

Q&A with Abraham (Avi) Loeb (January 25, 2019)

**Dear Dr. Loeb,
have you worried about the state of the world yet today?**

Of course, there is a lot to worry about. But at the same time, there is a lot to be hopeful about. There is a famous quote by [Nachman of Breslov](#) who said: “The whole world is nothing but a very narrow bridge, and the key is not to be fearful at all”.

Could you describe your profession in three sentences?

I get paid to think about the sky. My main interests involve the beginning and future of the universe, the nature of black holes and the search for extraterrestrial life. I was born on a farm and consider science as a privilege to continue my childhood curiosity about the world.

How did they get to it? Do you remember the moment when you realized what it was you wanted to spend your life with?

As a child, I was mostly interested in philosophy. I used to drive a tractor to the hills of my village and read books on existentialism. By age 18 I was drafted to the Israeli military. Since I preferred intellectual work I compromised on pursuing physics-based work during my obligatory service. This led me to a postdoctoral offer under the condition that I will switch to astrophysics and eventually to a faculty position at Harvard. At that point, I also realized that astrophysics offers exciting philosophical questions. It was similar to a situation where you follow an arranged marriage and then realize that you ended up marrying your true love. I am now the founding director of the [Black Hole Initiative](#), the only center in the world which focuses on black holes. This center is also unique in that it brings together scientists and philosophers. In this way, it closes a circle for me with my early love to philosophy. I am currently writing my first paper for a philosophy journal.

**Dear Mr. Loeb, in order for you to slowly get used to the spirit of our conversation: You graduated in plasma physics when you were 24. So far so normal but - what is plasma physics?
And what was the topic of your dissertation?**

My dissertation was in plasma physics, which is the physics of hot gases. Its title was: “Particle Acceleration to High Energies and Amplification of Coherent Radiation by Electromagnetic Interactions in Plasmas”.

**My conversation is about making science and scientists a bit easier to grasp. In other words, I use my own stupidity as a benchmark, like most people do. So pardon me if the topics I am interested in are a little simplistic. What I am interested in to begin with is the universe:
Tell me how you can manage to imagine its immensity without hitting your head against the wall.**

The physical size of the universe is not difficult to imagine, just the way an ant could imagine the size of a big city. It takes a long time to traverse but it is just bigger than the length scales one encounters on a daily basis. So, there is nothing qualitatively difficult to understand here. Just bigger in the same way that the distance between continents is bigger than your height.

What is overwhelming about the universe is its content. First the fact that same laws that govern nature in laboratory experiments also control the way the Universe behaves on vast scales. This should not be taken for granted. The universe could have been chaotic. Humans do not obey our societal laws at nearly the same precision as nature obeys the physical laws. This fact alone amazes me. But then, the universe contains a

remarkable wealth of phenomena far more extreme than we find on Earth, including exploding stars, accelerated expansion of the universe, dark matter, black holes, numerous planets of different shapes and compositions, and so on.

Realizing that there are more habitable planets in the volume that we can observe than there are grains of sand on all beaches on Earth implies to me that we cannot be alone. When you roll the dice so many times, there must be life elsewhere. We just need to find it. And once we find other intelligent civilizations, the key question is: “are they smarter than we are?” and if so “what can we learn from them?”

The universe was always there?

We do not know what happened before the Big Bang. This is one of the unsolved mysteries of modern cosmology.

This leads me to the next problem of my limited mind. As always. The universe was always there, and it is infinite. Are there any scientific findings that can help you deal with this basic information?

Yes, we can search for clues from the beginning of the universe. There are some observables such as gravitational waves or the statistics of density fluctuations that can inform us about what happened in the universe before or shortly after the Big Bang.

So you can almost understand the excessively challenged person who imagines a God who creates the universe and the earth. That is, however, not helpful for me. What is that God? A superpower... Where does it come from? Is it the universe? Where was it before the universe was created and what was that before?

There are many definitions of God and I only relate to the philosophical God as defined by Baruch Spinoza. This definition reflects the remarkable order that the laws of nature exhibit, which I mentioned before.

Let's move on to the next spectacle of the layman, those black holes in which matter disappears. Where does it disappear to?

Stephen Hawking demonstrated through a detailed calculation almost half a century ago that black holes evaporate by emitting thermal radiation. Nothing survives according to this calculation. There is a fundamental question that physicists are still struggling with: where does the information that went into the black hole go? Quantum mechanics implies that information cannot disappear, yet Hawking's calculation implied that it does. This “information paradox” is one of the unsolved problems in modern physics.

Or something else:

You founded the Black Hole Initiative. Apart from that marvelous name, what are you doing?

The [Black Hole Initiative](#) brings together astronomers, physicists, mathematicians and philosophers who are all excited about exploring black holes. The astronomers are hoping to get an image of a black hole, the physicists hope to solve the information paradox, the mathematicians and philosophers want to figure out what the nature of the singularity is at the center of a black hole. This is the region where Albert Einstein's theory of gravity breaks down because it does not incorporate quantum mechanics.

Theoretically, it makes sense to me that all sorts of things are to be found in the universe, if it is infinite. Are there really any scientists doubting that beyond this earth forms of life are existent somewhere in this cosmos?

Yes, there is a large contingency of scientists who think that we are unique or special. To me this is a sign of arrogance. I prefer to adopt the principle of “cosmic modesty”, by which the fact that we exist implies that we are not alone because a quarter of all the stars have planets with surface conditions similar to those on Earth.

Let us now take a look at this missile that was spotted in the shape of a cigar or a rusty white bread.
<https://blogs.scientificamerican.com/observations/6-strange-facts-about-the-interstellar-visitor-oumuamua/>

Since you have already said a lot about this topic – <https://www.zeit.de/wissen/2018-11/oumuamua-aliens-ausserirdisches-leben-harvard-komet-abraham-loeb> let me only briefly ask: Did the entirely logical explanation that it was an alien flying object damage your reputation?

Not at all. Last week I had five film producers contact me with the request to produce a documentary about my life and work.

And - isn't it absurd that one can run the risk of losing one's reputation if one is curious, which is actually the basic drive of all knowledge, of all inventions?

I agree. But I do not care what other people think. My own career taught me to ignore social trends and follow the principles I believe in: innovation and taking risk are essential for making discoveries. Prejudice should be banned from the scientific conversation.

That flying object - why didn't the sighting appear on all prime time news? Despite my excessive curiosity and consumption of all the news, I, for example, have only heard about it very late.

Eventually it did. I did not anticipate this much reaction. We wrote a regular scientific paper aimed at explaining an anomaly in the data, namely the extra force exhibited by ‘Oumuamua’s trajectory in addition to the Sun’s gravity, in the absence of visible cometary outgassing. We suggested ‘Oumuamua may be pushed by sunlight, like the light-sails we are currently developing in the [Breakthrough Starshot initiative](#) that I am involved in.

For comparison, last year I published another paper that explained an anomaly of an unusually cold gas in the early universe, as reported by the EDGES experiment. In that paper, we conjectured that dark matter has some small electric charge to explain away the anomaly. The dark matter paper was accepted for publication within a few weeks and received little attention from the media.

The reaction to the light-sail paper was different. I did not plan to have a press release about it, but the editor of *The Astrophysical Journal Letters* wrote to me in an e-mail: “You should consider a press release on this one”. Before I had time to act, though, two bloggers reported on our posting on arXiv (where I regularly post papers before they get accepted for publication, in order to get comments from the community before the paper is finalized). Within days, the item went viral on social media.

Since then I have received dozens of requests on a daily basis from TV, radio, and newspaper outlets. Over the past week, I had five film producers request to make documentaries about my work and life, and so on. So, yes... this was totally unexpected. But I do my best to use this public attention for a good purpose: to explain

that most of the time frontier science involves uncertainty due to lack of data, that innovation and risk-taking is essential for making discoveries, that prejudice should be banned from the scientific discourse, and that mistakes should be tolerated in order for innovation to prevail.

Do you think that – if I may put it rather plainly - governments know about extraterrestrial life quite well, yet relatively little is being communicated, because the human aversion to everything foreign would better be confined to earthlings in order to politicize? A party promising defence from extraterrestrials may find itself in argumentative difficulties much quicker than populists who promise little walls.

No, I do not think governments are competent enough to hold such secrets for a long time.

A very unscientific question, but: extraterrestrial life can be a gas, it can have forms we cannot imagine with our limited brains, which can only rely on the known. So, from time to time, do you imagine that you and your team would succeed in making contact with aliens? What does it look like, if so?

It would be shocking, because most likely they would be much more advanced than we are. I am very hopeful that we will establish contact in my lifetime.

You are doing research on light sails. Can you explain the principle in simple terms?

We are basically developing the technology of pushing a sail with light in the same way that a sail on a sailboat is pushed by air reflected off its surface.

People who are on fire for what they are doing have moments of pure endorphin release, intoxicating excitement in between routine and disappointment. What was the last thing you did feel that?

Not applicable to me.

Do you succeed in ignoring the current political development - towards deliberately idiotic dictators, sponsored by neoliberal forces, hostility to science in the name of the voter - or do you notice that, and how much does it offend your intellect?

Sometimes what I hear makes me doubt that our civilization is intelligent. We might be the laughing stock of more advanced civilizations if they are watching us.

What do you consider your greatest achievement so far?

My main scientific accomplishments had to do with making innovative predictions about the universe that turned up to be true. The top twelve of them are summarized in the following document, https://www.cfa.harvard.edu/~loeb/Predictions_Loeb.pdf

Do you have a positive final appeal to console us with?

One of the areas I promote is space archaeology, namely the search for relics from ancient cultures that are not around anymore, in space, the same way we do when digging into the ground. My hope is that finding relics from dead civilizations in space will teach us an important lesson to get our act together, treat our planet and other people better, so that we will avoid a similar fate.