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This is a graded discussion: 10 points possible

Show Due Dates

D5(BH) Weekly Discussion

Erin O'Connor

Feb 12 at 10:51pm

41

REVIEW INFO ON UPCOMING TEST and INFO ON CLASS EXPECTATIONS AND GRADING

- **Info on upcoming tests (and all tests for semester)**
- **Info on Class Expectations & Grading**

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.

We 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:/

Lukas Gott (https://canvas.sbcc.edu/courses/46681/users/417976)

Feb 19, 2022

DISCUSS: Near the end of the chapter the author discussed how while space and time were once seen as infinite, the general theory of relativity explains how space and time are dynamic and has a finite beginning/end. I found it incredibly interesting to know that if a body moves, or a force acts, it affects the curvature of space and time, altering the universes course. It's crazy for me to believe that the universe is consistently changing, and with the possibility of space and time being finite, could end at any time.

QUESTION: Do you believe in the multiverse theory? Why or why not?

Reply

(http

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

Feb 19, 2022

DISCUSSION: As you said, if a body moves, it affects the curvature of space and time. The curvature of space-time in response then affects how bodies move. It's like a never ending chain reaction that reinforces how everything is literally connected. It makes me wonder about how masses on Earth, including humans, affect each other. Perhaps gravity between bodies on Earth is so subtle that it doesn't affect us, or it could be that it's so subtle that we're not aware of its affect on us and the decisions we make. For example, perhaps some are people drawn to live in big cities because they subconsciously like the feeling of the gravity from extra humans and large buildings. Conversely, other people could be drawn to live rurally because they subconsciously don't like the sensation of additional gravity.

ANSWER: I feel that I need to learn a lot more about the idea of multiverses and other theories before deciding whether I believe in it or not. But If we do live in a multiverse, I wonder whether it's even possible to travel between them if we could. Each universe could

have evolved in different ways to follow its own set of physics laws and perhaps that would limit us from being able to cross between them.

Reply

(http

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

3:15pm

Originally Posted 3/2/22

What a great example you gave about what if people were subconsciously feeling the effects of gravity in big cities with lots of other people, and then those that like to live in the country are living there because they don't like that sensation of extra gravity. Scientifically, the amount of gravity we're talking about is so minute that it would be unimaginable to detect, but who knows, maybe people can sense it in some way. After all, our other senses are very sensitive, the eyes can detect just a few photons of light, and the ear can detect just a few atoms banging on the eardrum. So anything is possible.

Reply

(http

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

Feb 20, 2022

Hi Lukas,

I don't know if it is possible, I don't think so because there are not so many proofs to think this might be true, but as we are in a universe that we know nothing of it, if there is a minimum possible, we can not deny it.

Very good discussion!

Reply

(http

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

Feb 20, 2022

Obviously there's not nearly enough evidence to suggest that the multiverse theory is true, but at the same time, we know way too little of the universe to rule it as not possible. Personally I like to believe that the multiverse theory is possible, largely just for the fun of wanting it to be true. I think that'd really be amazing.

Reply

(http

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

Mar 2, 2022

It's great to see all this interest in the Multiverse theory. Although you might expect that this would be impossible to address, in fact, you can make a very strong argument using science and statistics that it is true! Rob Geller who is a professor out at UCSB who I met in grad school when he was doing research on black holes, he teaches about this. I plan to have him on one of our Zoom Chats, and I'll be sure to have him explain how you can literally "prove" that the Multiverse theory is correct.

Reply

(http

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

3:12pm

Originally Posted 3/2/22

Good discussion and great question about the Multiverse Theory. A lot of students were interested and responded to your question.

Reply

(https:/

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

Feb 20, 2022

QUESTION: I'm so fascinated with the concept of Relativistic Time Dilation. It's simply amazing that actual time travel is built into our universe's natural state! Travel faster and your time slows down while the universe ages around you. I do find it unnerving though to know that there's no way to reverse time dilation. If you accidentally traveled too fast or too long, you wouldn't be able to fix it. Do you think reverse time dilation is possible and we just haven't figured it out yet, or do you think it doesn't exist?

Reply

(http

Hana Putnam (https://canvas.sbcc.edu/courses/46681/users/427074)

Feb 20, 2022

ANSWER: Sara, I had the same thought regarding backwards time travel! This seems like a really complicated topic but I can't think of a way that it would work. I feel like there is a

way to try and use the light cone diagrams to illustrate the answer to your question. I can't conceive of a way that you'd be able to move back into the past from a given point in the present because, by convention, everything you experience after the present is the future (in the context of light cone diagrams at least).

Reply

Hana Putnam (https://canvas.sbcc.edu/courses/46681/users/427074)

Feb 20, 2022

DISCUSSION: I really enjoyed learning about the twin paradox and time dilation this week. It's so cool to think that forward time travel really is possible! It also made me think about the practical implications of sending someone on a mission that would take them to alpha Centauri. This person would have to make tremendous personal sacrifices in the name of science! I can't imagine not seeing my loved ones for 16 years, not to mention the societal changes that would likely be hard to fathom.

QUESTION: I still feel pretty confused about Einstein's theory of general relativity. On page 30 of the text, Hawking says, "Bodies like the earth are not made to move on curved orbits by a force called gravity; instead, they follow the nearest thing to a straight path in a curved space" which seems to suggest that "gravity" is not responsible for the earth's orbit. However, later on gravity is used to explain how Mercury's orbit is elongated due to the relatively large gravitational effects given its close proximity to the sun. Does gravity create four-dimensional space-time resulting in the geodesic? Or are these two concepts separate?

Reply

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

Feb 20, 2022

Answer: The concept of "gravity" is that objects are falling along with the bending of spacetime. The path that objects follow is called a "geodesic" therefore it is following what feels like a "downward slope through spacetime" (Bloomfield, 2019).

I would say that they are in fact the same concept together, and I also think that this is a very interesting question.

Reply

(http

Victor Jensen (https://canvas.sbcc.edu/courses/46681/users/416476)

Feb 20, 2022

He was stating that gravity is not a force. It's similar to drawing a straight line on a globe, then flattening out the globe. The straight line will become curved. There is no force present that pulls the line into a curve, it is just a side effect of flattening out a dimension.

Space is not curved due to gravity, but due to mass interacting with the Higgs field, something far above our level. This is the issue with the standard example of putting a heavy object on a stretchy surface, like a trampoline, and rolling balls around it as an example of how gravity works. That example is using gravity to show a bad example of gravity.

Here's a pretty good video on the topic:
https://youtu.be/XRr1kaXKBsU (https://youtu.be/XRr1kaXKBsU)

Edited by **Victor Jensen (https://canvas.sbcc.edu/courses/46681/users/416476)** on Feb 20 at 9:53pm

Reply

(https:/

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

Feb 20, 2022

Discussion: I have been taught many times what Newton's law is but never in detail like the book has shown us, the example of the twin paradox was very interesting. With one twin taking a long trip into space and the other staying on earth and the idea that one would age at a different pace than the other. The idea is that an observed clock seems to run more slowly when the twin in space is traveling at a high speed past their counterpart.

Question: Is the twin actually older or is their appearance that of an aged twin? How much has actually changed about them internally?

Reply

(http

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

Feb 20, 2022

ANSWER

Hi Abigail,

From my understanding the twins actually experience times at completely different rates so they are in fact different ages. There is no "correct" time frame between the observation of the twins. The one who traveled at near light speed would experience 8 hours (for example) and be 8 hours older than they were when they left. The other twin that stayed on Earth and was, therefore, not moving close to the speed of light, actually experienced 16 years (for example) of time passing and is actually 16 years older than when the first twin left. Professor O'Connor gives an explanation of this that really helped me in this weeks lecture video starting at about one hour seven minutes.

Reply

(http

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

Feb 20, 2022

Hi Abigail,

The twin who experiences acceleration will return to Earth younger due to time dilation, which means moving clocks go slower, or less time passed on the spaceship compared to Earth.

Reply

(http

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

Feb 22, 2022

The lecture video mentioned that time slowing down actually happens on an atomic level, so the twin who accelerates and slows down time is actually slowing down the aging process of their body.

Reply

(http

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

3:13pm

Originally Posted 3/2/22

Yes, everyone learns about Newton's laws but then they hear about general relativity but it's not often explained properly. I'm glad that we get to talk about this in a bit more depth and that you are finding it interesting. Yes, the twin on the spaceship does actually age slower in every way. The atoms will vibrate slower, the electrical impulses will travel slower so the person on the spaceship will think slower, move slower, and exist in a slow way, but since things will behave slower they will not notice in any way.

Reply

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

Feb 20, 2022

DISCUSSION

One thing I found particularly interesting is that it was determined that light moved (as opposed to being instantaneous) as far back as 1676. The observation by Roemer of the apparent difference in timing of Jupiter's moons around Jupiter depending on the distance Jupiter is from Earth is amazingly clever. I am continually astounded by how much scientists and thinkers of the past were able to determine about the universe with relatively little data or technology. I would imagine that it was quite difficult to accurately record the orbits of Jupiter's moons without modern technology. To then determine that the only explanation for the apparent inconsistency is that something that, to normal observation happens instantaneous, is actually moving at a mind-boggling speed is really incredible. The fact that he was then able to calculate the speed of light (even though he was off by a bit) is that much more impressive.

I am also continuously trying to wrap my head around relativity and this lecture/reading helped me get a better handle on it. The time dealation image (with one person on the ground in another in a ship both observing the same light-based clock) was particularly helpful in demonstrating how the speed of light is the constant by which time must be measured. Since it is unchanging, time must effectively be relative so the observations of light can be consistent. Thinking about the speed of light as the constant by which time is determined really helped me visualize relativity a little better.

QUESTION

How do we think about the speed of light during hyperinflation? Was space expanding uniformly during that time or were there places where there was greater space inflation and so the light was "moving" away from other things a relatively faster rate? Does it even make sense to think about light separately from the space it is moving through, or does it only make sense within the context of space? If you need space for light, isn't that something through which it is moving a sort of ether? (Though obviously not in the way they were testing for it in the Michelson Morley Experiments.)

Reply

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

3:19pm

Originally Posted 3/2/22

You always have such thoughtful responses and such great questions. It is amazing that Rohmer was able to measure the speed of light in the 1600s. I think it's another great example of someone ahead of his time, very much like Eratosthenes measuring the size of the Earth hundreds of years BC.

Reply

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

Feb 20, 2022

DISCUSSION:

A concept I have never heard about is that bodies in space follow straight lines in a four-dimensional space but they appear to move along a curved path in our three-dimensional space. I had trouble working this out in my head when reading about it but the plane's shadow analogy made this easier to understand. The introduction of the fourth dimension is exciting and I hope we learn more about it.

QUESTION:

How many dimensions are there? How many more dimensions could there be if the multiverse theory is true?

Reply

Victor Jensen (https://canvas.sbcc.edu/courses/46681/users/416476)

Feb 20, 2022

According to string theory, there must be at least ten dimensions. Isn't that crazy? These ten dimensions describe every possible thing in a multiverse that us humans can comprehend.

Reply

(http

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

3:14pm

Originally Posted 3/2/22

The principles of general relativity are very strange, and so people often have not heard of them. One of my goals in this class is to introduce you to all the strangest ideas that humans actually believe are true. So now you can really impress your friends with some strange thinking.

Reply

(https:/

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

Feb 20, 2022

DISCUSSION: I found interesting this week's videos and reading! I like all the topics related to space and time and all the theories. One of the biggest questions in modern science is whether we can travel in time, I think everything related to it is very cool, and there is a slight possibility we can do it. If we do time travel, everything could change, but it would alter many things and have many consequences. I also found it interesting that it explained how a body moves; it is something that if you don't study it, it is tough to think about it.

QUESTION: Do you think we will be able to do time travel in the future?

Reply

(http

Victor Jensen (https://canvas.sbcc.edu/courses/46681/users/416476)

Feb 20, 2022

Sadly the type of time travel presented by Hawking is one we already do. Moving forward in time. How fast one moves forward can be sped up or even basically stopped in extreme conditions, but going backwards still holds to be impossible.

Reply

(http

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

Thursday

In my opinion, I think we will never be able to achieve time travel back in time unless we become 4 dimensional beings. I do think we might be able to travel forward in time on a

regular basis sometime in the future though.

Reply

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

3:18pm

Maybe eventually we'll become 4 dimensional beings. There's always hope for us (maybe.. haha).

Reply

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

3:11pm

Originally Posted 3/2/22

Time travel is very intriguing. You asked about being able to travel into the future and that is indeed a possibility. In fact, it's the one thing that physics says we absolutely can do. It's traveling back in time that we cannot do. Look at what Naomi wrote in the discussion, about her favorite Twilight Zone where two lovers meet and then one leaves on a space journey and that person speeds up his time so he can be with her at the same age, but then she freezes herself so she can be with him at the same age, and so it gets all messed up.

Reply

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

Feb 20, 2022

DISCUSSION

It was really cool learning about the twin paradox, and it reminded me of one of my favourite twilight zone episodes; where an astronaut found his sweetheart right before his mission. So in order to wait for him, the girl freezes herself for 80 years (which was how long his trip was going to be on earth time); little did she know, he "sped up" his time so he could age "normally", or should I say "earthly" just to be able to spend the twilight years with her; and when he got back she was still a young woman when he was a grandpa. It's kind of sad, but I always loved that they shifted the dynamic space and earth time.

I also found the hourglass cone diagram of possibilities that lead up to and event and the possibilities from that event to be refreshing. I feel like that's something I've always understood but could never put in it such a simple yet straightforward manner.

I attached a link as well, if anyone found the hammer and the feather video interesting. This was done in the world's largest vacuum, not as cool as the moon, but it gets points for being in HD picture and sound.

dropping a bowling ball and a feather in world's largest vacuum (https://www.youtube.com/watch?v=E43-CfukEgs)

QUESTION

How is curved light different from a mirage? and how have we proved that it's gravitational and not anything else?

Reply

(http

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

3:19pm

I love your reference to that Twilight Zone. I don't think I saw that one, but what an amazing plot. I love science fiction because I think it's much more human and emotion oriented than people realize. You take humans and put them in very extreme situations to see what they would do. It's very similar to the famous Grimm's Fairy Tale story about the girl with the long hair who wanted a brush, but so she sold her hair to get a chain for her husband's watch. Do you remember that one?

Reply

(https:/

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

Feb 20, 2022

DISCUSS:

It was really interesting learning about relativity. Knowing that thats even an aspect of our universe is mind blowing to me. It was also interesting learning about how gravity is just the warping of 4-D spacetime. It makes me wonder if us humans will ever reach a point in evolution and time where we can understand 4-D without the need for lower dimensional representations.

QUESTION:

Whenever I see renderings of black holes online they all have a really interesting warped ring of light surrounding them. I was wondering if thats because of the warping of spacetime caused by such a massive object that was discussed in this weeks lecture or some other phenomenon?

Reply

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

Feb 20, 2022

Hi Malcolm!

I believe the light around black holes comes from the accretion disk, a super hot collection of gas and dust going around the black hole at crazy high speeds. We can't see anything past the event horizon, the invisible boundary around the black hole that marks where light cannot escape its gravity, which is what makes it look like a literal "black hole." The accretion disk emits different types of light (both visible and not, as in x-rays and radio), and it releases photons that are pulled to the very edge of the event horizon where gravity to bends their paths around the black hole forming a "photon sphere" just outside the event horizon.

Reply

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

3:17pm

Originally Posted 3/2/22

Good question. Will we evolve to understand the fourth dimension, or will we evolve to actually sense it and see it? Never thought of that, but you're post made me think of that, and since human senses could potentially evolve in a way that a new sense might develop, perhaps that's a possibility. And yes, when you see diagrams of black holes, they're trying to show the curvature of space-time, and so if it looks a bit curvy, I think that's an accurate representation or an attempt to accurately represent such a strange concept is 4th dimensional curved space-time

Reply

Victor Jensen (https://canvas.sbcc.edu/courses/46681/users/416476)

Feb 20, 2022

Light cones were an incredibly interesting topic, and a neat way to visualize the dimension of time. Lookback time, the side effect of these cones, is also incredible. While we can't have an exact number of the age of the universe, lookback time does give us an absolute minimum age. Another neat side-effect of lookback time plus gravitational lensing is that sometimes we can observe the same event happen multiple times in the sky. An astronomer once used this as a sort of "party trick" where he predicted the time a star would go supernova to the day, and was correct, because the same star was reflected four times in the sky and the other three reflections had already gone. By measuring the time difference between the reflections, he could pretend to predict astronomical events to the hour.

I wonder if humanity will ever be able to effectively send people forward in time. While the inability to ever send information into the past is painful, imagine the interesting things that could come from being sent forward. Incurable diseases? Just go forward a bit to see if they're cured. Research that requires more than a lifetime? Just hop forward until the Nobel prize winning event occurs! I'd love to be able to live long enough to see when humans geographically isolated on other planets start speciating, or a bit longer until some of those civilizations collapse and leave behind neat space ruins. Once enough time has passed, it'd likely feel like stepping into another universe. Just be sure to bring your loved ones, as there's no going back (unless Futurama was right that you can just go forward until time loops, buuut a "big crunch" prefacing the nth Big Bang would be quite hard to survive). Also hope that humans haven't evolved to some godlike beings that see you as nothing but a wild animal.

QUESTION: A goofy philosophical question, but if you were certainly dying soon with no chance of being saved, would you take the opportunity to be sent forward to the death of the universe itself? Dying alongside all of creation; quite poetic.

Edited by **Victor Jensen** (https://canvas.sbcc.edu/courses/46681/users/416476) on Feb 20 at 10:20pm

Reply

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

3:14pm

Originally Posted 3/2/22

Very nice explanation about geodesics and curved space-time. You might want to consider being a teacher someday. About string theory and higher Dimensions, what's even more intriguing is that they are not just simply spatial Dimensions but they are folded or curled Dimensions. I don't fully understand it, but Brian Greene who is the famous String Theory

author, rolls up a piece of paper and explains what curled dimensions are. We will talk about those when we discussed string theory near the end of the class.

Reply

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

Feb 20, 2022

DISCUSSION:
The twin paradox was very interesting to read about, even more so because I had recently watched the movie Interstellar which deals with this idea. In Interstellar, Cooper travels through a wormhole found by Saturn that leads to a planet that is possibly habitable. It was stated that every hour that goes by is 7 years on Earth which is already incredible to think about. So seeing how the twin paradox was incorporated into a movie such as Interstellar was really fascinating.

QUESTION:
If you travel far enough away from Earth just like from Interstellar, could the twin paradox be considered another form of time travel?

Reply

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

3:11pm

Originally Posted 3/2/22

Great that you saw the movie Interstellar! That is a well-done movie and it adheres to the principles of science better than most others. They even hired Kip Thorne as a consultant and he's an expert on black holes. Keep in mind that the time dilation used by the movie Interstellar was a different type of time dilation than the twin paradox. There are two types, one has to do with traveling at high speeds in special relativity, and the other has to do with General relativistic time-dilation resulting from strong gravity or strong curvature of space-time.

Reply

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

Feb 20, 2022

I had always thought of the ether as being a much older concept, having died out or been proven false not long after the scientific revolution or the enlightenment. Thus, I was quite surprised to learn that it was around the turn of the century that this theory was finally disproven. Though, looking back, I certainly do see the logic behind the idea and I find it fun to visualize and say *(~ ether ~)*. I also found it funny that Einstein's first big break onto the scene was his argument against the need for the ether.

QUESTION: Is there a difference between "ether" and "aether" or is it just a spelling preference thing? What are other ways to prove Einstein's general theory of relativity besides the ones mentioned in the reading/lecture?

Reply

(http

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

Feb 22, 2022

ANSWER: I believe the difference is just the spelling, with aether being an old fashioned (Latin?) version.

Reply

(http

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

3:10pm

Originally Posted on 3/2/22

Great responses. Very thoughtful. I think the two terms for ether are just different spellings. Think of like Old English versus Modern English.

Reply

(https:/

Malachi Scott (https://canvas.sbcc.edu/courses/46681/users/409981)

Feb 22, 2022

Discuss: One thing I found unusually interesting was the general theory of relativity. the portion where it discusses in that scenario that space and time are now dynamic quantities particularly intrigued me. To consider the concept of it all, that when an object is moved or a force is acted the curvature of space & time is affected. This is crazy enough and then you proceed the reading to learn that the structure of space-time also affects how that said object or force acts.

Although, this leaves me with the question of why one cannot talk about the universe with just one notion of the two, for example space but not time?

Reply

(http

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

3:16pm

Originally Posted 3/2/22

Very thoughtful response.

Reply