MARK HARTMAN: What if we said that both of them were the same luminosity, but instead, star 1 was way out here? And now, d1 is greater than d2. Which one of these stars, in the image, is going to have a higher flux, is going to look brighter when we look at an image of that star?

So talk with your groups, and I'm going to do the same thing. I want you to then be able to come up and explain to us which has the higher flux when we measure from here on earth.

OK. Now, no changing your vote. How many people think that star 1 is going to have the higher flux? So zero. How many people think star 2 is going to have the higher flux? We have, like, five or six hands shoot up, and then just a couple hands-- yeah, I guess. All right, now that I've seen what everybody else has voted. So let's say we had 10 votes for star 2.

Who would like to come and explain why? Lauren? You don't have to write anything if you don't want to, but go ahead.

AUDIENCE: Well, if you--

MARK HARTMAN: Use it to point.

AUDIENCE: OK. So if it's the luminosity divided by 4 pi, because this is squared, then the luminosity's the same. This is the bigger number than this is, so this would be an even bigger number. And so then this would be a bigger number for the first star than it would be for the second.

And if you divide something by a bigger number, then the answer will end up being even smaller. I don't know if that made sense or not. But so the bigger the number you're dividing by, then the smaller the answer will end up being, I guess.

MARK HARTMAN: OK, so who would like to-- no, that was great. Who would like to take what Lauren said and say it in their own words? Explain it again. You can only volunteer yourself. Sorry, Nikki. You can't volunteer your teammate. Peter? OK, go ahead.

AUDIENCE: Flux is luminosity over 4 pi times the distance squared. Luminosity, for both of the stars, is 10. But star 1 has a larger distance. So if it's 10 divided by a large distance, then you're going to get a small flux. But if it's luminosity divided by a small distance, you're going to get a bigger flux.

MARK HARTMAN: OK, that's good. So if something is further away, if this distance is large, this number, the surface area of that imaginary sphere, gets a lot bigger. So we all said that this star, which is the same luminosity but it's closer, is going to have a higher flux.

So what I'm going to say now here is 20 times the luminosity of the sun. So star 1 is 20 times the luminosity of the sun. It's a certain distance away, far distance. Star 2 is less luminous, so it's only 10 solar luminosities. But the distance is half as much. So which one of those stars is going to show up in our image? Which is going to have a higher flux?

So everybody decided?

AUDIENCE: Yes.

MARK HARTMAN: Yes, OK. How many people think that star 1 is going to have a higher flux? So I got one, two, three, four. How many people say that star 2 is going to have a higher flux? And you can't vote twice. No fair changing your vote. So we've got one, two, three. And you guys abstain?

AUDIENCE: [INAUDIBLE]

MARK HARTMAN: What's that?

AUDIENCE: We said it would be [? either. ?]

MARK HARTMAN: OK. So we had one, two, three who said that star 2 is going to be the same. And how many people think it's going to be the same?

AUDIENCE: I said [? either. ?]

MARK HARTMAN: OK, I have one, two, three. And you guys don't count.

AUDIENCE: [? Even, ?]

MARK HARTMAN: You want to do even?

AUDIENCE: Yeah.

MARK HARTMAN: OK-- one, two, three, four, five, say even. Five say same. And so then we'll take two of you off there, and we'll go back to two.

So who wants to try to explain what they're thinking? Somebody who said that the flux from star 1 is going to be greater. I think you guys said that, didn't you?

AUDIENCE: What?

AUDIENCE: No.

MARK HARTMAN: Didn't you guys say that? Who said that?

AUDIENCE: He said that.

MARK HARTMAN: Chris said that.

AUDIENCE: No, I didn't/

MARK HARTMAN: Yes, you did.

AUDIENCE: I changed my answer.

MARK HARTMAN: OK. Then what did you change your answer to?

AUDIENCE: The one with the most people.

MARK HARTMAN: No, that's not how it works. I want you to come up, and I want you to explain, because I heard a couple of good things coming from you guys over there about why this one would have a higher flux. So stand up. There you go.

AUDIENCE: Why do I need a marker for?

MARK HARTMAN: Just in case, to point. If you wanted to write something, you can. Now, here's a tip. When you're up here talking to people, you always want to make sure that you turn around and look at them.

If you need to, we'll do a thing called touch, turn, and talk. So if you're talking about this thing up there, you don't want to be like, so then star 1 is up there, and there's another thing down here. That's the worst thing that you can do. You will run into that if you go to college because some professors will talk like this as they write on the board, and then you can't hear anything.

But I want you guys to point to something, turn around, say what you have to say about it. And then point again at something else, and then go from there. So Chris, you want to model that for us?

AUDIENCE: Sure.

MARK HARTMAN: OK.

AUDIENCE: I said that this one was going to brighter-- [? well, ?] get flux because--

MARK HARTMAN: OK, so you touched. Now turn around. Now talk to us.

AUDIENCE: I said that that was going to be brighter because this one is twice as luminous as this one. And it's 1.5, you said, right? The distance is 1.5.

MARK HARTMAN: It's twice as far away.

AUDIENCE: It's twice as far away, but it's-- wait, what? You just messed me up. Wait. Hold on. What was the other thing?

MARK HARTMAN: So this one is twice as luminous, but it's also twice as far away.

AUDIENCE: That's it?

MARK HARTMAN: Yeah.

AUDIENCE: Well, then they're going to be the same.

MARK HARTMAN: OK. So let's hear why you think they're going to be the same, because a lot of people said they were going to be the same.

AUDIENCE: Well, if this one's half as luminous as that one, and then this one's twice as far as that one, if you divide both of those factors, then it would be-- 2 divided by 2 is 1, and 1 divided by 1 is 1. So they're both 1.

MARK HARTMAN: OK. I can kind of see some of that. Who else said that it was the same who wants to come up and say that? That was good. And it did the touch, turn, and talk. Somebody else who said it was the same. Peter already did one. Anybody else want a chance? OK. Peter, go ahead.

AUDIENCE: [INAUDIBLE] I basically did the same thing Chris did. l1 is-- the distance is twice as long as l2. So it's times 2. But then-- so l2 is only half as luminous. I mean, l1 is two times as luminous as l2. So that's also times 2. And it cancels out to equal 1.

MARK HARTMAN: OK. So the first time, you said l1 is twice as luminous. But then what did you say about the distance? Because I think you said luminous again.

AUDIENCE: Oh. The distance for the first one is twice that of the second one.

MARK HARTMAN: OK. So if your distance gets bigger, what's going to happen to your flux?

AUDIENCE: It will decrease.

MARK HARTMAN: OK. So you're saying because on the top, l1 is twice as luminous, but then it's going to be twice as far. So you divide by 2 down here. So they kind of cancel out. OK.

What about somebody who said that f2 was going to be larger, that star 2 was going to be more luminous? Why would you say that? One of those three people.

AUDIENCE: I think that now.

MARK HARTMAN: You already got to change your answer twice. Let's think about who was one of the people who voted for f2 right away? You guys? Bianca?

AUDIENCE: Well, because you--

MARK HARTMAN: Turn, turn, and talk.

AUDIENCE: Because even though this is 2 times and it looks like it would cancel out, you square it. So it's really 4, not 2. So then if you do it out, so it's 20 [INAUDIBLE] divided by [? 4 ?] d squared--

MARK HARTMAN: If we rewrite and we just say that this is d, and this is 2d-- right? That's what we said.

AUDIENCE: Oh, yeah.

MARK HARTMAN: That's fine. Keep going.

AUDIENCE: And this would be 10 [? L7 ?] over 4 pi, and just d squared because there's no 2. It's not twice the length. So then this would cancel out to be 5. And then since the bottoms are the same, [? you can ?] see 5 is [INAUDIBLE]

MARK HARTMAN: OK. So does that convince anybody? Somebody else want to say that?

AUDIENCE: It [? convinced ?] me.

MARK HARTMAN: It convinced you?

AUDIENCE: [? Well-- ?]

MARK HARTMAN: OK, Chris, do you want to come back up here and explain why you think?

AUDIENCE: No, I didn't think because of the same way she did. I was just thinking because you said that if it was a farther distance-- not today, but Thursday or Wednesday, you said that the energy, it loses particles. And they become weaker as they travel. So I thought even though the distance was only half, it wouldn't get actually half of the amount as the other one. [? That would ?] get less than half because [INAUDIBLE].

MARK HARTMAN: Oh, OK. That's actually important. On Thursday, we didn't say that the particles got weaker, necessarily. The particles are always the same. They don't change. It's just that as they get further away from you, they spread out because they're going on straight lines, and those straight lines diverge from each other.

So as you go further out, yeah, the luminosity of this one is bigger. But every time that you double the distance away, the amount of flux that you get doesn't just drop by a factor of 2. It doesn't drop in half. It drops to one quarter of what the original was. Because if you think about it, the area, if I had-- say that Bianca was holding a light bulb. Pretend like you're holding a light bulb.

If I'm up here, I'm collecting this area of particles. As I go further back, those particles all spread out. If I go twice as far away, it's not that I'm just collecting twice fewer particles. I'm actually collecting four times fewer particles because this factor has to do with 4 pi times the distance to the object squared.

So even though we've doubled our luminosity between these two, distance always wins. When you've got something that's really far away, it's always going to get overpowered. This flux is always going to be overpowered by the distance.

So based on what we just said-- so the [? actual ?] what you would see is that the flux from the second [? star, ?] even though the other one is twice as luminous, the flux from the second star is still going to be more. You're still going to get more counts. So here is my question to you guys. What would I have to do to star 1?