Professor proposes how a black hole in orbit around a planet could be a sign of an advanced civilization

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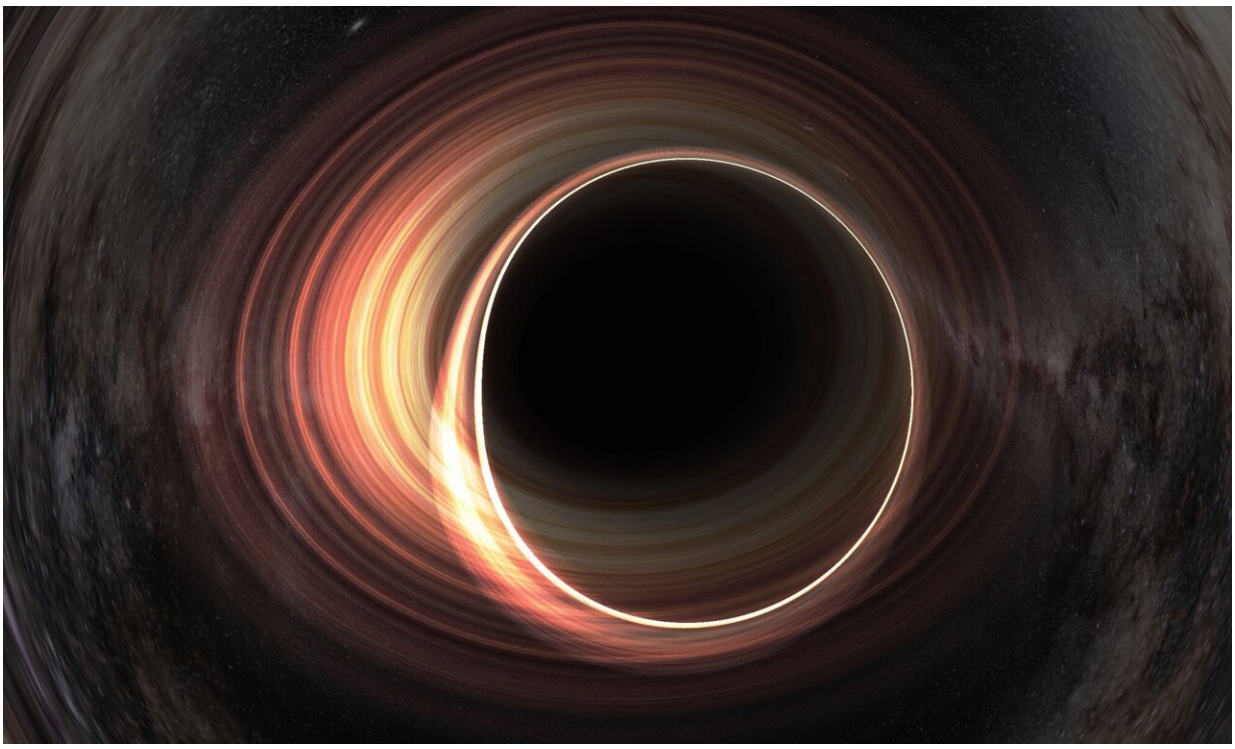

Ray traced shadow of a spinning and charged black hole. Credit: Simon Tyran, CC BY-SA 4.0

In 1971, English mathematical physicist and Nobel-prize winner Roger Penrose proposed how energy could be extracted from a rotating black

hole. He argued that this could be done by building a harness around the black hole's accretion disk, where infalling matter is accelerated to close to the speed of light, triggering the release of energy in multiple wavelengths.

Since then, multiple researchers have suggested that advanced civilizations could use this method (the Penrose Process) to power their civilization and that this represents a technosignature we should be on the lookout for.

Examples include John M. Smart's Transcension Hypothesis, a proposed resolution to the Fermi Paradox where he suggested advanced intelligence may migrate to the region surrounding black holes to take advantage of the energy available.

The latest comes from Harvard Professor Avi Loeb, who proposed in a recent paper how advanced civilizations could rely on a "Black Hole Moon" to provide their home planet with power indefinitely. The way this black hole would illuminate the planet it orbits, he argues, would constitute a potential technosignature for future SETI surveys.

Professor Loeb is the Frank B. Baird Jr. Professor of Science at Harvard University, the Director of the Director of the Institute for Theory and Computation at the Harvard-Smithsonian Center of Astrophysics (CfA), the founding Director of the Black Hole Initiative (BHI), and the head of the Galileo Project.

His latest paper, "Illumination of a Planet by a Black Hole Moon as a Technological Signature," was recently published in the *Research Notes of the AAS*.

In 1975, Stephen Hawking theorized that black holes emit photons, neutrinos, and some larger particles—thereafter known as "Hawking

Radiation." Since then, proposals for using black holes as an energy source generally fall into one of two camps.

On the one hand, there's the possibility of harnessing the angular momentum of their accretion disks (the "Penrose Process") or capturing the heat and energy generated by their hypervelocity jets (perhaps in the form of a Dyson Sphere). On the other, there's the possibility of feeding matter onto the black hole and harnessing the resulting Hawking Radiation.

In his paper, Loeb proposes how an advanced civilization could rely on the latter process by engineering a black hole that would orbit its home planet. This black hole would be very small, weighing just one hundred thousand tons (10^{11} g).

If left unchecked, this black hole would evaporate in just a year and a half through the emission of Hawking Radiation. But as Loeb told Universe Today via email, it could be maintained by accreting relatively small amounts of matter (2.2 kg; 4.85 lbs) onto it per second. In exchange, it would provide an endless supply of power:

"This black hole system is the most efficient engine that I ever thought about. The fuel is converted to energy with the perfect efficiency of 100%, because the mass falling into the black hole is ultimately coming out as Hawking radiation. I have not seen this idea discussed before and had a "Eureka moment" when I realized it a few weeks ago. The only other method for converting mass to radiation with 100% efficiency is matter-antimatter annihilation."

As Loeb indicates, the amount of antimatter required is beyond anything humanity can achieve at present. Since 1995, the particle colliders at CERN have managed to produce less than 10 nanograms of antimatter, which is enough to power a 60-watt lightbulb for four hours. In

comparison, Loeb's proposed 10^{11}g black hole could continuously supply 40 quadrillion (4015) Watts.

"The global energy use is a few terra-Watts, ten thousand times less than the power supply of this black hole," Loeb added. "The other advantage of this black hole engine is that it can use any form of matter as fuel. It could be trash. There is no better way to recycle trash than convert it into clean energy with 100% efficiency."

Another advantage is that a black hole can use any form of matter as fuel, including whatever waste the civilization produces. In this respect, a black hole engine would solve an advanced civilization's garbage problems while providing an inexhaustible supply of energy in return.

Globally, humans produce roughly 1.92 billion metric tons (2.12 US tons) of waste annually, which is having a severe impact on our environment. This would be enough to feed a black hole engine weighing 10^{11} g for more than 437 million years.

As to how such a feat could be accomplished, Loeb refers to a previous op-ed in which he theorized that a sufficiently advanced civilization could create a "baby universe" through quantum tunneling. Whereas such a feat would be something only a Type III Civilization (or more advanced) could achieve, a black hole engine would be much simpler and perhaps something a Type II Civilization could engineer.

"This is the big challenge. The good news is that it is much easier to produce such a black hole than a baby universe. But any production line of a 10^{11} g black hole requires compressing matter or radiation to a mass density that is 60 orders of magnitude above the density of solid iron. The density of atomic nuclei or neutron stars is only 15 orders of magnitude above solid density. This was possible to achieve in the cosmic radiation density less than a femtosecond after the Big Bang."

This was the subject of another recently written paper by Loeb in which he argued that, based on General Relativity, black holes can be made out of light. But what is most interesting about this proposed black hole engine is the way it would be detectable light-years away, making it a viable technosignature that would indicate the existence of an advanced civilization.

Like many proposed technosignatures, particularly Dyson Spheres and other megastructures, the existence of a black hole engine is speculative and theoretical. But as Freeman Dyson himself once related, whatever we can conceive (and if the physics are sound), a sufficiently advanced civilization may have already been created. Said Loeb:

"The black hole engine could be discovered as a rogue rocky planet that is illuminated by a gamma-ray moon with no stellar-mass companion. If we ever find evidence for such an engine, we would need to consider the possibility that the source was created or trapped as a primordial black hole by a highly advanced technological civilization. There is no better marker of technological innovation than creating a furnace out of spacetime curvature in the form of a mini black hole."

More information: Abraham Loeb, Illumination of a Planet by a Black Hole Moon as a Technological Signature, *Research Notes of the AAS* (2024). DOI: 10.3847/2515-5172/ad6e7a

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