

# The End of Time Could Be of Our Own Making

Avi Loeb

In response to "[The Good Soldier](#)" (Vol. 5, No. 2)

**"Do I dare Disturb the universe?"**

[The Love Song of J. Alfred Prufrock](#)

By [T. S. Eliot](#)

*To the editors:*

In "*Until the End of Time*", Brian Greene describes the unavoidable cosmic fate awaiting us given the laws of physics that govern nature. In his review of the book, David Berlinski argues that our "free will" is not governed by unavoidable forecasts. Are we merely passive passengers on a train driven by the laws of nature towards a destination that we cannot avoid? Or could we get a hold of the control car and shape our future at will, providing a surprising twist to the cosmic plot?

My answer is a definite "yes". If so, how? Through space travel. We can demonstrate that this is not "an argument among billiard balls about which pocket they might join", in Berlinski's words. Rather, our cosmic fate is in our hands. Let me explain.

The accelerated expansion of the Universe pushes resources away from us at an ever-growing speed. Once the Universe will age by a factor of ten, all stars outside our Local Group of galaxies will not be accessible to us - as they will be receding away faster than light. Is there something we can do to avoid this cosmic fate? Following the lesson from Aesop's fable<sup>1</sup> "*The Ants and the Grasshopper*", it would be prudent to collect as much fuel as possible before it is too late, for the purpose of keeping us warm in the frigid cosmic winter that awaits us. In addition, it would be beneficial for us to reside in the company of as many alien civilizations as possible with whom we could share technology, for the same reason that animals feel empowered by congregating in large herds.

After writing a few papers on the gloomy cosmic isolation that is expected in our long-term cosmic future<sup>2-5</sup>, I received an optimistic e-mail<sup>6</sup> from Freeman Dyson in 2011, where he suggested contemplating a vast "cosmic engineering" project, in which we (in collaboration with any neighboring civilizations, if they exist and cooperate) will concentrate matter from a large-scale region around us to a small enough volume, such that it will stay bound by its own gravity and not expand with the rest of the Universe.

Fortunately, mother Nature had been kind to us as it spontaneously gave birth to the same massive reservoir of fuel that we would have aspired to collect by artificial means. Primordial inhomogeneities from the early universe led to the gravitational collapse of regions as large as tens of millions of light years, assembling all the matter in them into clusters of galaxies - each containing the equivalent of a thousand Milky Way galaxies. Therefore, an advanced civilization does not need to embark on a giant construction project as suggested by Dyson, but only needs to propel itself towards the nearest galaxy cluster and take advantage of the cluster resources as fuel for its future prosperity.

The nearest cluster to us is *Virgo*, whose center is about fifty million light years away. Another massive cluster, *Coma*, is six times farther. Other advanced civilizations might have already migrated towards clusters of galaxies in recent cosmic history, similarly to the movement of ancient civilizations towards rivers or lakes on Earth. Once settled in a cluster, a civilization could hop from one star to another and harvest their energy output just like a butterfly hovering over flowers in a hunt for their nectar. The added benefit of naturally-produced clusters is that they contain stars of all masses, much like a cosmic bag that collected everything from its environment. The most common stars weigh a tenth of the mass of the Sun, but are expected to shine for a thousand times longer because they burn their fuel at a slower rate. Hence, they could keep a civilization warm for up to ten trillion years into the future. The nearest examples of dwarf stars in the form of Proxima Centauri or TRAPPIST-1 are known to host habitable Earth-size planets around them, implying that these abundant stars offer attractive parking spots for civilizations that rely on liquid water.

In order to traverse a hundred million light years within the age of the Universe, our spacecrafts need to exceed a percent of the speed of light. This is a hundred times faster than the speed of any chemical rocket launched so far by our civilization into space. The *Starshot Initiative*<sup>7</sup> is the first funded project to develop a light-sail technology that could propel a spacecraft up to a significant fraction of the speed of light. If successful, our civilization could contemplate a future journey to the *Virgo* or *Coma* clusters. This would be an impressive feat of long-term planning. When looking at photo albums that are billions of years old, our descendants might reminisce on the early times that their parent technological civilization spent within the Milky Way galaxy. By then, that birth site will be receding away from them at an ever-increasing speed until its image will freeze and fade away for eternity<sup>2</sup>.

Would this accomplishment demonstrate that humans have free will or could it be that we are merely following what nature destined us to do, without even knowing it? As long as Brian Greene finds this end surprising and outside the scope of his book, I rest my case.

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