGNETIC SPECTRUM." HERE YOU CAN SEE THE WHOLE RANGE OF ALL LIGHT SORTED BY WAVELENGTHS.



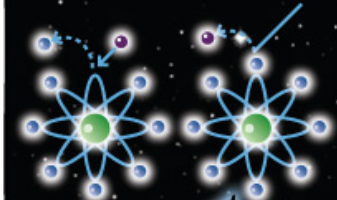
HERE IN THE MIDDLE YOU SEE THE VISIBLE LIGHT, THE SPECTRUM, THE RAINBOW, ALL SQUASHED TOGETHER, GOING FROM THE SHORTER WAVELENGTHS OF VIOLET TO THE LONGER WAVELENGTHS OF RED.



OVER HERE WE HAVE LIGHT WITH WAVELENGTHS EVEN SHORTER THAN VIOLET. WE CAN'T SEE THIS LIGHT WITH OUR EYES, BUT THAT'S WHAT WE CALL ULTRAVIOLET LIGHT. THE NEAR ULTRAVIOLET LIGHT HAS WAVELENGTHS SHORTER THAN VISIBLE VIOLET LIGHT, AND THE FAR ULTRAVIOLET LIGHT HAS EVEN SHORTER WAVELENGTHS!



AND THE SHORTER THE WAVELENGTH OF LIGHT, THE MORE ENERGY IT HAS. THAT'S WHY THE FAR ULTRAVIOLET LIGHT HAS ENOUGH ENERGY TO IONIZE THE ATOMS IN THE UPPER ATMOSPHERE, BUT THE NEAR ULTRAVIOLET LIGHT DOES NOT.



IF YOU GO TO EVEN **SHORTER** WAVELENGTHS YOU GET TO X-RAYS AND GAMMA RAYS WHICH HAVE EVEN **MORE** ENERGY. THE SUN EMITS A LITTLE OF THIS LIGHT AS WELL, BUT IT ALSO GETS STOPPED IN THE UPPER ATMOSPHERE BY BEING ABSORBED BY ATOMS AND IONIZING THEM.



YOUZZA!!

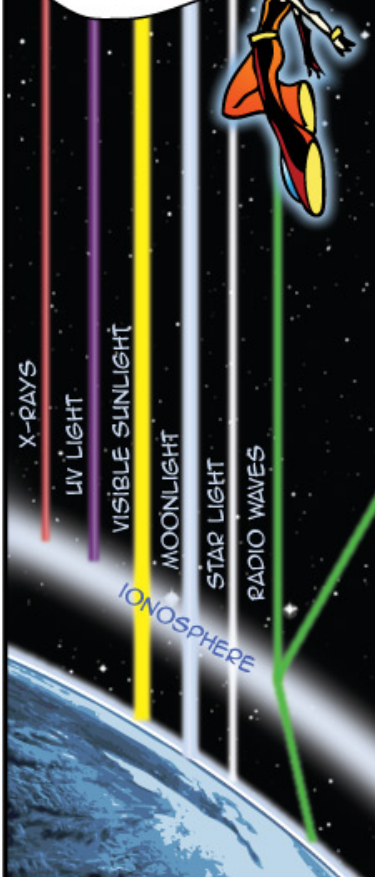
X-RAYS GAMMA RAYS

ON THE OTHER SIDE OF THE VISIBLE LIGHT SPECTRUM WE HAVE THE LIGHT WITH WAVELENGTHS **LONGER** THAN RED (AND LESS ENERGETIC), WHICH WE CALL "INFRARED LIGHT." AND BEYOND THAT WE HAVE EVEN LONGER WAVELENGTH LIGHT THAT WE CALL "MICROWAVES" AND "RADIO WAVES." VISIBLE LIGHT HAS A WAVELENGTH OF AROUND ONE TENTH-KILOMETER WHILE RADIO WAVES HAVE WAVELENGTHS OF TENS OF CENTIMETERS UP TO SEVERAL KILOMETERS.



RADIO WAVES MICROWAVES INFRARED LIGHT

SO THE IONOSPHERE AFFECTS LIGHT, BUT ONLY **SOME** OF THE LIGHT. VISIBLE LIGHT GOES RIGHT THROUGH THE IONOSPHERE (THAT'S WHY YOU CAN SEE THE SUN, THE MOON, AND THE STARS). AND WE ALREADY KNOW THAT ALL THE X-RAYS AND MOST OF THE ULTRAVIOLET LIGHT ARE ABSORBED. BUT RADIO WAVE LIGHT IS BENT AND SOMETIMES EVEN REFLECTED BACK BY THE IONOSPHERE.



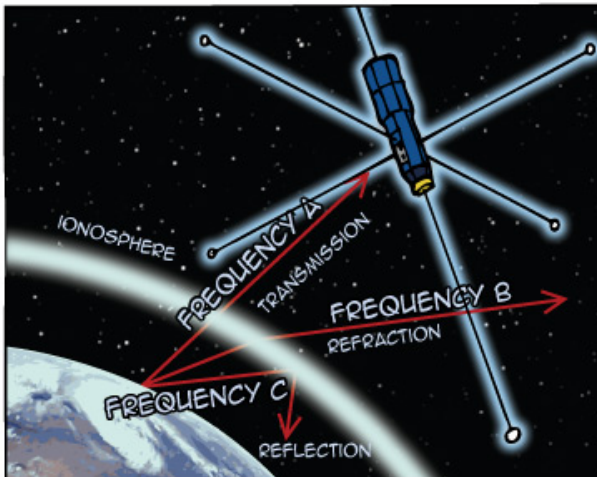
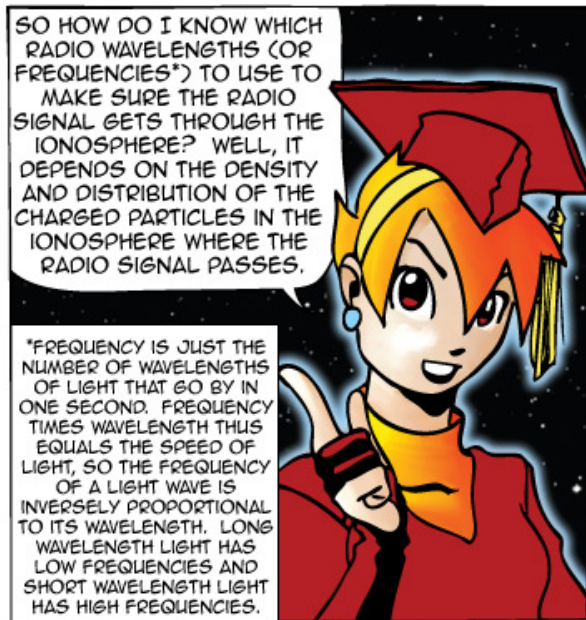
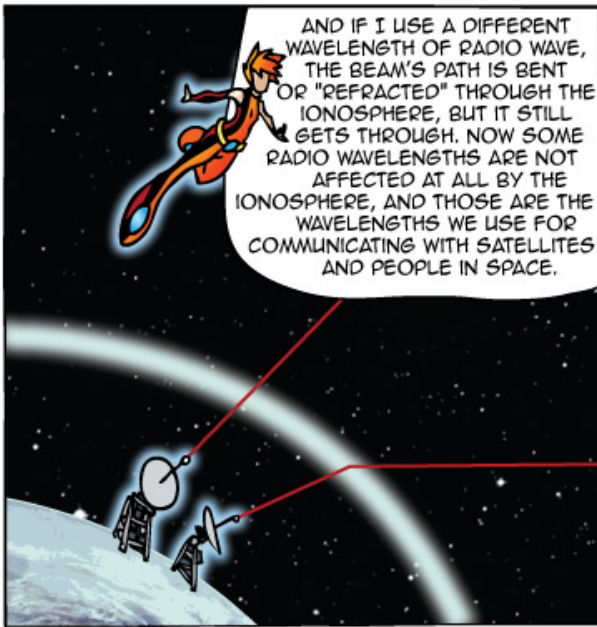
IF I SHINE A LASER BEAM FROM THE EARTH TO SPACE, THE VISIBLE LIGHT BEAM GOES OFF IN A STRAIGHT LINE THROUGH THE IONOSPHERE. BUT IF I BEAM A RADIO SIGNAL WITH THE RIGHT WAVELENGTH OUT TOWARDS SPACE, THE IONOSPHERE WILL REFLECT IT JUST LIKE A MIRROR REFLECTS VISIBLE LIGHT.



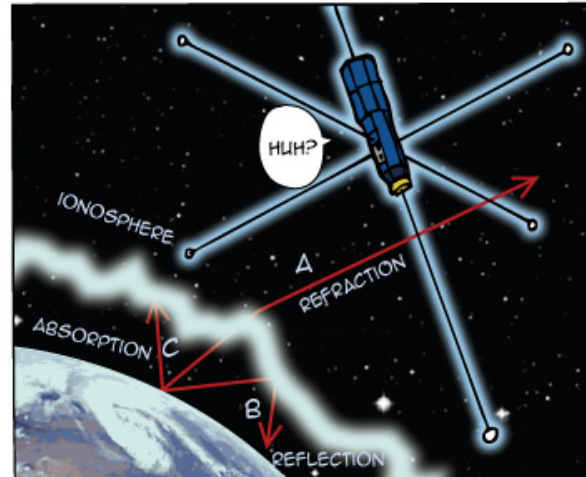
THIS IS HOW HAM RADIO OPERATORS AND SHORTWAVE RADIO CAN SEND RADIO SIGNALS FROM ONE SIDE OF THE WORLD TO THE OTHER. THEIR RADIO SIGNALS ZIG-ZAG BACK AND FORTH SEVERAL TIMES BETWEEN THE IONOSPHERE AND THE GROUND WHILE GOING AROUND THE WORLD.

THIS IS THE BBC WORLD SERVICE IN LONDON, BROADCASTING AROUND THE WORLD COURTESY OF THE EARTH'S IONOSPHERE AND THE LAWS OF PHYSICS.

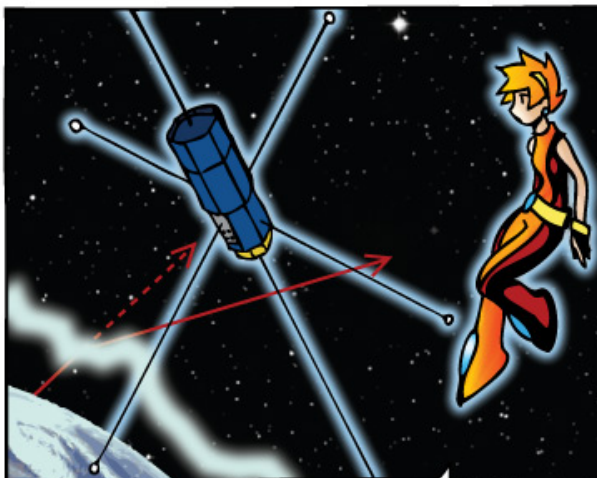




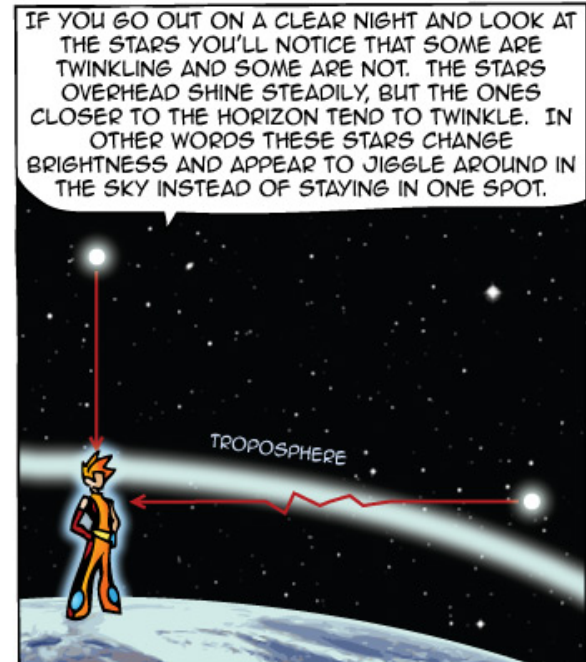
IF THE IONOSPHERE IS QUIET AND THE DISTRIBUTION OF THE CHARGED PARTICLES IS SMOOTH (AS IT IS MOST OF THE TIME), THEN WE CAN USE REGULAR FREQUENCIES TO DO WHATEVER WE WANT TO DO.



BUT SOMETIMES THE IONOSPHERE BECOMES DISTURBED AND IF IT'S BAD ENOUGH THIS MESSES UP OUR RADIO COMMUNICATIONS.

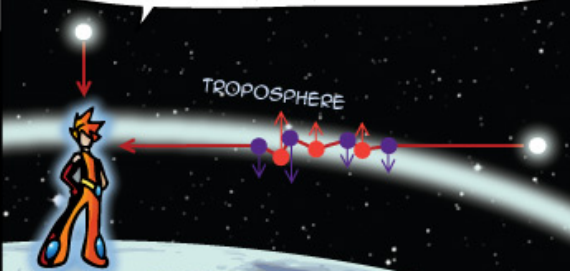


THIS BIGGEST PROBLEM WITH SATELLITE COMMUNICATION IS WHERE THE SIGNAL GETS REFRACTED OR ABSORBED BY THE IONOSPHERE WHEN WE DIDN'T EXPECT IT AND THAT MESSES UP THE SIGNAL. THIS IS CALLED "SCINTILLATION." ACTUALLY YOU'VE SEEN SCINTILLATION IN THE VISIBLE LIGHT BEFORE. IT'S CALLED "TWINKLING."



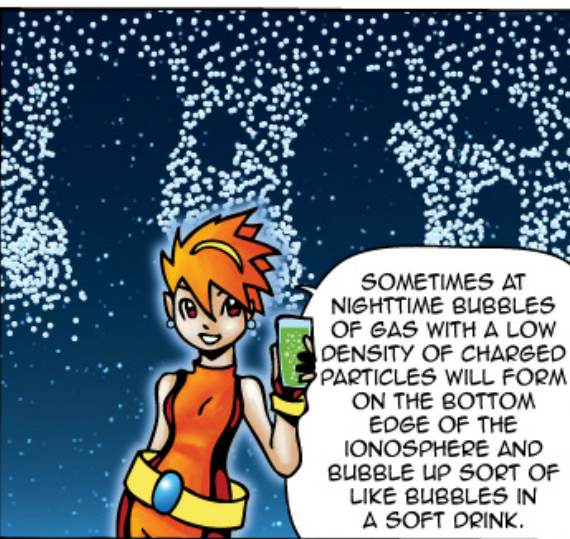
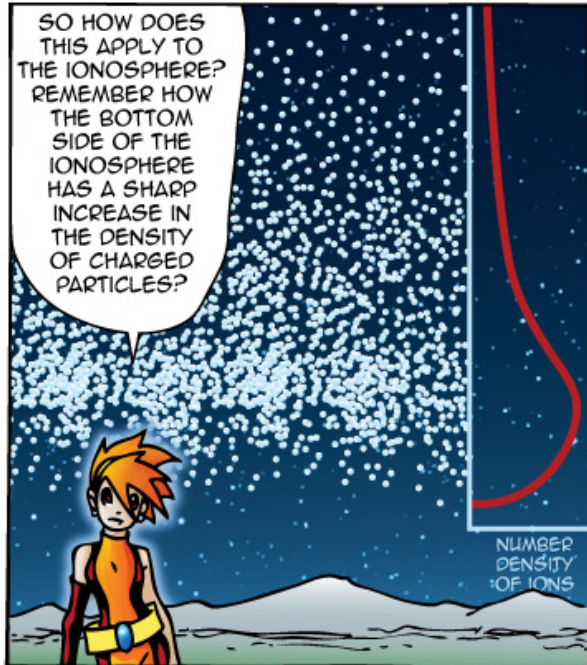
IF YOU GO OUT ON A CLEAR NIGHT AND LOOK AT THE STARS YOU'LL NOTICE THAT SOME ARE TWINKLING AND SOME ARE NOT. THE STARS OVERHEAD SHINE STEADILY, BUT THE ONES CLOSER TO THE HORIZON TEND TO TWINKLE. IN OTHER WORDS THESE STARS CHANGE BRIGHTNESS AND APPEAR TO JIGGLE AROUND IN THE SKY INSTEAD OF STAYING IN ONE SPOT.

THE REASON FOR THE STAR TWINKLING IS THE REFRACTION OF THE STARLIGHT BY THE AIR IN THE TROPOSPHERE*. BLOBS OF HOT AIR RISE UP FROM THE GROUND AND BLOBS OF COOL AIR SINK DOWN FROM HIGHER ALTITUDES. VISIBLE LIGHT IS REFRACTED BY PASSING THROUGH THESE BLOBS OF HOTTER AND COOLER AIR. SO WHEN YOU LOOK TOWARDS THE HORIZON, YOU'RE LOOKING THROUGH LOTS OF THESE BLOBS, SO THAT'S WHAT MAKES THE STARLIGHT TWINKLE OR SCINTILLATE.

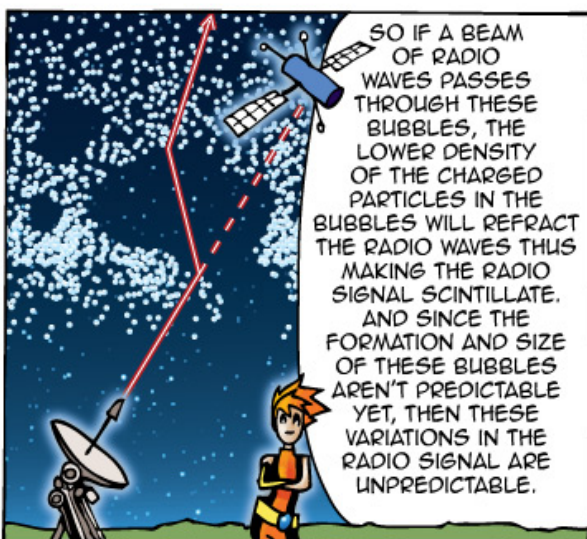


THE TROPOSPHERE IS THE BOTTOM LAYER OF THE ATMOSPHERE FROM THE GROUND UP TO BETWEEN 15 TO 20 KILOMETERS WHERE ALL THE WEATHER OCCURS.

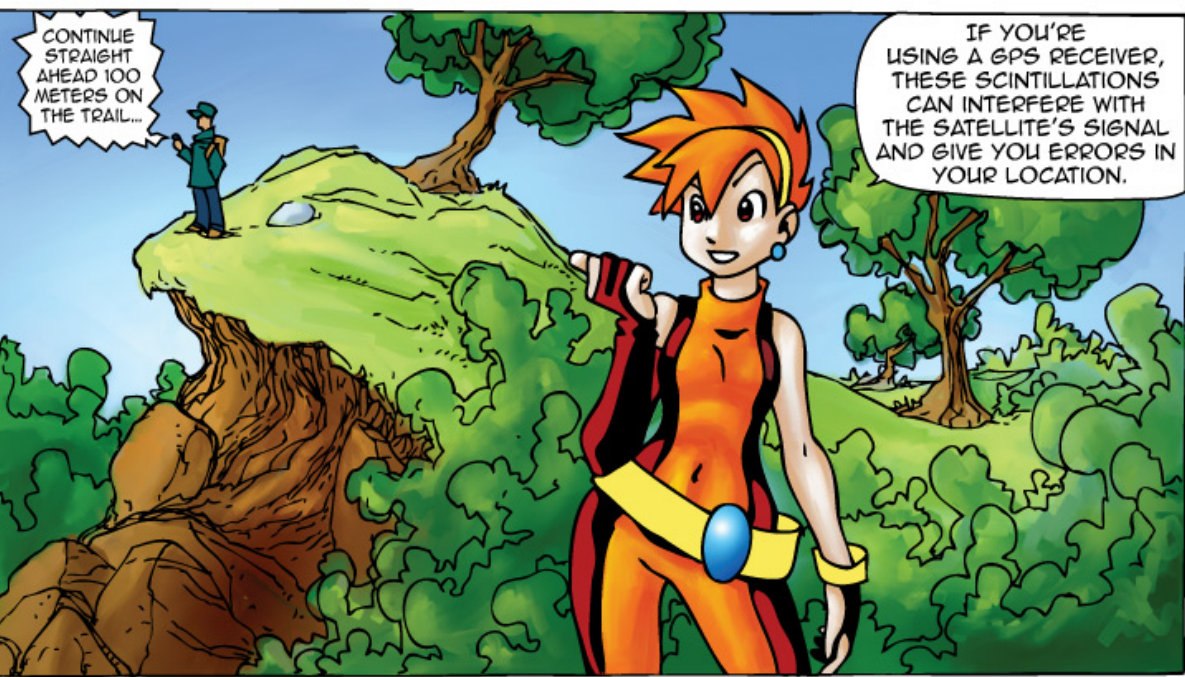
SO HOW DOES THIS APPLY TO THE IONOSPHERE? REMEMBER HOW THE BOTTOM SIDE OF THE IONOSPHERE HAS A SHARP INCREASE IN THE DENSITY OF CHARGED PARTICLES?



SOMETIMES AT NIGHTTIME BUBBLES OF GAS WITH A LOW DENSITY OF CHARGED PARTICLES WILL FORM ON THE BOTTOM EDGE OF THE IONOSPHERE AND BUBBLE UP SORT OF LIKE BUBBLES IN A SOFT DRINK.



SO IF A BEAM OF RADIO WAVES PASSES THROUGH THESE BUBBLES, THE LOWER DENSITY OF THE CHARGED PARTICLES IN THE BUBBLES WILL REFRACT THE RADIO WAVES THUS MAKING THE RADIO SIGNAL SCINTILLATE. AND SINCE THE FORMATION AND SIZE OF THESE BUBBLES AREN'T PREDICTABLE YET, THEN THESE VARIATIONS IN THE RADIO SIGNAL ARE UNPREDICTABLE.



CONTINUE STRAIGHT AHEAD 100 METERS ON THE TRAIL...

IF YOU'RE USING A GPS RECEIVER, THESE SCINTILLATIONS CAN INTERFERE WITH THE SATELLITE'S SIGNAL AND GIVE YOU ERRORS IN YOUR LOCATION.



AND IF YOU TRY TO SEND VIDEO OR AUDIO WITH A RADIO SIGNAL BETWEEN A SATELLITE AND THE GROUND, THEN THESE SCINTILLATIONS WILL INTRODUCE NOISE INTO THE SIGNAL AND DEGRADE THE QUALITY.

⋈⋆⋆
 ⋆⋆⋆⋆⋆
 #⋆@⋆⋆
 ⋆^⋆⋆
 @#⋆⋆



BUT THESE BUBBLES IN THE IONOSPHERE DON'T HAPPEN ALL THE TIME. THEY ONLY HAPPEN ON SOME NIGHTS, AND EVEN THEN SOMETIMES IT'S SOON AFTER SUNSET AND OTHER TIMES IT DOESN'T START UNTIL AFTER MIDNIGHT.



IT'S LIKE WEATHER. IN FACT IT IS WEATHER. IT'S WHAT WE CALL "SPACE WEATHER." IT'S DESCRIBING THE CHANGING ENVIRONMENTAL CONDITIONS OF THE PLASMA IN SPACE.


Space Weather
 QUARTERLY

Ionospheric
 Disturbances
 ISSUE!

SEE SPACEWEATHER.COM OR WWW.SWPC.NOAA.GOV FOR THE CURRENT SPACE WEATHER INFORMATION.



THIS IS WHY WE PUT THE CINDI INSTRUMENTS ON THE C/NOFS SATELLITE. WE WANT TO FIND OUT WHAT TRIGGERS THESE BUBBLES. CAN WE FIND OUT WHAT CONDITIONS CAUSE THEM TO FORM OR NOT TO FORM? IF WE CAN, THEN WE CAN GIVE THE SATELLITE OPERATORS A FORECAST WARNING TELLING THEM WHEN THEY NEED TO SWITCH THEIR COMMUNICATION FREQUENCIES, OR IF THEY CAN'T DO THAT, AT LEAST THEY CAN WARN THEIR USERS TO BEWARE OF ERRORS.



THERE'S A LOT MORE GOING ON IN THE IONOSPHERE THAN JUST THESE BUBBLES. WE'RE STUDYING IT ALL THE TIME WITH SATELLITES, ROCKETS, RADARS, LASERS, AND SPECIAL CAMERAS ON THE GROUND.

JUST LIKE THE WEATHER DOWN WHERE YOU ARE, SPACE WEATHER IN THE IONOSPHERE IS VERY COMPLEX AND WE'RE LEARNING NEW STUFF ALL THE TIME!



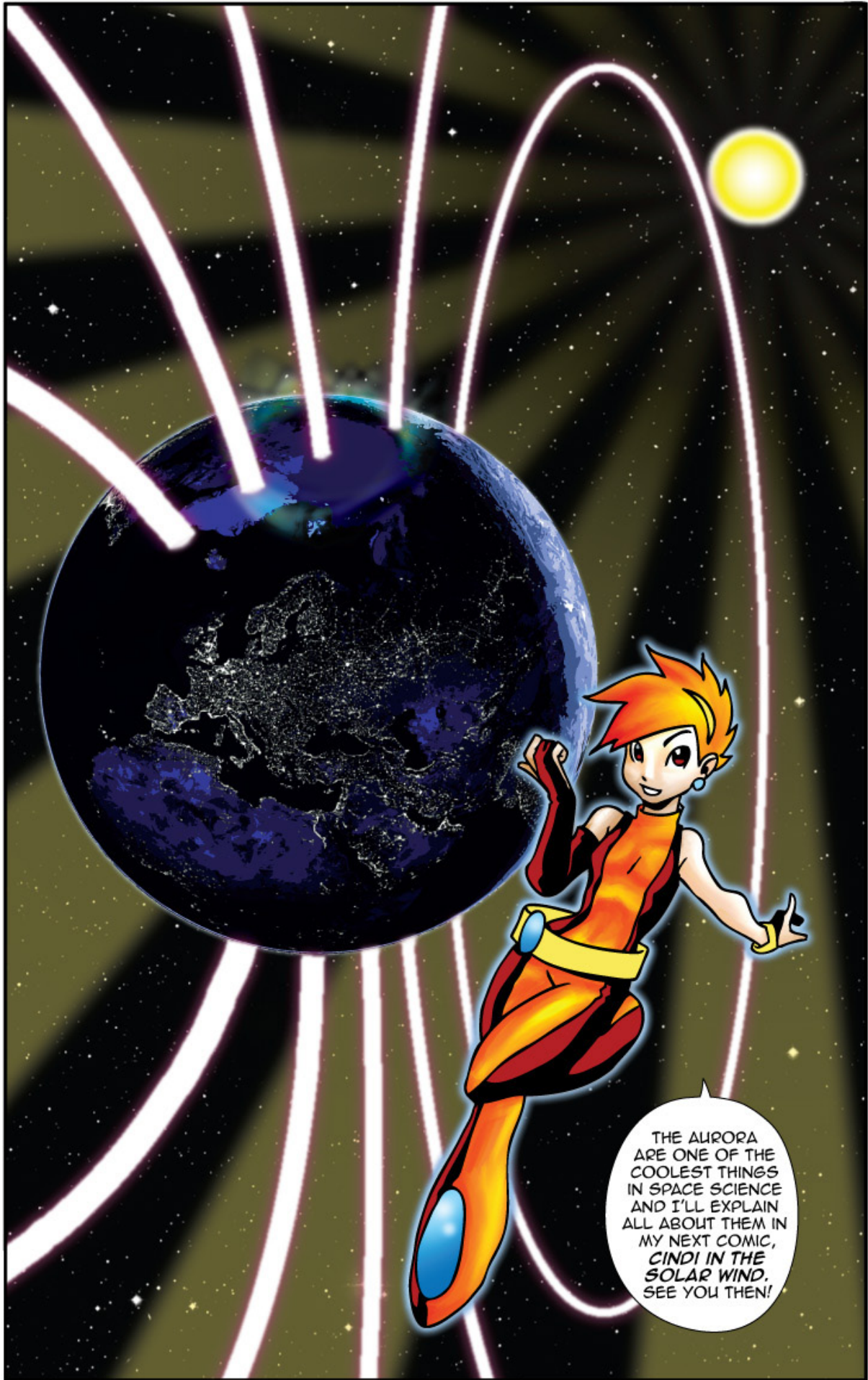
BUT I WANT TO CORRECT SOMETHING I SAID EARLIER. I SAID THAT THE IONOSPHERE IS INVISIBLE TO YOUR NAKED EYE. THAT'S TRUE ON *MOST* OF THE EARTH.

BUT UP IN THE POLAR REGIONS, NEAR THE EARTH'S NORTH AND SOUTH MAGNETIC POLES, THERE ARE PLACES WHERE PARTICLES FROM SPACE COME STREAKING DOWN AND HIT THE IONS AND NEUTRAL PARTICLES IN THE IONOSPHERE. AND WHEN THAT HAPPENS, THE IONS AND NEUTRAL PARTICLES START TO GLOW, JUST LIKE THE GAS IN A NEON SIGN.



AND THIS
GLOW OF THE
IONOSPHERE IS
WHAT WE CALL
THE "AURORA,"
THE NORTHERN
OR SOUTHERN
LIGHTS!





THE AURORA
ARE ONE OF THE
COOLEST THINGS
IN SPACE SCIENCE
AND I'LL EXPLAIN
ALL ABOUT THEM IN
MY NEXT COMIC,
*CINDI IN THE
SOLAR WIND.*
SEE YOU THEN!

WOULD YOU LIKE TO KNOW MORE ABOUT THE EARTH'S IONOSPHERE, THE CINDI MISSION, THE C/NOFS SATELLITE, AND DOWNLOAD THIS COMIC BOOK AND A COPY OF MY FIRST BOOK CINDI IN SPACE? THEN COME TO OUR REALLY COOL WEBSITE:

[HTTP://CINDISPACE.UTDALLAS.EDU/EDUCATION/](http://cindispace.utdallas.edu/education/)

ON OUR WEBSITE WE HAVE MORE INFORMATION ABOUT THE CINDI MISSION THERE, CLASSROOM PROJECTS, VIDEOS ABOUT SPACE SCIENCE AND THE CINDI MISSION, AND EVEN REAL DATA FROM CINDI! COME SEE THE LATEST CINDI NEWS THERE!

AND HERE ARE ALL THE FOLKS WHO CREATED THIS COMIC BOOK:
CINDI CHARACTER CREATED AND DEVELOPED BY:

**DR. MARY URQUHART
AND DR. MARC HAIRSTON**

SCRIPT AND STORYBOARDING BY:

DR. MARC HAIRSTON

EDUCATIONAL CONTENT OVERSIGHT BY:

DR. MARY URQUHART

AMAZING CHARACTER DESIGNS,
STUPENDOUS ARTWORK,
STUNNING LAYOUTS, AND
IMPECCABLE LETTERING BY:

ERIK LERVOLD

GRAND HIGH CINDI COMICS

ULTRA DIRECTOR AND CHEERLEADER:

DR. MARC HAIRSTON

SPECIAL THANKS TO DR. GREG EARLE
AT THE UNIVERSITY OF TEXAS AT DALLAS
AND DR. FRENCHY LUNNING AT THE
MINNEAPOLIS COLLEGE
OF ART AND DESIGN.



NO PROTONS OR
ELECTRONS OR
ELECTROMAGNETIC WAVES
WERE HARMED IN THE
MAKING OF THIS BOOK.

THIS BOOK WAS PRODUCED WITH FUNDS
FROM NASA UNDER THE EDUCATION AND
PUBLIC OUTREACH PROGRAM OF THE
CINDI SMALL EXPLORER MISSION
(NASA CONTRACT NAS5-01068).
COPIES OF THIS BOOK MAY BE FREELY
COPIED AND REDISTRIBUTED SO LONG
AS ALL THESE CREDITS REMAIN ATTACHED.
FOR ANY FURTHER QUESTIONS OR
COMMENTS, PLEASE CONTACT US BY
EMAIL AT HAIRSTON@UTDALLAS.EDU
AND URQUHART@UTDALLAS.EDU.

©2010 THE UNIVERSITY OF TEXAS AT DALLAS

LERVOLD '09