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This is a graded discussion: **10 points possible**

Show Due Dates

D11(BH) Weekly Discussion

Erin O'Connor

Apr 3 at 1:24pm

2 33

Due this week

First, be sure to do the reading and watch the lectures:
Assigned reading and lectures

Then answer the following questions in this discussion forum (and yes, you may look to see what others write, but try to find what they might have missed and you should go back to the original reading and lectures to get answers for yourself). Then post your own question at the end, and then answer someone else's question. If no question is available, go ahead and check back later until the due date. If nothing comes available you can then pick any question you wish.

/e hope to emulate a seminar classroom environment where students can share ideas. Always be respectful with all communications you have with your esteemed fellow colleagues (your fellow students) in this course.

- 1. DISCUSS in some detail something you found unusually interesting or intriguing in the reading or lecture material. Are there new insights that you have gained (something you had not thought of or considered before)? Focus on one of the concepts and explain as best you can in your own words. (4 pts)
- 2. Post a question that you have about something you read. Be sincere. What do you want to know? Write the word QUESTION all in caps, so that your fellow classmates know what your proposed question to the class is. (3 pts)
- 3. ANSWER the question of another student according to what we discussed in the lectures or what you read in the assigned readings (don't just make something up). Try to answer a question that no one else has responded to yet (but not a hard and fast rule). A good way to respond to another student's question would be to say something like, "Good question! The answer can be found on page..." and give the quote from the reading. You are free to reference other sources outside of class material, but always consider the credibility of the source, state what the source is, and give the link. (3 pts)

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Reply

(https:/

Luke Rutherford (https://canvas.sbcc.edu/courses/46681/users/373514)

Apr 9, 2022

DISCUSS:

I am intrigued by the thought that if a small black hole was on earth it would oscillate through the surface eventually settling in the center. I am also amazed at the fact that people were able to figure out that there can't be more than 300 within a cubic light year. All this is determined without positive evidence of primordial black holes.

QUESTION:

If there was a small black hole on earth why would it oscillate through the surface instead of eating up the earth?

Reply

(http

Abigail Jacobs (*She/Her*) (https://canvas.sbcc.edu/courses/46681/users/367167)

Apr 10, 2022

Hi Luke!

I think your question is very interesting and the only thing I can think of would be our gravity which is only found here on earth.

Reply

(http

Sarah Savage (https://canvas.sbcc.edu/courses/46681/users/375381)

Apr 10, 2022

ANSWER: Hi Luke, I think that a small black hole passing through Earth would be eating up Earth as it went, and that it would continue to do so once it settled in Earth's core. I have no clue how long it would take it to destroy Earth, or if it could do that before Earth is enveloped by our expanding Sun, but it does seem possible!

Reply

(http [Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)](https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

The whole concept of microscopic black holes is very intriguing. Most people have never thought of such a thing. But theoretically they can exist and we have reason to believe that they have been created and do exist, but because they are small we are not able to detect them very easily. And yes, isn't it powerful how mathematics and logic and common sense can allow us to determine that there cannot be more than 300 within a cubic parsec, that shows the power of analytical thought. This is how humans have come to develop such modern technology and innovative solutions to Global problems. Hopefully we can continue to solve and address these world problems on into the future, in such productive and thoughtful meaningful ways.

Reply

(http [Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)](https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Small black holes would oscillate through the earth almost as if the Earth material wasn't there. Anything that touched this very small microscopic Event Horizon wood be engulfed into it and it wouldn't even slow it down. There would likely be minute gravitational drag effects and so eventually it would settle at the center of the earth, to the best of my understanding, but it would initially just fall through the Earth as if the Earth surface material wasn't even there.

Reply

(https:/ [Abigail Jacobs (*She/Her*) (https://canvas.sbcc.edu/courses/46681/users/367167)](https://canvas.sbcc.edu/courses/46681/users/367167)

Apr 10, 2022

Discussion:

I am always really interested in the videos because I am a super visual learner and they help me better my understanding, so this week I found the black holes video super interesting. Blackholes are such a mystery to us but they have some patterns that scientists are able to see and understand, in the beginning when they showed the photon sphere I was kind of blown away. It was so beautiful and anytime I have thought about a black hole I think of a dark blob in space but they actually emit radiation. They also eat stars to grow in size! I have also seen the steven hawking movie the theory of everything so many times and never realized how complex blackholes were and how much time and vulnerability he put into his research.

He made the zeroth to the third law that talked about the blackholes and how they survive, I think it's really cool how much he was able to contribute to our understanding of such a mysterious object!

Question:

If nothing travels at the speed of light, except light, how can a blackhole also pull light into itself?

Edited by Abigail Jacobs (https://canvas.sbcc.edu/courses/46681/users/367167) on Apr 10 at 2:52pm

Reply

(http

Franco Diaz Campo (https://canvas.sbcc.edu/courses/46681/users/403036)

Apr 10, 2022

Hi Abigail,

That's a very good question!! I think because of the power itself has, a black hole is very massive, and the power it is suppose to have is immense. I am not completely sure of that one, but if I am wrong, I would be pleased of knowing which is the main reason of it.

Very nice work!

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

That's great that you find the videos helpful. With modern technology and computer generated imagery, these images are very realistic and represent how black holes would really look like if you could actually be close enough to see them. The light coming from the black holes is not from within the black hole, and it's not even the Hawking radiation which is very long wavelength and very weak radiation, but it's the light being generated from the accretion disk itself. Stephen Hawking really did inspire so many scientists and non-scientists with his work. And the story of his life is also a testament of the persistence, endurance, and capacity of human determination, ingenuity, and survival. He has inspired us all in many ways.

Reply

(https://

Sarah Savage (https://canvas.sbcc.edu/courses/46681/users/375381)

Apr 10, 2022

DISCUSS: It's fascinating that black holes were initially found to violate the Laws of Thermodynamics, but then scientists were able to use the event horizon's properties to interpret the laws in such a way that the laws do apply. Also, I find it impressive that scientists come up with all of these "out there" ideas and they have to be brave enough to present their findings and take on criticisms from the scientific community. It seems like the great scientists all faced this and kept pushing forward. I think a lot of people would be too afraid of what others might think or of being proven wrong to even put themselves out there.

QUESTION: In Chapter 7 of the Hawking book, it was mentioned that when two black holes merge to create a larger black hole, the sum of the event horizons' areas is greater than or equal to the individual event horizons. This was also mentioned regarding the 2nd Law of Thermodynamics - that entropy of a combined system is greater than the sum of the isolated systems. How can the resulting event horizon be greater than? Where is the additional event horizon matter coming from?

Reply

(http **Brian Wolden (https://canvas.sbcc.edu/courses/46681/users/274832)**

Apr 10, 2022

Hi Sarah,

I wondered this same thing! I looked around a bit but couldn't find a good answer. My best guess is that basically under no realistic circumstances will two black holes merge without their entropy increasing somewhat during the process. Basically, the process of merging increases entropy in of itself. This could maybe be from matter orbiting the event horizon or CMB radiation that is absorbed? I'm also wondering if this is a short lived increase in that it seems like the massive amount of energy put into the gravitational waves should also decrease their total mass, which would decrease their event horizon and thus the entropy of the black hole. Definitely not sure on this one but would love to find out!

Reply

(http **Sarah Savage (https://canvas.sbcc.edu/courses/46681/users/375381)**

Apr 11, 2022

Hi Brian, those are really good thoughts! It got me thinking more about black hole mergers. It’s thought that nothing can come out of a black hole but maybe it could with enough gravity but we just haven’t witnessed it? If there were two black holes merging where one was significantly larger than the other, could the gravity of the larger one pull material out of the smaller one, therefore increasing the amount of material in the resulting event horizon?

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Human nature is to resist change, so great scientists, but also great poets and artists and politicians, they must push against the resistance of the masses. Sometimes it ends in death, especially in politics, but also for scientists. There were two previous people who contended that the world was round prior to Galileo and they were burned at the stake. The Neil de Grasse Tyson Cosmos series, in the first episode, features them and talks about what happened to them. It's a terrible example of how it can be difficult and dangerous and scary to challenge the status quo. Galileo was placed under house arrest through the and of his years due to his challenges of the geocentric ideology adopted by the church.

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

The reason that the surface area of a black hole created from the merger of two smaller black holes, and why the surface area of the combined black hole is greater than the surface area of the sum of the surface areas of the original two black holes, has to do with geometry. If I have a black hole of "mass one", with "radius one", I can calculate "area one" which is the surface area of that black hole. I can do the same for a second black hole with mass two and radius two which would give area two. If I then combine the masses and calculate the new Schwarzschild radius using the formulas in my paper on black holes posted in the class, you will find that the surface area, using the geometry equation "four pi r squared", that surface area will be greater for the combined black hole, then for the sum of the two initial surface areas. you're not creating something from nothing because this is just a mathematical calculation of surface area. This is exactly what led Hawking to help in the development of the black hole laws of thermodynamics.

Reply

(https:/

Franco Diaz Campo (https://canvas.sbcc.edu/courses/46681/users/403036)

Apr 10, 2022

DISCUSSION

Hi Everyone,

I hope you are doing well. For this week, we didn't have much things to study. It was a great week since we saw a bit more of black holes and how it works, and knowing more of it, is very important for enlarge our knowledge of it. We also watched a great video of Neutron Stars, which I find very interesting because now I understand better their function and some specific details. Another thing I want to talk about is of the quizzes we did for this week, I don't want to say that they were impossible, but they did had some grade of difficulty which is good since it helps us to concentrate and study more for having a good grade.

QUESTION

Why do you think Neutron Stars are important?

Reply

(http

Alak Fryt (*He/Him*) (https://canvas.sbcc.edu/courses/46681/users/354278)

Apr 10, 2022

I would say that Neuron Stars are important because neuron star collisions are one of the main sources of the heavier elements that we find in our universe.

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Good responses, and I'm glad to hear that you felt the quiz was challenging but that it helped you focus and learn more about the material.

Reply

(http

Naomi Xu (https://canvas.sbcc.edu/courses/46681/users/27955)

Thursday

I second Alak, neutron star collisions are the reason we have elements like gold and uranium!

Reply

(https:/)

Brian Wolden (https://canvas.sbcc.edu/courses/46681/users/274832)

Apr 10, 2022

DISCUSSION

This week's material really helped clarify some of the concepts around black holes and Hawking radiation. I had some understanding of the basics of Hawking radiation before I took this class but I learned this week that I had been thinking about them somewhat incorrectly. I had previously thought of the space where virtual particles were created being within the event horizon, or rather, that one was created within, and one was created outside the event horizon, with the one outside being able to escape and the one inside being unable to escape. The mechanism by which this happened was always a little confusing. The explanation that these are actually created near the threshold of the event horizon, due to the uncertainty principle and how there can't be actual empty space, despite being very strange, makes more sense to me. From there, it seems like the anti-particle is absorbed by the black hole because it has negative energy which is in turn further reduced because of the proximity to the high mass of the black hole. It's not entirely clear to me if it is the negative energy particle that is always absorbed or if it becomes the negative energy particle because it is absorbed… Either way, the positive energy particle may sometimes escape becoming a real particle that is Hawking radiation. The negative energy particle then reduces the mass of the black hole. It also seems like the reason smaller black holes are hotter is because of the energy required to escape the influence of the black hole, though I am not 100% clear on this either. Since smaller black holes exert less influence, it takes less energy to "escape" their influence, so the radiation that escapes has more energy remaining that it would if it had to travel farther to escape the influence of the black hole. This all is very interesting and I look forward to looking into it further, either in this class or on my own!

QUEESTION

Stephen Hawking talks about what happens when a black hole, via Hawking radiation, evaporates to a point that its mass is extremely small. While he concedes that it isn't clear what would happen, he suggests that it would likely completely evaporate and result in a very powerful emission of energy. During this week's lecture, it was also noted that, when the LHC was nearing completion, there were concerns by some people that microscopic black holes would be created and destroy the Earth. I remember when people were talking about this and actually had discussions with friends regarding these black holes being so small that they would evaporate nearly instantly and have no impact on the space or matter around them. My question is, if these hypothetical microscopic black holes (or ones created in our atmosphere or elsewhere) were created and evaporated, would they also emit (relatively) large amounts of energy? If so, I would imagine that the energy would have to be equivalent to whatever mass remains in those black holes and so would be relatively small. However, why are the ones that Hawking references that are “equivalent to the explosion of millions of H-bombs” (Hawking 137), “exploding” at this stage instead of when they are the mass of a few elementary particles, like those potentially created by the LHC? I would imagine that, since black holes “have no hair” and we can’t distinguish between those created via energy and matter, we also couldn’t differentiate between one that started out large (on the scale of primordial black holes) and then evaporated to the size of one created via colliding particles, and one just created via a collider. This suggests to me that they should behave identically as they evaporate to nothing. Does this mean that there is a critical mass larger than that hypothetically created by a collider at which point they “explode” or is there something else going on with primordial black holes or black holes evaporating that I am missing?

Reply

(http Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

That was a very good description of virtual particle pair creation at the Event Horizon of a black hole. I think you have about as good an understanding as anyone can have on the topic. Like with quantum mechanics, and this is a quantum mechanical process, one can never truly understand, at least not in a macroscopic intuitive sense. You can develop intuition by solving problems, and your description shows that you are well on the way to doing that. The question about why is it the negative energy particle falls in while the positive energy particle radiates out, that has been a challenge for me as well. We are not talking matter and antimatter. Negative energy and positive energy particles are different. I've never gotten a satisfactory answer from anyone about that. But your sentence about having it BECOMES the negative energy particles somehow BECAUSE it is absorbed by the black hole, that seems to be more what is going on. Somehow the particle that is absorbed, having to do with the process itself, results in decreasing the mass of the black hole, while the other particle radiates away as Hawking radiation.

Reply

(http Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

These are excellent questions. I've never read a discussion that addresses these specific questions, but I can use my background in physics and my understanding of black holes to offer some possible explanations. I think what is going on here has to do with the difference between microscopic black holes that might be created through cosmic-ray interactions in the upper atmosphere, or with particle accelerators. The microscopic black holes would have a mass on the order of the mass of a single proton or so. If you convert the full energy by Einstein's E equals MC squared of a single proton, you will get a release of energy, but it will not be thousands of times more powerful than an h-bomb. I think the primordial black holes that Hawking is referring to are the size of mountains perhaps, so when they evaporate the mass conversion would be enough to generate an explosion that would be thousands of times that of an h-bomb or maybe Millions. There are two concepts going on here. During the evaporation of a primordial black hole, as the black hole evaporates the rate of energy release, the Hawking radiation, increases exponentially, but at the same time the amount of mass in the black hole is decreasing, so which affect wins out or how they combine, that would be a calculation that would have to be made and I think that's the calculation Hawking made when he was trying to estimate how many primordial black holes could be exploding within a cubic parsec, and he came up with a maximum possibility of 300. It seems that he has calculated what that release of radiation would be and yes, it is much more than what would occur in a particle accelerator or in the upper atmosphere. Very good questions and perhaps the answer lies in the arguments that I have tried to make above.

Reply

(https:/

Alak Fryt (*He/Him*) (https://canvas.sbcc.edu/courses/46681/users/354278)

Apr 10, 2022

DISCUSSION: I found it interesting to understand the thought process that went into figuring out how black holes could emit radiation. It was cool seeing how it started from observing how the areas of event horizons increase as they merge and then how that would relate to the entropy of the black holes. Then it was the question of how black holes satisfy the laws of thermodynamics which was also cool to read about. Just generally seeing the process that goes into asking each scientific question is so interesting.

QUESTION: I understand that the math adds up to support that black holes do appear to emit particles, but I'm still unsure about how the particles work and how it would appear from an observer that the black hole is emitting particles.

Reply

(http

Brian Wolden (https://canvas.sbcc.edu/courses/46681/users/274832)

Apr 10, 2022

Hi Alak,

As far as I understand it, the area immediately around the event horizon of a black hole should be "empty" space. However, according to the uncertainty principle, space can't ever truly be empty. If it were, the value of the space and the rate of change of the space would both have to be zero, which is basically the same as not knowing the position and velocity of a particle, but applied to the properties of a location. Basically, it can't actually be zero so it can't actually be empty. This is where quantum mechanics gets really weird in that the uncertainty principle isn't a limit of our ability to know things about a space or a particle but is actually a limit of the universe and space itself. Since that space can't be empty but, at the same time, it should be empty, virtual particle/antiparticle pairs are constantly being created and reforming to annihilate one another because there has to be some level of uncertainty in that space, and those virtual particles create that uncertainty. Near a black hole, sometimes the virtual antiparticle will be absorbed by the black hole while the virtual particle escapes the black hole's gravity. The antiparticle has negative energy and therefore decreases the mass of the black hole. (I think it could be thought of as colliding with a particle within the black hole and them annihilating one another, but I'm not sure about that.) The virtual particle moves away from the black hole at a rate fast enough to escape its gravity. It is now a "real" particle with energy and that is what is referred to as Hawking Radiation. I may be wrong, but it seems to me that it isn't really the black whole that is emitting radiation but rather that the black whole is creating conditions around it such that antiparticles are created and absorbed by the black hole, reducing its mass, while simultaneously creating particles that radiate from just outside the event horizon. Without the black hole there, the particle and antiparticle wouldn't exist long enough to do anything of significance. The black hole is the only thing strong enough to influence each half individually so it results in this weird form of radiation.

I hope that helps! It is definitely a super weird phenomena and hard to conceptualize.

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Yes, it was this revelation, that the surface area of the event horizon of a black hole ALWAYS increases (except due to Hawking radiation itself), that lead Hawking to conclude this had to do with Entropy.

Reply

(https://

[Lexie Brent (https://canvas.sbcc.edu/courses/46681/users/122267)](https://canvas.sbcc.edu/courses/46681/users/122267)

Apr 10, 2022

I must have very little concept of size when it comes to numbers because when hearing that all the protons in the universe added up to be less than a googol I was sure I heard incorrect. *ALL* the protons? In the ***UNIVERSE***??? And then someone thought that a googol wasn't enough so there should be a googol*plex?* These are mind-boggling numbers indeed. I find it interesting that no primordial black holes have been found yet their existence seems to be widely accepted (correct me if I'm wrong there). It's also fascinating to go into the hypothetical situations that the sci-fi genre inspires and introduces. Writing an official academic research paper and figuring out whether or not you can extract energy from certain black holes vs others seems almost like doing a Mythbusters astronomy version.

QUESTION: In the book, Hawking says the "decrease in the entropy of the black hole is more than compensated for by the entropy of the emitted radiation." I don't quite understand, how does emitting radiation create entropy?

Reply

(http

[Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)](https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Very thoughtful responses. You clearly have been digging into the material and it's great to see your detailed in-depth responses. Yes, a Google is an unimaginably large number. when one says there are 10 to the 70th protons in the universe, if they were to then say there are 10 to the 71 protons, one might think that oh it's just 71 instead of 70, but what people don't realize is that by adding that additional zero, you're saying there are ten times more protons than the previous number. That's why the number is so unimaginably big. It's like saying there are 10 to the 15 galaxies in the universe and if I were to say there are 10 to the 16 well then I'm saying there are ten times what I thought of originally. It just goes up exponentially, quite literally.

Reply

(http

[Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)](https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

And yes, the abstract hypothetical investigations, like trying to make a black hole heat engine, they are very silly in one sense, but insights in physics and math can be developed that may sometimes be applied in other areas. Sort of like the Apollo missions to the Moon ended up in the development of freeze drying for food, seems like a very abstract and unrelated topic, but it's something that has been used in food production now in a big way. Similarly, the need to miniaturize computers led to the development of semiconductor technology that is why our phones have computers in them that are so small and has revolutionized the computer industry. I don't think much will come from my thermodynamics of black hole heat engine paper, but if there are lots of these crazy hypothetical investigations, some of them will yield meaningful and important results in society.

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

That was a great question regarding entropy and radiation. The best way I can try to answer this is to have you imagine dropping a glass of water and having it spill and shatter across the floor. If I were to break up the pieces even smaller than they would represent higher entropy, higher levels of disorder. I Could Break Up the Pieces so small that they're not even pieces anymore but they are atoms and photons. when you take matter and convert it to Photon energy and spread it out as much as possible, that's the most disorderly state that we can represent that matter and so therefore it represents the highest entropy. When black holes radiate energy they are radiating in the highest form of entropy and therefore that compensates for whatever matter fell in. The organization of the matter falling in has been completely lost and radiated out as the highest level of disorder possible in the universe.

Reply

(https:/

Naomi Xu (https://canvas.sbcc.edu/courses/46681/users/27955)

Apr 11, 2022

DISCUSS

I got the event horizon question wrong on the quiz so I did a little googling and found this page

https://physics.stackexchange.com/questions/321525/if-you-hover-just-above-the-event-horizon-of-a-black-hole-would-you-see-the-fut (https://physics.stackexchange.com/questions/321525/if-you-hover-just-above-the-event-horizon-of-a-black-hole-would-you-see-the-fut)

I thought the one where someone calculated the time relations of the different observers was really cool

QUESTION

Is singularity the beginning of our universe or the end? or both? or do we not know that?

Reply

(http

Sarah Savage (https://canvas.sbcc.edu/courses/46681/users/375381)

Apr 12, 2022

ANSWER: I think that it could be possible that both the beginning and end of the universe are a singularity. It seems like that would mean that space would have to have existed before the singularity to exist. I believe that the Big Bang Theory is that space-time was created with the big bang, which was an explosion from everywhere at once. So I think then it wouldn't have come from a singularity. Not sure if these "birth of the universe" theories work together or not.

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Great link! I also liked how they were talking about seeing the "future" from above the event horizon. A singularity can describe both the beginning and the end of the universe, if we assume a closed universe (as opposed to open or flat).

Reply

(http

Malcolm Tircuit (https://canvas.sbcc.edu/courses/46681/users/427388)

Thursday

I have read that the universe did in fact come from a singularity. By definition, a singularity is something that has an aspect of itself that is infinite. In this case the singularity the the universe came from would be infinitely small and have all the mass in the universe. I don't think we know if the universe will return to its state of being a singularity yet but maybe we will sometime in the future.

Reply

(https:/

Malcolm Tircuit (https://canvas.sbcc.edu/courses/46681/users/427388)

Apr 11, 2022

DISCUSS:

Learning what a googol and googolplex were was really interesting. I didn't know that a number could be that big. It makes me think about how the universe is both infinitely big and infinitely small. It was also great hearing a more in depth description of what hawking radiation is. I didn't know that the negative particles actually decrease the entropy of the black hole it falls into.

QUESTION:

I have heard that Einstien also predicted the existence of wormholes but we have not found any evidence of that yet. Do you think we will find proof that wormholes exist sometime in the close future?

Reply

(http

Erin O'Connor (https://canvas.sbcc.edu/courses/46681/users/24247)

Apr 29, 2022

Numbers dealing with astronomy and cosmology are so big, that they are quite mind-boggling. The googol, the idea that there are such big numbers, and even the googolplex, can help us with describing these large numbers of the universe. Abigail in the class also asked about googols, and I did a lengthy response helping to visualize why these numbers get so big and how they can be so difficult to relate to and understand. Take a look at what I wrote there. I've always loved playing with numbers and it can be fun trying to think of things that add up to a googol, like how tall would a stack of papers be if it had a googol pages, etc. Or, if a person has freckles, how many of these persons would you need to have a googol freckles (I actually calculated this for fun once, when I was in high school, for the pretty freckled girl sitting in front of me.. haha).

Reply