Physics 419
Lecture 7: Determinism, Conservation Laws and Limits of the Classical World
Feb. 16, 2021

1 Themes

- Causality Revisited
- Determinism
- Newtonian puzzles
- Olber's Paradox

2 Causality

Hume: Causation is a misguided mental construct.

Kant: Causation is established by pure reason alone and inextricable from any sensible view of the physical world.

Lewis: Causation is established by counterfactual dependency. Counterfactuals and free will . Free will is simply the ability to do otherwise. This statement is best understood as the existence of a possible world in which one did otherwise. Each world can be purely deterministic but as long there is no logical inconsistency with the existence of other possible worlds, then the ability to do otherwise exists.

3 Determinism

Hume: While most saw free will and determinism as being incompatible, Hume saw free will and indeterminism as being incompatible. His argument is as follows. Let's assume that one's actions are not determined by any prior events. Hence, your actions are not determined by your character, preferences, wishes, desires, etc. That is, your actions are random. Then the question arises, how can we hold someone responsible if their actions are not determined by their character. Hence for Hume, free will entails determinism; human behaviour arises from a causal chain. It is not random. There must be some causal connection linking your actions to your desires for their to be anything such as moral responsibility. Desires are shaped in part by one's history. For Hume, free will is to be understood on the counterfactual account as the hypothetical ability to do otherwise. Since there is nothing necessary about desires and preferences, there is no logical problem to entertain the possibility that things could have been otherwise. Hume's view goes under another name: compatibilism. You should think how is this view compatible with Hume's view that there is no such thing as causation.

The reason I bring this example up is that whether or not free will exists is a scientific question. So if we live in a Newtonian world which is deterministic from where does free will originate? Moral responsibility is generally only viewed as relevant if one has free will. But moral responsibility is a social and cultural matter. But if Newton rules out free will, then is morality moot? So the question of moral responsibility in a Newtonian world looms large.

Moral responsibility and determinism: Harry G. Frankfurt (author of 2005 monogram entitled, "On Bullshit") It is generally assumed that one has to be able to do otherwise for one to be held morally responsible (however one wants to define that) for one's actions. This is the principle of alternative possibilities (PAP). John Frankfurt established a set of counterexamples to this from which it became clear that determinism and moral responsibility are not necessarily incompatible. Let's take two individuals, Jones and Homer. Jones deliberates and ponders the possibility of stealing a computer from Best Buy. Let's assume he does not own Best Buy. Hence, it would be stealing if he goes through with his actions. Let's say after much deliberation he decides to steal the computer. Now let's introduce Homer, an individual who has the power and the intention to make Jones do whatever he wants. But Homer holds his cards close to his chest and only intervenes when he has to change the course of Jones's actions. By coincidence, Homer wants Jones to steal the computer. And hence Homer does not have to intervene. Because Jones deliberates and does what he wants without any intervention, Jones is morally responsible for stealing the computer. However, there is only one output in this deterministic system. Namely, Jones must steal the computer. Hence, we have a perfectly deterministic system (in this instance) but Jones is morally responsible. Are there any loopholes in this argument? This example comes from a long line of examples of this sort known as Frankfurt examples. The key point this example illustrates is that someone does not need to be able to do otherwise to be morally responsible.

There are many who object to Frankfurt-style counterexamples to PAP. Here is a summary of the argument that goes under the headline of flicker of freedom: "Suppose Jones's choice is undetermined up to the moment when it occurs, as many incompatibilists and libertarians require of a free choice. Then a

Frankfurt controller, such as Black, would face a problem in attempting to control Jones's choice. For if it is undetermined up to the moment when he chooses whether Jones will choose A or B, then the controller Black cannot know before Jones actually chooses what Jones is going to do. Black may wait until Jones actually chooses in order to see what Jones is going to do. But then it will be too late for Black to intervene. Jones will be responsible for the choice in that case, since Black stayed out of it. But Jones will also have had alternative possibilities, since Jones's choice of A or B was undetermined and therefore it could have gone either way. Suppose, by contrast, Black wants to ensure that Jones will make the choice Black wants (choice A). Then Black cannot stay out of it until Jones chooses. He must instead act in advance to bring it about that Jones chooses A. In that case, Jones will indeed have no alternative possibilities, but neither will Jones be responsible for the outcome. Black will be responsible since Black will have intervened in order to bring it about that Jones would choose as Black wanted." This quotation is from the 2006 book Moral Responsibility and Alternative Possibilities, edited by David Widerker and Michael McKenna.

The Frankfurt and Gettier examples occupy a unique place in analytical philosophy because they demolish two well-established theories, JTB and PAP, which occupy a grand place in the pantheon of philosophy. The Knobe effect is another such example (to be discussed in class).

4 Newtonian cosmology

The universe must be infinite for several reasons:

- A finite one would run down due to friction (e.g., tides).
- A finite one has a center (i.e., absolute position).
- Hard to reconcile Euclidean geometry with a finite universe.
- Olber's Paradox:

In an infinite, homogeneous (that is, uniform density) universe that is unchanging in time, then regardless of where one looks in the sky, one should eventually see a star albeit far out. Hence, there should be no dark spots in the sky. Dark spots indicate that part of the sky is cold. Why such drastic temperature gradients persist between bright objects and dark objects is the question? Mathematically, this paradox can be stated as follows. Consider a shell in the sky of radius R and width W. The flux energy from one star is $f = L/(4\pi R^2)$. Hence in each shell, the flux energy decreases with the inverse distance squared. So a shell that is twice as far out as our original shell must have a flux energy that is four times smaller. But the assumption that the universe is homogeneous at a large scale would tell us that all shells must have the same luminosity. The only way this can happen is if the number of stars increases by a factor of 4. So what this means is that the density of stars is independent of the radius. We can formulate this mathematically by the following construction. Let n (independent of R) be the density of stars in the volume carved out by the shell. The number of stars in the volume is $N = n4\pi R^2 W$. The total luminosity from the stars in the shell is $F = Nf = nLW$, a number independent of the distance the stars are from us. This means that all shells we can slice the sky in should be equally bright. So lets take lots of slices. We should see brightness everywhere. But we do not. This suggests that the world is in a state of disequilibrium. Note saying that there is dust in the dark regions does not work. Dust will heat up and radiate energy. That is, the dust would just heat up and glow like a star. So there should be radiation in the dark regions. But the dark regions are cold. So this does not work.

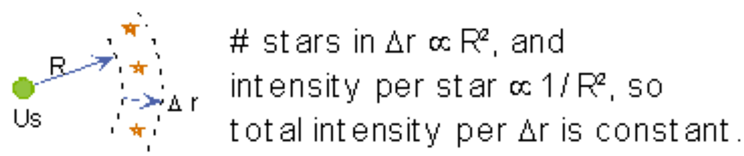

Figure 1: Cross-section of sky to illustrate the luminosity calculation in notes.

Brief primer on heat and energy

1. kinetic energy ($mv^2/2$)

2. potential energy (depends on positions of objects with forces between them, e.g. $-GM_1M_2/r_{12}$ for gravity)

3. chemical energy, "heat": That which flows across the boundary of a thermodynamic system by virtue of the temperature difference.

The history of heat illustrates how the interpretation of data is colored by one's theoretical framework. In the 18th century, heat was thought to be a fluid, the caloric. Lavoisier proposed that the temperature of an object depended on the amount of caloric it contained, like the height of water in a container depends on the amount of fluid it contains. Just as water flows from higher to lower, heat would flow from hotter to colder regions.

Count Rumford's cannon-boring experiment (1798) was the first blow against the caloric theory. Rumford rubbed a blunt tool used to bore a cannon against a flat plate. He then placed the plate and tool in a beaker of water. After a while, the water boiled. Since the only items Rumford transferred to the beaker were the tool and the plate, the boiling of the water must have occurred from these items alone. Hence, we have an instance of heating without a caloric. Rumford reasoned that heat must be nothing more than motion. In fact, a fairly good definition of energy is: motion that is entirely convertible into heat and hence a temperature increase or decrease. Notice, on this definition, energy provides a qualitatively different measure of motion than does the momentum. The momentum is mass*velocity. A particle that is moving back and forth in a straight line has no net momentum because the forward and backward momenta exactly cancel. However, such a particle has energy because the energy goes as the square of the velocity.

There may be ways around this problem: 1) the stars stop beyond some point, or 2) we are experiencing a 1 chance in $(10^{10})^{80}$ year dis-equilbrium in the universe. Neither of these is acceptable, however. The answer lies in the assumption of a static universe. Understanding what force regulates the grand cosmic motion is the big unanswered question.

5 Conclusions on Newton

Newton has given us 1) gravity, 2) an explanation of Kepler's laws, 3) symmetry and invariance (translational, rotational), 4) conservation of momentum, 5) absolute space, and 6) static universe.