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Rainer Weiss - Interview

Interview, October 2017
"Space is enormously stiff. You can't squish it"

Telephone interview with Rainer Weiss following the announcement of the 2017 Nobel Prize in Physics on 3 October 2017. The interviewer is Adam Smith, Chief Scientific Officer of Nobel Media. In this telephone interview, recorded immediately after his Nobel Prize was publicly announced, Rainer Weiss explains why measuring the effect of gravitational waves is so very hard to achieve, despite the extraordinarily high energies involved.

Transcript of the interview
[Rainer Weiss]: Hello
[Adam Smith]: Good morning, my name is Adam Smith calling from Nobelprize.org, the website of the Nobel Prize in Stockholm.
[Rainer Weiss]: Yeah, very good, I already talked to some of your ... with your colleagues this morning.
[Adam Smith]: First of all congratulations on the award of the Nobel Prize.
[Rainer Weiss]: Well thank you.
[Adam Smith]: It must be very special, in particular because you came up with the idea of this detector.
[Rainer Weiss]: Well be careful with that. Other people also had thought of detectors, so be careful with that. I mean, in fact there was a group in Russia in 1962 - Gertsenshtein and Pustovoit - I can't pronounce it for you well. They wrote a little paper in a Russian journal which none of us knew about that, not to do it by interferometry so much, but to use light as a way of doing this. And then it turns out, Joe Weber, unbeknownst to us, but also Joe Weber, who was sort of the first person to start thinking about this.
[Adam Smith]: With his Weber bars.
[Rainer Weiss]: Yeah the Weber bar, but at the end of the Weber bars he also has some notes about that maybe we should do this with interferometry. The whole world tried to reproduce the Weber experiments. I don't know, you're probably too young to know that, but the thing is that in '60 ... Weber made his big announcement in '69 and ... where he showed that he had, in three bars, he had seen gravitational waves and then that got, virtually everybody, well many, many groups, both in Europe and Asia and in the United States, tried to reproduce this and to everybody's disappointment nobody saw the same thing that Joe did, Joe Weber did. And, the way it happened in my life is I was teaching a course in general relativity, in the middle of that epic, sort of 1967, and I couldn't explain the way a Weber bar worked. Mostly because I just didn't know enough, ok, but it was that ... I thought that there must be an easier way to explain how a gravitational wave interacts with matter. If one just looked at the most primitive thing of all, 3D floating masses out in space and look at how the space between them changed because of the gravitational wave coming between them. And I gave that as a problem in the course, you know, and the kids in this course did it, because it's a fairly straightforward calculation. And that was sort of '67 and by about '72, '71 it turned out that many people were not seeing, I mean it was already quite clear that the bar technique and Weber's experiments were not being seen by others. And so I spent a summer thinking about, maybe this idea that I gave as an exercise in a course would be a nice way to try and do this because it was so easy to understand it. And that then turned into LIGO, but other people had thought of it. I didn't know that.
[Adam Smith]: Nevertheless a journey from the early seventies to now. The sense of achievement and excitement must be quite ...
[Rainer Weiss]: Oh no doubt. I mean look ... the thing ... it has nothing to do with pride. I did something that others didn't do. I actually did a calculation of what might be all the things that get in the way of being able to do it. Which actually turned out to be very useful. You know the different noises that would make it impossible to see it, or possible to see it, you had to solve a whole set of problems, and that was my contribution to it in the early days.
[Adam Smith]: Well that's it. It's quite mind-boggling to think of how precise this piece of equipment is.
[Rainer Weiss]: Yeah. [Laughs] That's true, and it's ... that's what took by the way. I think the easiest way to say it is that the concept is very straightforward. You measure the time it takes light to go between two orthogonal directions in the gravitational wave. And you measure that time very carefully, and that idea's sort of trivial. I mean most people who know a little bit of physics can make that calculation. On the other hand what happens to make it actually happen because the sizes of things is so small and I think the easiest way to say it ... Are you familiar with exponential notation, can I use that?
[Adam Smith]: You can yes.

[Rainer Weiss]: Well ok, I think the best way of saying it is this way. There are two factors of 1012 that had to be solved. One of them was that the light wavelength itself is 10-6 meters and so you had to devise a way to make light, which has this wavelength of 10-6 to go, to be good enough so you could measure 10-18 meters, and that is a factor of 1012. And that was not the hardest problem, but that was one of the major problems between, let's say 1972 to 2015. But the other one is another factor of 1012 which is just as serious and that's much harder to solve. And that took longer. And that took more effort. And that was that even though you may have this wonderful method of now breaking up a light fringe so you could do a part in 1012 of it, you still don't know that the thing that you're measuring is not being pushed around by forces that make it move much, much more, that are not gravitational, that are not gravitational waves. But other forces like thermal noise, like seismic motion, or god knows all the different things that happen in the world, that you were not being ... That, that same mirror that you're looking at is not being pushed around by, by things that make it move more than 10-18 meters. And that is another factor of 1012 about because it turns out that ground motion is about a few microns, 10-6 meters again. So you have to devise a wonderful way to get rid of the ground motion and then get rid of the thermal noise and now it's really at the point where we're worrying about the quantum noise. So ... But, it was all pretty well organised, I mean in the sense that people knew what the problems would be. It's just that it takes time to do a thing like that.

[Adam Smith]: The contrast between the minute precision to make the measurement and the size of the actual gravitational wave which is ...

[Rainer Weiss]: Yeah, yeah yeah. It's really ... What it tells you is something really interesting. It tells you that space is very, very stiff to distortion. You know the Einstein waves can be thought of as a distortion of space, and time. But the way we see it, we see it as a distortion of space. And space is enormously stiff. You can't squish it, you can't change its dimensions so easily. And it turns out that I think the easiest way to see that, or say it is that, it's ... I'll give you an example so that you can use it or think about it. If you put this whole thing that was detected, you know, back in the first detection, and put it not at a billion light years away , but rather put it at the sun, the distance of the sun. Suppose the sun had, somehow, put out those gravitational waves. You would have had a motion at the earth of, a motion of over a km, of about only 10-6 m. It's still tiny. In fact you could just about hear it in your ear, but the amount of power that went through you is something like 1024 watts per cm^2. It's huge. In other words, it's ... you know the sun puts out about 104 watts.

[Adam Smith]: So you can translate that into what, though?

[Rainer Weiss]: Yeah, yeah, in fact we did translate that in that initial paper into the amount of power was sort of brighter than anything in the universe, by 50 times brighter for the few moments in which that gravitational wave was actually, you know, travelling through you. It's an enormously stiff, the system just does not like to make, you cannot distort space very much but you do get a little bit and that's what we measure.

[Adam Smith]: That is a really beautiful concept to mention on this call, thank you so much. We will hopefully discuss all these things more when you come to Stockholm. You will be coming to Stockholm in December?

[Rainer Weiss]: Of course I will, and I intend, at least if you can manage it I would like to ... I prefer really often to talk to high school students, mostly because I think they're the future for us. And, I know I have to give lectures, I'm very happy to do that and so are my colleagues. But if you think that there's some high school students that would benefit from understanding this a little better I'd be very happy to do that.

[Adam Smith]: We will most certainly work to fill rooms with high school students for you. That's a great objective. We very, very much look forward to welcoming you to Stockholm. How do you feel about the coming day which will be completely taken over by this.

[Rainer Weiss]: What today? I don't know, I'm at home, still not completely dressed! Well I am now, a little but, yes I know that I have to confront all my colleagues and it's a charming thing to do, it's just a little awkward that's all.

[Adam Smith]: Good luck with finishing getting dressed and we look forward to meeting you in Stockholm in December.

[Rainer Weiss]: Yeah I'm very happy to come. I've been there once with - you gave a Nobel Prize to one of my colleagues named John Mather and George Smoot.

[Adam Smith]: Of course, because you also worked on the COBE project with them.

[Rainer Weiss]: Oh yeah I worked on that with them and I've been there and it's really quite a pleasure to come there.

[Adam Smith]: OK, well we greatly look forward to meeting you. Thank you so much.

[Rainer Weiss]: Bye bye.