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This is a graded discussion: 10 points possible

Show Due Dates

D12(BH) Weekly Discussion

Erin O'Connor

Apr 9 at 8:49am

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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

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

Apr 15, 2022

Discussion:

The Schrodinger equation, looking at this equation by its-self without explication looks like something no one could solve. After watching the 9-minute video it's a very interesting and complex equation. Being able to use an equation to predict where an electron could be inside of for example a box is crazy to me since how we can't see an electron. It's also such a wild concept to me because we're using math to predict something's position while we can't see the object that we are trying to describe. It's also very particular because the energy can only be found in very specific places inside of the box not outside.

Question:

Where does the Schrodinger equation fail?

Reply

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

Apr 17, 2022

In the equation video, we learned that Schrodinger's equation is based on Newtonian physics. I would assume that the equation fails relativistically due to this.

Reply

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

Apr 17, 2022

ANSWER

Hi Abigail,

After doing short research, I saw that the equation fails in describing the dynamics of highly energetic particles, it means that in the formula, it doesn't make sense, and that is where it doesn't work.

Thanks,

Franco Diaz.

Reply

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

May 1, 2022

Yes, Schrodinger's solution of a particle in a box is a famous example done by physics students when they take quantum mechanics. The box is the simplest way to find an electron and learn about energy levels, and in a simplistic way describes how an electron is trapped in an atom, which is sort of like a round box. It's more mathematically difficult to explain an actual atom then a box, so that's why they teach students about electrons in boxes first.

Reply

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

Apr 16, 2022

QUESTION: How does entropy with black holes work?

I feel like gravity in general decreases entropy as time goes on. Gravity turns the disordered vague clouds into ordered solid spheres, but the entropy still increases because temperature and rotational momentum increase. When gravity is pulled to the most extreme, down to a singularity, does temperature still even apply meaningfully? The particles can't be in motion if they're compressed into a single point. The particles orbiting the black hole are highly disordered, hot and moving incredibly fast, but what about when time approaches infinity? Eventually everything becomes one with the singularity.

If the expansion of the universe never ends, won't every gravitationally locked pocket eventually collapse into a singularity? Wouldn't concepts like the event horizon and gravitational force lose meaning when there's nothing left outside the singularity (making the one description of the event horizon increasing as a sign of increasing entropy not really make sense)? Would all the energy of the entire pocket become rotational inertia (the only one I feel still has meaning)? Is there ever a point where a black hole could rotate fast enough to rip itself apart?

I imagine these questions are just a mix of stupid questions, and questions without answers. Still, gravity is a force theoretically capable of turning a highly-disordered universe (in a pocket

that's gravitationally locked) into a highly-ordered point spontaneously via pressure. Just seems out-of-place.

Reply

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

May 1, 2022

I think your ideas are very good. You bring up many topics, some of which I've seen research papers about, and some of which are speculative but meaningful nonetheless. About black holes ripping themselves apart, that can happen with White Dwarfs and Neutron Stars perhaps, but not theoretically with Black Holes (at least I have never heard of it). But there is still much to learn about Black Holes. Perhaps YOU will be the one to figure it out someday!

Reply

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

Apr 17, 2022

DISCUSS:

I have always wondered about ways to establish time's flow and existence and the three arrows of time explain time well. I find it interesting that the thermodynamic arrow and the psychological arrow work together, well the psychological arrow follows the thermodynamic arrow. The cosmological arrow is in agreeance with the thermodynamic arrow making each arrow point in the same direction.

QUESTION:

If the cosmological arrow points backward then the universe is contracting. Is time flowing backward, like the cup reassembling onto the table, only constituted by the universe contracting?

Reply

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

Apr 17, 2022

ANSWER:

If I'm understanding the lecture video on the Arrows of Time, then if the Cosmological Arrow points backward, that means that the universe is contracting. But the Thermodynamic Arrow wouldn't move backward because entropy would continue to increase. The Psychological Arrow always points the same direction as the Thermodynamic Arrow, so it wouldn't reverse either, so we'd continue to perceive the passing of time to be in the direction we currently experience. However, is the Cosmological Arrow shifts to point backward, then intelligent beings will no longer exist. So, time would never truly move backward and no beings would exist to experience the contraction.

Reply

(http

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

May 1, 2022

Yes, thinking of time as separate arrows I think is really constructive. Simplistically, one could imagine that if the thermodynamic arrow reverses during the contraction of the Big Bang, then time should go backwards, but Hawking makes a point to say that thermodynamically heat will continue to increase entropy in the universe, but I'm not so sure how that will work at the very end when the universe collapses into a singularity. So, it's still a mystery to me.

Reply

(http

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

May 1, 2022

That's a great question. I think you meant to say that Schrodinger's cat is based on quantum mechanics, not Newtonian physics, but you are right in that there is no consideration of relativistic effects. I guess the cat would would have to be traveling near the speed of light before you have to work out the relativistic effects.. haha. I know cats are fast, so I guess this would be important to do... haha.

Reply

(https:/

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

Apr 17, 2022

DISCUSS:

Learning about entropy was fascinating because it felt so familiar yet so abstract at the same time. we experience these rules and tendencies every day yet when e apply them to bigger scales it becomes incredibly complex. It was really interesting hearing the thought that maybe life as we know it can only exist in the stage of the universe's life where it is expanding. It makes me think of what life could look like in other stages of the universe. The idea of Schrodinger's cat never really made sense to me until this lesson. The idea that the cat was both dead and alive at the same time was kind of like something I just had to accept. Now I understand that it is extrapolated from the quantum scale through a Geiger counter. It was also interesting to think about whether the cat counts as an observer or not.

QUESTION:

Could it be possible that maybe there is no way to unify quantum mechanics and relativity because they are simply two different perspectives of the same thing? Maybe our entire universe is a combination of multiple perspectives which we can only observe one at a time.

Reply

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

Apr 17, 2022

Hi Malcolm,

Good question! I think this is more of a philosophical and epistemological question than a scientific one, though there are certainly A LOT of scientific ramifications of understanding a grand unification theory. First, even if quantum mechanics and relativity couldn't be reconciled by us because of some limit of perception, that doesn't mean that they are actually different things. I don't think that is what you are trying to say but thought I would throw it out there as there are, as I think you are suggesting, potentially, things we may not be able to know because of the limits of our perspective, but that doesn't mean they don't "exist". What happened before, or to initiate, the big bang may be one of these.

However, I think there are some philosophical presuppositions that have to be made for science to work that require the assumption that there is a set of rules the universe follows that can be reconciled with one another. Again, whether or not these rules can be comprehended by us may be another question but regardless, we can't really know if we will be able to comprehend them or not. The major reason I see that logic and the scientific method necessitate a grand unified theory is Occam's Razor which basically says, if you have two theories of equal explanatory power, the simpler (or maybe the one

with fewer assumptions) of the two is likely the correct one. It seems to me that keeping quantum mechanics and relativity separate has less explanatory power and/or is more complicated. Basically, without unification, there is a gap between mechanisms within the universe. You get to a certain point in a physical phenomena and you have to either say "we don't know what happens here" or "magic makes it happen". So we need to assume that there is an answer to "what happens in that place or thing we don't understand?" or "How do we get from A to B?".

More fundamentally than this, we have to assume that things can be known and understood by us. Without this assumption, the concept of science or even knowledge itself kind of breaks down. Given that we have to make that assumption in the first place, why limit what we can understand? Basically, we have to assume there is an answer in order to even develop a framework (like the scientific method) to find the answer.

Reply

(http

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

May 1, 2022

That's an important insight, to realize that the cat is simply representing the quantum mechanical wave function probabilities of the radioactive decay process. This is known as entanglement, where when action is related to or dependent on another action, and if the first action is quantum mechanical, like radioactivity, well then the macroscopic cat must follow suit. Glad you followed along. I think many people don't catch that at all.

Reply

(http

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

May 1, 2022

I like your question. Hawking addresses this by imagining the laws of physics as different maps. One map can show you well what's happening in one area, but you need other maps to see other areas, and the maps overlap so that you can use both theories sometimes to explain the same thing, but in different ways.

Reply

(https:/

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

Apr 17, 2022

DISCUSSION

Hi everyone,

I liked it a lot this week! We didn't have a tremendous amount of homework for this week, and I think it was very cool because this is a rest week in my country, so I have a lot of time to rest. Although this, we saw exciting videos about physics that I enjoyed watching and studying. The quiz we did for this week was relatively easy, but the footage had fascinating facts that helped me learn more about black holes. I found it interesting that we saw a short video of Schrödinger's Cat, but I understand perfectly the concept and what they tried to say.

QUESTION

What do you you think about the video of Schrödinger's Cat?

Reply

(http

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

May 1, 2022

I'm glad that the week I didn't assign as much homework was a special rest week for you in your country. That means you will be energized and ready to go again for next week. Schrodinger's cat I think is really interesting and I hope the videos and discussions helped with the ideas.

Reply

(http

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

Thursday

I find the idea of Schrödinger's cat extremely fascinating. The idea of a thing being in a superposed state is mind boggling. Also, the thought that the wave function actually isn't collapsing but we are simply becoming a part of it very interesting as well. The first time I heard of Schrödinger's cat was in this show called "Dark" where they used it to explain how a character could have two completely different futures at the same time. At that point I though it was something that was created for the show but when I learned it was a real scientific concept it blew my mind!

Reply

(http

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

Thursday

Schrödinger's Cat makes sense, I can follow the logic of the explanation, but where I get lost is the Copenhagen Interpretation. I know what the words mean, but just how did they prove that mathematically.

Reply

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

Apr 17, 2022

DISCUSS:

Learning about the Arrows of Time was fascinating! All three of these Arrows must point in the same direction in order for conditions to support intelligent life. However, the Cosmological Arrow of Time can change direction independent of the other two Arrows, but is dependent upon whether the universe is in the expanding or contracting phase. I have certainly thought that it would be terrible to know we were living in a collapsing phase because it might feel like "the end is nigh". So I suppose there is some comfort in knowing that humans wouldn't be collapsed to our death when the universe collapses, though obviously something else would have to make us extinct before that happened.

QUESTION:

If the life cycle of the universe is expansion and then collapse, could the life cycle of black holes be the reverse? Collapse and then expansion? Do you think there could be a point where a black hold can no longer consume any more and would somehow eject everything back out?

Reply

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

May 1, 2022

That's a good point, to be in the collapsing phase of the universe would be sort of fatalistic. I'm sure we'll come up with new physics when the time comes so that we can escape into a different parallel universe. If you watch the old Star Treks, there are several episodes (at least two which come to mind) where civilizations escape into their own "past" or planet's history. So, we'll just have to get creative.

Reply

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

May 1, 2022

Very intriguing idea that black holes are the opposite of the universe's expansion and collapse, and in a sense there is much truth in that black holes collapse, but then radiate Hawking radiation and evaporate. But I don't know of any mechanism that would have them splurge out everything they've gobbled up for all of the universe's history. But the only thing we know for sure is that we don't know everything for sure. I'm keeping my fingers crossed.

Reply

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

Apr 17, 2022

DISCUSSION

I really enjoyed Stephen Hawking's argument for why we must observe time in the direction we do. While I had heard that the direction of time is based on entropy and that there is not really anything to dictate that time has to move in the direction that we perceive it to, I had never really understood the mechanism by which that worked. Hawking's explanation and argument made that clearer.

He breaks it down into (at least) three different "arrows of time". The first is the thermodynamic arrow of time or increasing entropy. The second is the psychological arrow, or our observation of time. The third is the cosmological arrow, or the expansion (as opposed to contraction) of the Universe. Hawking explains how the thermodynamic arrow basically necessitates the psychological arrow. This is because, in order for us to create memory, which dictates the direction of time (i.e. past vs future), energy needs to be spent. Memory is basically localized order within our brains from a "messy" state of on/off switches to a state that has order or, at least, utility because it is a specific state, rather than one of countless random states. Hawking uses the example of a computer but human or computer, energy is required to bring about this more ordered state. Energy (heat) increases entropy and, in fact, the energy required to create memory increases entropy A LOT more than entropy is decreased by the creation of the more ordered "memory" state. This means that, as far as we understand it, the creation of memories always increases entropy. Therefore, memories only work in a universe in which entropy is increasing.

The third arrow (and really the first two as well) is necessitated by the anthropic principle which basically says, the Universe is this way because, if it weren't, we couldn't be around for us to

observe that the Universe is this way. This works best in things that are statistical inevitabilities such as the question “Why are the conditions on Earth such that intelligent life evolved?” The answer being, “There are (at least) hundreds of billions of galaxies with 100 billion stars in each galaxy and potentially many planets and moons for each of those stars. Statistically, some of those will have conditions suitable for life. We are “lucky” enough to be on one of those because, if we weren’t, there wouldn’t be anyone here to ask the question in the first place.” It is sort of equivalent to Descartes’ “Cogito Ergo Sum; I think, therefore, I am”. So, regarding the expansion of the Universe, if the entropy of expansion must line up with the thermodynamic and psychological arrows for us to be able to observe the passage of time at all, we are in an expansion because, if we weren’t, we wouldn’t be able to form memories or even form questions. Hawking does also talk about how it may be that contraction of the Universe may also increase entropy, though he doesn’t go into detail as to how.

QUESTION

So bear with me on this one… If entropy is increasing in our universe, there are three possible fates of the universe, as discussed earlier in this class; closed, resulting in the big crunch, open, resulting in continued expansion or even a big rip, or flat, where expansion continues indefinitely but at with the expansion slowing infinitely as well. The big crunch could lead to another big bang singularity, starting the process over. My question has to do with the other two possibilities. It also appears that entropy and the increase of disorder is really more of a statistical model and that it is, for example, possible for every particle in a given space to spontaneously relocate to the other side of my yard (or the Universe, for that matter), but the odds of that happening are so infinitesimally small that it wouldn’t happen in the life of the Universe. My question is, is it statistically possible for every particle, virtual particle, everything, to spontaneously relocate into a singularity, and that the recreation of that singularity results in a new big bang? The odds of that must be mind bogglingly unlikely but, if there is no big crunch, time goes on literally forever, which means that eventually it would happen, right? I’m not sure how the expansion of space enters into this but it seems like space is just the effects of quantum mechanics on what should otherwise be empty area, so would the same probabilities apply? Can “empty” space come into and out of existence spontaneous too? The primary reason why this might not be the case is if the probability of that event happening is constantly increasing at a faster rate than the passage of time so that, if the probability of the event happening decreases faster than the passage of time, it will still always remain basically statistically impossible. I would think that this is more likely in the open model than the flat model, but I definitely don’t know enough about QM and the expansion of the Universe to know if any of this makes sense…

Reply

(http

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

May 1, 2022

I love your discussion about the arrows of time and the anthropic principle. Clearly this is right up your alley as a philosophy double major, and your contributions to the discussion or very well thought-out and significant.

Reply

(http

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

May 1, 2022

Your question is really intriguing as well. If I understood correctly your suggesting that through quantum mechanical tunneling maybe every atom in the universe and every photon and every subatomic particle would somehow quantum mechanically tunnel to the same position in space (or close to it), a small region of space that would then collapse down to a singularity and in that way end the universe. I guess one could calculate a probability for this but it would be a gogol of the times greater than the current age of the universe, which would cause one to think it's impossible. But only impossible in finite time. When you consider infinite time, then it's guaranteed to happen eventually. So this is the striking and shocking possibility that I have never thought of before. It seems impossibly impossible, but again we're talking about infinite time. However, the end of the universe isn't going to be due to to quantum mechanical tunneling, but if it's a closed universe it'll be due to gravity. It will be gravity, the force, that will bring all these particles together. They won't have to quantum mechanical tunnel, because gravity will bring them all together in the far distant future and then the universe can end. But when things come to an end, there are new beginnings - or so we hope.

Reply

(https:/

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

Apr 17, 2022

DISCUSS

I've attached a clip of "rick and morty"'s spin on schrodinger's cat, excuse the language lol

https://www.youtube.com/watch?v=lm2BSWjcYvI (https://www.youtube.com/watch?v=lm2BSWjcYvI)

(https://www.youtube.com/watch?v=lm2BSWjcYvI)

QUESTION

I don't quite understand how entropy falls under the laws of thermodynamics? Is it just cause of the transfer of energies?

Reply

(http

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

May 1, 2022

I love all the floating Schrodinger cats in the video clip that "are" and "are not".

Reply

(http

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

May 1, 2022

About your question as to why entropy falls under the laws of thermodynamics, I'm not so sure why. I guess if you think of chemistry, what causes a chemical reaction to occur spontaneously has to do with whether entropy increases.
It seems exothermic reactions always result in increased entropy, while endothermic reactions would require energy to force them to happen.

Reply