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Fishing mission from another star?

When a peculiar object stole into the solar system in 2017, Harvard astronomer Avi Loeb sparked a firestorm by suggesting that it was a spaceship from somewhere else in the galaxy, on a reconnaissance mission. But he wasn't kidding

Oded Carmeli

Loeb. "As children we ask ourselves about the world, allow ourselves to err. As a scientist, you're supposed to enjoy the privilege of being able to continue your childhood. Not to worry about the ego, but about uncovering the truth. Especially after you get tenure." *Moti Milrod*

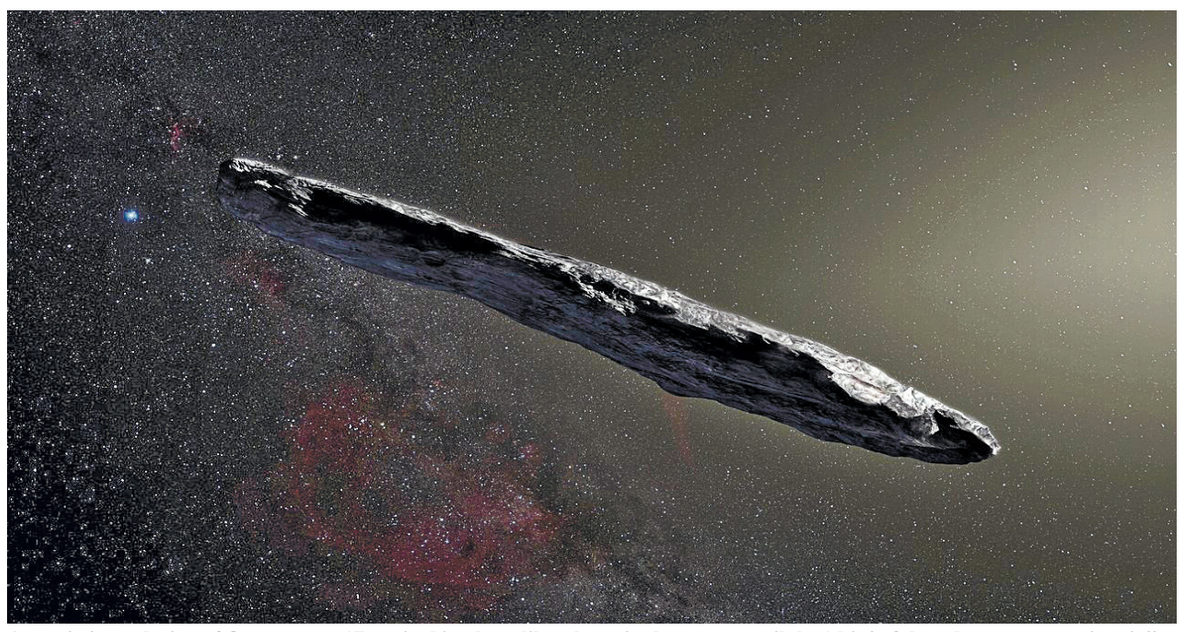
"I don't care what people say," asserts Avi Loeb, chairman of Harvard University's astronomy department and author of one of the most controversial articles in the realm of science last year (and also one of the most popular in the general media). "It doesn't matter to me," he continues. "I say what I think, and if the broad public takes an interest in what I say, that's a welcome result as far as I'm concerned, but an indirect result. Science isn't like politics: It is not based on popularity polls."

Prof. Abraham Loeb, 56, was born in Beit Hanan, a moshav in central Israel, and studied physics at the Hebrew University of Jerusalem as part of the Israel Defense Forces' Talpiot program for recruits who demonstrate outstanding academic ability. Freeman Dyson, the theoretical physicist, and the late astrophysicist John Bahcall admitted Loeb to the Institute for Advanced Study in Princeton, whose past faculty members included Albert Einstein and J. Robert Oppenheimer. In 2012, Time magazine named Loeb one of the 25 most influential people in the field of space. He has won prizes, written books and published 700 articles in the world's leading scientific journals. Last October, Loeb and his postdoctoral student Shmuel Bialy, also an Israeli, published an article in the scientific outlet "The Astrophysical Journal Letters," which seriously raised the possibility that an intelligent species of aliens had sent a spaceship to Earth.

The "spaceship" in question is called Oumuamua. For those who don't keep up with space news, Oumuamua is the first object in history to pass through the solar system and be identified as definitely originating outside of it. The first interstellar guest came to us from the direction of Vega, the brightest star in the Lyra constellation, which is 26 light-years from us. In the 1997 film "Contact," it's the star from which the radio signal is sent to Jodie Foster.

Oumuamua was actually discovered by a Canadian astronomer, Robert Weryk, using the Pan-STARRS telescope at the Haleakala Observatory in Hawaii. "Oumuamua" is Hawaiian for "first distant messenger" – in a word, "scout." It was discovered on October 19, 2017, suspiciously close to Earth (relatively speaking, of course: Oumuamua was 33 million kilometers away from us when it was sighted – 85 times farther than the moon is from Earth).

Whereas all the planets, asteroids and meteors that originate within the solar system more or less circle what is called the Ecliptic plane, that of our sun, since they were formed from the same disc of gas and dust that rotated around itself, Oumuamua entered the solar system north of the plane, in an extreme hyperbolic orbit and at a speed of 26.3 kilometers per second faster relative to the motion of the sun.



An artist's rendering of Oumuamua. "It waited in place, like a buoy in the ocean, until the 'ship' of the solar system ran into it." *ESO / M. Kornmesser*

A reconstruction of its trajectory shows that Oumuamua traversed the ecliptic plane on September 6, 2017, when the sun's gravity accelerated the object to a velocity of 87.8 kilometers per second. On September 9, the object passed closer to the sun than the orbit of Mercury. And on October 14, five days before it was discovered in Hawaii, the object passed 24.18 million kilometers away from Earth, or 62 times the distance from here to the moon.

What does it feel like to sit next to colleagues in a university lunchroom a day after publishing an article arguing that Oumuamua may actually be a reconnaissance spaceship?

Loeb: "The article I published was written, in part, on the basis of conversations I had with colleagues whom I respect scientifically. Scientists of senior status said themselves that this object was peculiar but were apprehensive about making their thoughts public. I don't understand that. After all, academic tenure is intended to give scientists the freedom to take risks without having to worry about their jobs. Unfortunately, most scientists achieve tenure – and go on tending to their image. As children we ask ourselves about the world, we allow ourselves to err. Ego doesn't play a part. We learn about the world with innocence and honesty. As a scientist, you're supposed to enjoy the privilege of being able to continue your childhood. Not to worry about the ego, but about uncovering the truth. Especially after you get tenure."

Without tenure you wouldn't have published the article?

"I suppose not. It's not just the tenure. I'm head of the astronomy department, and founding director of the Black Hole Initiative [an interdisciplinary center at Harvard dedicated to the study of black holes]. In addition, I'm director of the Board on Physics and Astronomy of the National Academies. So it could be that I'm committing image suicide, if this turns out to be incorrect. On the other hand, if it turns out to be correct, it's one of the greatest discoveries in human history. For us to make progress in understanding the universe, we need to be credible, and the only way to be credible is to follow what you see, not yourself. Besides, what's the worst thing that can happen to me? I'll be relieved of my administrative duties? This will bring the benefit that I'll have more time for science."

'Gravitational pushes'

The first friend from another solar system stirred great excitement among scientists, but its form and behavior also raised multiple questions.

"It was subjected to observation, but not enough," Loeb told me with disappointment, when I met with him in Tel Aviv at the end of December. "It was only under consecutive observation for six days, from October 25 to 31 – namely, a week after its discovery. At first they said, Okay, it's a comet – but no comet tail was visible. Comets are made of ice, which evaporates as the comet approaches the sun. But we didn't see a trail of gas or dust in Oumuamua. So the thinking was that it must be an asteroid – simply a chunk of stone. But the object rotated on its axis for eight hours, and during that time its brightness changed by a factor of 10, whereas the brightness of all the asteroids that we're familiar with changes, at most, by a factor of three. If we assume that the light reflection is constant, that means its length is at least 10 times greater than its thickness.

"There are two possibilities in regard to this extreme geometry," Loeb continues. "One is that it's in the shape of a cigar, the other than it has the shape of a pancake. The truth is that the same observers who examined Oumuamua's light variation reached the conclusion that if it receives a lot of gravitational pushes during the voyage – which is reasonable, because it spent a lot of time in interstellar space – its shape is pancake-flat. Subsequently additional qualities were discovered, such as its origin."

I wrote above that Oumuamua originated at Vega, but that's not completely accurate: The universe is a vast place, and even at Oumuamua's velocity – a velocity that no human spaceship has achieved – a voyage from Vega to the solar system would take 600,000 years. But in the meantime, Vega is orbiting the center of the Milky Way, like the sun and all the other stars, and it wasn't in that region of the heavens 600,000 years ago.

"If you average the velocities of all the stars in the region," Loeb explains, "you get a system that's called the 'local standard of rest.' Oumuamua was at rest relative to that system. It didn't come to us. It waited in place, like a buoy on the surface of the ocean, until the 'ship' of the solar system ran into it. To make things clear, only one of 500 stars in the system is as much at rest as Oumuamua. The probability of that is very low. After all, if it were a stone that was simply hurled from a different solar system, we would expect it to have the velocity of its star system, not the average velocity of all the thousands of stars in the vicinity."

However, the biggest surprise came last June, when new data from the Hubble Space Telescope showed that the mysterious object had accelerated during its visit to the inner solar system in 2017 – an acceleration that is not explained by the sun's force of gravity.

Acceleration of that sort can be explained by the rocket effect of comets: The comet approaches the sun, the sun warms the ice of the comet and the ice escapes into space in the form of gas, an emission that makes the comet accelerate like a rocket. But the observations did not reveal a comet tail behind Oumuamua. Moreover, gas emission would have brought about a rapid change in the rate of the object's spin, a change which was also not observed in practice, and it also might have torn the object apart.

If it wasn't comet outgassing, what force caused Oumuamua to accelerate? It is precisely here where Loeb enters the picture. According to his calculations, Oumuamua's acceleration was caused by a push.

"The only hypothesis I could think of," he relates, "is a push from solar radiation pressure. For that to work, the object would have to be very thin, less than a millimeter thick, in other words a type of pancake. In addition, the Spitzer Space Telescope found no evidence of heat emission from the object, and that means that it is at least 10 times more reflective than a typical comet or asteroid. What we have, then, is a thin, flat, shiny object. So I arrived at the idea of a solar sail: A solar sail is a spaceship that uses the sun for propulsion. Instead of using fuel, it is propelled ahead by reflecting light. In fact, it's a technology that our civilization is developing at this very time."

Bottles in space

Avi Loeb definitely knows a thing or two about solar sails. In 2016, the physicist and venture capitalist Yuri Milner, together with Stephen Hawking, Mark Zuckerberg and others, established Breakthrough Starshot, an initiative to accelerate solar sails to one-fifth the speed of light in order to explore the neighboring solar system, Alpha Centauri, which is four light-years away from us. Loeb was appointed the project's scientific director.

"The first question we asked is whether a sail like Oumuamua could survive billions of years in the Milky Way – and we discovered that it could. Being hit by interstellar dust or gas won't wear it down. Afterward, we tried to calculate the acceleration a solar sail would cause in an object [such as a ship or probe], and we found that the acceleration is consistent with that of Oumuamua.

"We have no way of knowing whether it's active technology, or a spaceship that is no longer operative and is continuing to float in space. But if Oumuamua was created together with a whole population of similar objects that were launched randomly, the fact that we discovered it means that its creators launched a quadrillion probes like it to every star in the Milky Way. Of course, the randomness is significantly reduced if we assume that Oumuamua was a reconnaissance mission that was deliberately sent to the inner solar system – namely, to the habitable region where life would be feasible. But we need to remember that humanity didn't broadcast anything tens of thousands of years ago, when the object was still in interstellar space. They didn't know there was intelligent life here. Which is why I think it's just a fishing expedition."

Fishing for what?

"I don't know. I love walking along the seashore when I'm on vacation, like here in Tel Aviv, and looking at the seashells with my daughters. Occasionally we find a glass bottle among the shells. In my opinion, the 'bottle' needs to be investigated. Until now we were looking for signatures of alien cultures in radio broadcasts, because we developed that technology in the last century. But another way is to look for a message in a bottle. Humanity launched Voyager 1 and 2, which are already in interstellar space. They're messages in bottles. And in this century there will be a great many systems to which a great many bottles will be sent, and at far greater velocities."

Like Breakthrough Starshot?

"Exactly. Our goal is to accelerate solar sails to one-fifth the speed of light, so that they will reach Alpha Centauri within 20 years. And the reason is clear: I am 56 years old, and Yuri Milner is 57. At that speed we will be able to see the pictures in our lifetime. Of course, the sails will continue on their way long after Milner and I are no longer around, maybe after none of us will still be here. It's possible that space is filled with sails like these and we just don't see them. We only saw Oumuamua because this is the first time we've had technology that's sensitive enough to identify objects of a few dozen to hundreds of meters in size from the illumination of the sun. In three years, the building of the LSST telescope will be completed. It will be far more sensitive than Pan-STARRS and certainly we will see many more objects that originate outside the solar system. Then we'll find out whether Oumuamua is an anomaly or not.

"The importance of my article lies in attracting the attention of astronomers so that they will use the best telescopes and look for the next object, and will even plan an encounter with it in space. The current propulsion technology doesn't offer us the possibility to chase after Oumuamua. The visitor comes for dinner, goes out into the street and disappears in the dark. It's possible we will never know what it was looking for."

But the project Breakthrough Listen used a radio telescope and listened to Oumuamua with amazing sensitivity, to the point of being able to receive a call from a regular mobile phone, from within the object. But we heard nothing.

"When I suggested to Milner that we listen to Oumuamua, back in November 2017, we knew that the chance of picking up something was poor to non-existent. Because even if a signal had been sent, it wouldn't necessarily have been sent in our direction – it would be in the form of a ray. In other words, even if this explorer broadcast back to its operators, we wouldn't necessarily have seen that. We also wouldn't know which frequency it was broadcasting on. And it's also possible that it wasn't broadcasting all the time, but only at particular times. And maybe there's no longer anyone for it to broadcast to."

Okay, this object was silent, but if they're out there, why haven't we heard any radio signals directed at us? We've been listening to the expanses of space for decades and hearing only the blood pounding in our ears.

"If to judge by our own behavior, it seems to me that the likeliest explanation is that civilizations develop the technologies that destroy them. There's a length of time during which a culture is still careful – for example, not to get into a nuclear war. But consider that if the Nazis had developed nuclear weapons, human history might have led to mass destruction. And there are, of course, asteroids and there's global warming and plenty of other dangers. The technological window of opportunity might be very small. Sails like these are launched, but they no longer have anyone to broadcast back to."

'We are primitive'

In other words, to Enrico Fermi's paradox – "Where is everybody? – you reply: "Dead."

"Definitely. Most of them. Our approach should be an archaeological one. In the same way we dig in the ground to find cultures that no longer exist, we must dig in space in order to discover civilizations that existed outside the planet Earth."

Isn't it easier, and therefore more scientific, to assume that we are alone until it's proved otherwise?

"No. Anyone who claims that we are unique and special is guilty of arrogance. My premise is cosmic modesty. Today, thanks to the Kepler Space Telescope, we know that there are more planets like Earth than there are grains of sand on all the shores of all the seas. Imagine a king who manages to seize control of a piece of another country in a horrific battle, and who then thinks of himself as a great, omnipotent ruler. And then imagine that he succeeds in seizing control of all the land, or of the entire world: It would be like an ant that has wrapped its feelers around one grain of sand on a vast seashore. It's meaningless. I assume that we are not the only ants on the shore, that we are not alone."

That's speculation. You don't know that for certain.

"The search for extraterrestrial life is not speculation. It's a lot less speculative than the assumption that there is dark matter – invisible matter that constitutes 85 percent of the material in the universe. The dark matter hypothesis is part of the mainstream of astrophysics – and it is speculation. Life [elsewhere] in the universe is not speculation, for two reasons: (a) We exist on Earth; and (b) There are a great many more places that have physical conditions similar to Earth. Science contains many examples of hypotheses that haven't yet been borne out by observations, because science progresses on a basis of anomalies, on a basis of phenomena that aren't amenable to conventional explanations."

'If Oumuamua was created together with a whole population of similar objects that were launched randomly, the fact that we discovered it means that its creators launched a quadrillion probes like it to every star in the Milky Way.'

But there's a vast difference between the search for dark matter and the search for extraterrestrial life. You wouldn't have been interviewed on "Good Morning America" about an article dealing with dark matter.

"Because there's extensive science-fiction literature about contact with advanced civilizations, and not about dark matter. So what? Most scientists talk about a search for primitive life, but there's a taboo on the search for

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intelligent life. Maybe I don't understand that. After all, the only place where primitive life exists, namely Earth, also has intelligent life – if we're actually intelligent. Our science is not healthy. I asked a scientist who's researching objects in the Kuiper belt, a senior astronomer who discovered a large number of the objects there, if he had discovered changes in their brightness originating in artificial light. He replied, 'Why search? There's nothing to search for, it's clear that their brightness will change like light that's reflected back naturally from the sun.'

"If you're not ready to find exceptional things, you won't discover them. Of course, every argument needs to be based on evidence, but if the evidence points to an anomaly, we need to talk about an anomaly. Who cares if this anomaly appeared or did not appear in science-fiction books? I don't even like science fiction."

'As soon as we leave the solar system, I believe we will see a great deal of traffic out there.... Or we'll discover the remains of multiple dead civilizations.'

Come on, now. You don't like science fiction?

"No. When I read a book that contradicts the laws of nature, it bothers me. I like literature and I like science, but the combination bothers me."

So as a boy you didn't read "Rendezvous with Rama" by Arthur C. Clarke? Because it really recalls the encounter with Oumuamua.

"No. What occupied me were the basic problems of life."

The origin of life? Its distribution in the universe?

"Life itself, our life as human beings. I read books of philosophy, mainly existentialism. I was born in a moshav, and every afternoon I collected eggs and on weekends I would drive the tractor into the hills, to read there. I loved nature. I liked being alone. I don't have a footprint on the social networks. I think of ideas when I'm alone in the shower. And I never thought about being famous. I wrote a scientific article that was published in a scientific journal. I didn't even issue a press release. Two bloggers found the article in an archive, and it went viral."

And how did you feel about being a viral scientist? The report about your piece was obviously the most popular space article in the past year.

"I took advantage of the media exposure to explain the uncertainty of the scientific process. The populist movements in the United States and Europe rest in part on the fact that the public has lost faith in the scientific process. That's why people deny global warming, for example. One of my interviewers in Germany said, 'There are scientists who maintain that it's a mistake to go public when you're not yet certain.' Those scientists think that if we reveal situations of uncertainty, we won't be believed when we talk about climate change. But the lack of credibility is due precisely to the fact that we show the public only the final product. If a group of scientists closet themselves in a room, and then emerge to deliver a lecture on the result as though to students, people won't believe them – because they won't have seen the doubts, they won't have seen that there weren't enough data in the earlier stages.

"The right way is to persuade the public that the scientific process is a normal human activity, that it's no different from what a police detective does or a plumber who comes to fix a drainpipe. Scientists are considered an elite, because they themselves create that ivory tower artificially. They say, 'The public doesn't understand, so there's no need to share with them. We'll decide among ourselves what's right, and then we'll tell the politicians what needs to be done.' But then the populist politician says, 'Only the elite say that, they are hiding other things from us.' Because there's a leap to the stage of conclusions and policy. The differences of opinion in the scientific community are what lend humanity to the scientific process, and humanity lends credibility."

If we do actually discover that we're not alone in the universe, what effect would that discovery have on our life, do you think?

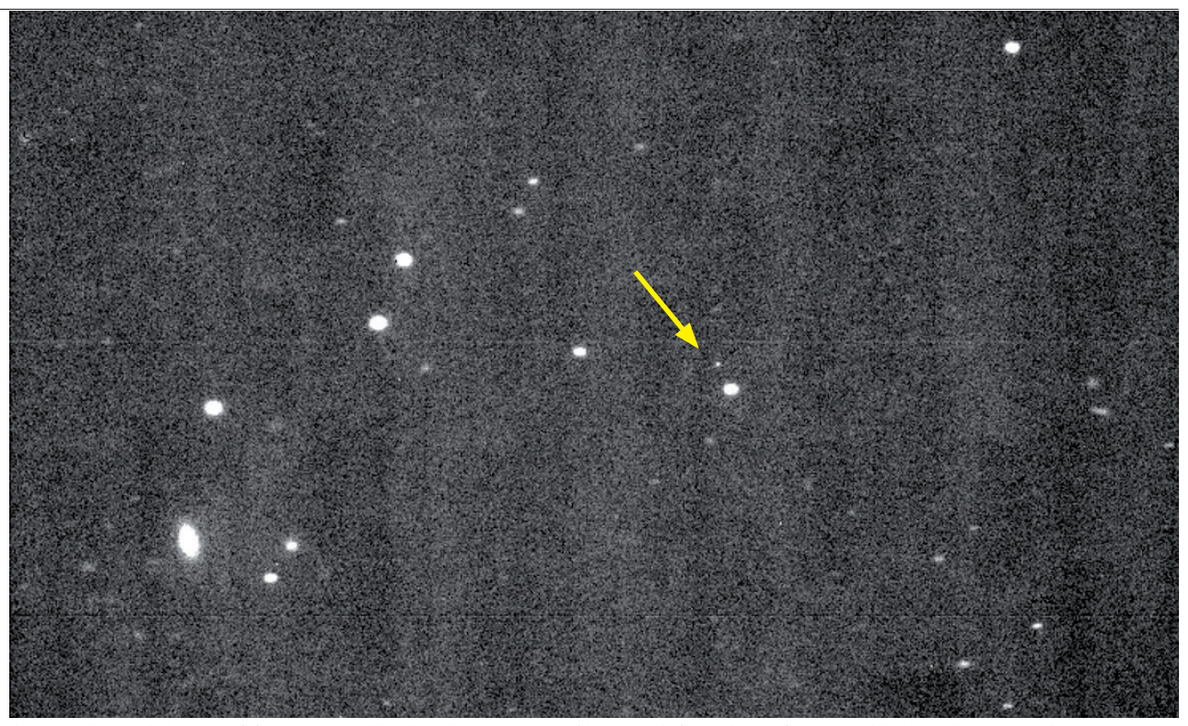
"A huge effect. They will probably be more advanced than we are, given that our technology developed only recently. We will be able to learn a great deal from them, about technologies that were developed across millions and billions of years. And it could be that this is the reason we haven't yet identified extraterrestrial intelligent life: because we are still primitive life that doesn't know how to read the signs. As soon as we leave the solar system, I believe we will see a great deal of traffic out there. Possibly we'll get a message that says, 'Welcome to the interstellar club.' Or we'll discover multiple dead civilizations – that is, we'll find their remains."

And that will be the good news? Because, if there are a lot of civilizations more developed than ours that were liquidated or liquidated themselves, that's not a good sign for the future.

"It will be an excellent sign. It will give us second thoughts about what we are doing here and now, so that we will not share the same fate. We need to comport ourselves much more decently and less militantly with one another, to cooperate, to prevent climate change and to settle in space. That should lead to a good place. The basic question is whether people are good, at the foundation."

And what's the answer, in your view?

"I believe they are. As soon as it becomes clear that there really have been many civilizations that have become extinct, I believe that people will learn the right lesson. And if we discover remnants of advanced technologies, they will prove to us that we are only at the start of the road; and that if we don't continue down that road, we will miss a great deal of what there is to see and experience in the universe. Imagine if cavemen had been shown the smartphone you're using to record me. What would they have thought about this special rock? Now imagine that Oumuamua is the iPhone, and we are the cavemen. Imagine scientists who are considered the visionaries of reason among the cavemen looking at the device and saying, 'No, it's just a rock. A special rock, but a rock. Where do you come off claiming it's not a rock?'"



A raw, telescopic image of Oumuamua (the tiny dot at center of image). A first visitor from outside the solar system? *ESO / O. Hainaut*

MOVES

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Allow me to suggest, though, that when Netanyahu goes all the way to Congress to lobby for crippling sanctions against the entire Iranian people, when he regularly orders and institutes collective punishment against all the Palestinian residents of Gaza and the West Bank, he is on shaky ground when at the same time, he insists that boycotts of Israel are violent anti-Semitism – while sanctions driven by Israel are framed as legitimate and statesmanlike and necessary.

In many ways, Israel's demonization of the BDS campaign has been more effective in swaying support to the Palestinian cause, than has the BDS campaign itself.

Seen from abroad, Israel's government appears wheezy, graft-ridden, authoritarian, woefully and cluelessly incompetent. Seen up close, it looks the same.

Every day that the Netanyahu government alienates Jews abroad, until recently the bedrock of international support for Israel, is a great day for the Palestinian cause.

Every day that the Netanyahu government coddles and courts white-nationalist activist regimes and activists at the expense of supporting Diaspora Jews legitimately fearful of mounting right-wing anti-Semitism, is a great day for the Palestinian cause.

Every day that the Netanyahu government chooses Donald Trump and fundamentalism over the pro-democracy, pro-equality and pro-pluralism views of the majority of Diaspora Jews, is a great day for the Palestinian cause.

Every day that radical settlers burn the Israeli flag, or write "Death to Zionism," or replace the Star of David with a swastika, is a great day for the Palestinian cause.

Maybe the fiery criticism of Rashida Tlaib has more to do with the critics than their target. Maybe it's pointing to a world in which advocates of an independent Palestine and of Palestinian rights are demanding that their voices be heard and their basic human rights be respected.

Maybe it describes a world in which Israeli leaders routinely dismiss the words occupation and apartheid – and Palestine – as if they were as obscene and unacceptable as, say, Rashida Tlaib's description of Donald Trump as "The Motherf*cker."

Israeli leaders and "explainers" can deny the reality of occupation and apartheid all they like. But if Israel continues in its current trajectory, it won't be the words "apartheid" or "occupation" that will become triggering obscenities connoting depths of injustice, inequality, and oppression. It will be the word "Israel" itself.