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Writer's Workshop Series
The Art of Science Fiction
No. 3

The Einstein Barrier, Part 1

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One of the problems faced by science fiction writers is that, in order for their writing to be convincing, they must understand the true scale of the universe. It is not enough to say that the universe is big. It is, of course, but to say so is like saying that a hurricane is damp. The universe is so incredibly huge that we mere human beings have trouble comprehending its true size. In fact, we are psychologically ill prepared to think about things as big as even a single star, let alone the 100 billion stars that make up our own galaxy, or the 100 billion other galaxies beyond our own. The universe is such a large place that even the most megalomaniacal among us are given pause when we first contemplate humanity's place in the scheme of things.

Even a simple thing like traveling to the nearest star is so far beyond twentieth century technology that many scientists doubt our species will ever be up to the task. Yet, we science fiction writers are required by both long convention and personal inclination to ignore such negative thoughts. Our ships ply the imaginary interstellar trade lanes with the ease of an airliner flying from Phoenix to LA. Our battle fleets prowl the dark gulf between galaxies, searching out other fleets equally capable. In much of science fiction, travel between the stars is taken as a given, with little or no explanation as to how such a thing might be possible.

Still, even if we elect not to inform the readers as to how it is done, a science fiction writer must understand the vast distances involved in star travel. And not only distance.

There is also the problem of the universal speed limit decreed by Albert Einstein in 1905, and for which no one has yet discovered a loophole. That speed limit is the speed of light — 300,000 kilometers per second (186,000 miles per second). Because it was Einstein who first postulated that nothing can ever exceed the speed of light, this limitation has come to be known in science fiction as The Einstein Barrier. It is the job of every science fiction writer to find a way around this most fundamental of limitations.

Most new writers, especially ones without a scientific background, assume that they can merely quote some huge number for the speed of their ship and then ignore the problem of interstellar distance. After all, the ships can only get faster, right? They do this by reasoning from analogy: Our ancestors took the better part of a year to cross the Great Plains of North America in their covered wagons. Now we fly the distance from the Sierra Madres to the Mississippi River in a couple of hours. (As I write this I am sandwiched into the next to the last seat on an old Boeing 727, somewhere over Nebraska.) No distance is too great if you have a vehicle able to cross that distance in a few hours or minutes, right?

Wrong! Unfortunately, the distances between the stars are several dozen orders of magnitude greater than the longest journey possible across the surface of the Earth. The

analogy "starship is to airplane as airplane is to covered wagon" breaks down utterly over interstellar distances. It is not even enough to say, "starship is to airplane as airplane is to *snail!*" For to reach the nearest star in a single human lifetime, a starship must attain velocities many hundreds of thousands times faster than the fastest airplane that ever flew. The comparison is more akin to airplane speed versus that of a giant, lumbering glacier. One flies at thousands of miles per hour while the other moves only a few feet each year.

Besides, as noted earlier, Einstein says that nothing can exceed the speed of light, most often abbreviated as *c*. (Note: It is the 300,000 kps of light speed that is the *c* in Einstein's $E=MC^2$.) Moreover, while light speed is a fantastically large number to those of us who live our lives at less than 100 miles per hour, on the scale of the universe, light speed is not even a slow crawl.

Let us consider for a moment the shortest of all interstellar distances, namely the distance between our own sun and the nearest star. The nearest star to Sol is Proxima Centauri, which is the small companion star to Alpha Centauri, the brightest of the points of light in the Constellation of the Centaur. If you are unfamiliar with this particular constellation, then you most likely live in the Northern Hemisphere. Alpha and Proxima Centauri are only visible in southern climes, such as Central and South America, and Australia.

Alpha and Proxima Centauri are both 4.3 light-years from the sun. Contrary to what you sometimes see in the movies, a light-year is not a measure of time, but one of distance. Specifically, it is the distance light travels (at 186,000 miles per second) in a standard year (365.25 days). For those not good at doing complex multiplication in their heads, that equates to a distance of approximately 5.87 *trillion* miles. That means that Alpha and Proxima Centauri are 25 trillion miles from Earth. To put it in terms that we can all understand, consider getting on an airliner and flying west. You would have to circumnavigate the globe some 235 million times in order to travel a single light-year and *one billion* times before you would put in the equivalent air miles of traveling to Alpha Centauri. Think of how sick you would get of watching the same in-flight movie during the five million years the flight would take.

Yet, Alpha Centauri is merely the closest of possible destinations. Other stars are dozens, hundreds, or thousands of light-years farther away. In fact, the Milky Way Galaxy, of which our own system is but a small part, is 100,000 light-years in diameter. Obviously, our ships must travel very much faster than the speed of light if our plots are not going to take generations to complete. (Just what are your characters going to do for the twenty years it takes your starship to get from Sol to Procyon traveling at 90% of the speed of light?)

So why did Albert Einstein decide that the speed of light is the universal speed limit in the first place? More importantly for us science fiction writers, is there any possibility that he is wrong? To answer that question, we need to go back in history to the late nineteenth century.

We of the twentieth century tend to look down our noses at those quaint people who inhabited the century immediately before ours. However, in their way, they also lived in a time of wonder, a century when the universe finally began to give up some of its most closely guarded secrets. By the 1880s, the nature of light had come to be fairly well understood. Light is a wave. It has frequency and wavelength. In fact, the difference between radio, television, heat, red, green, blue, x-rays, and gamma rays is simply a matter of decreasing wavelength (or increasing frequency). All the things listed are merely

different frequencies of "light," what we generically refer to as electromagnetic radiation. When sent though two narrow slits, light waves will interfere with one another in precisely the same way that ocean waves interfere when passing through two narrow openings in a sea wall. Light undergoes Doppler shift, the change in apparent wavelength depending on whether the source of a wave is approaching the observer or receding from him. Sound waves also undergo Doppler shifts, which is why the train whistle changes pitch just as the train passes you.

So since light is a wave, the nineteenth century scientists reasoned that it must be traveling in some "medium" — as air is the medium through which sound waves travel. They named this hypothetical medium "ether" and immediately set out to measure the velocity with which light passes through this ether. It turned out to be a difficult problem. While sound travels at approximately 1100 feet per second (depending on temperature), light is very much faster. All attempts at measuring the velocity failed until a scientist named Albert Michelson invented a device called the Michelson Interferometer.

Michelson's invention took a beam of light, split it in two, sent it down paths of unequal length, then using mirrors, recombined the beams and focused them on a glass screen. Because the split beams had traveled different distances, when they were recombined, they were out of synchronization with one another. And just as out-of-phase sound waves alternately cancel or reinforce one another (the "beating" noise you sometimes hear on airplanes when the two engines aren't quite synchronized), so too do out-of-phase light beams. In this case, they produce alternating light and dark bands on the screen. The number and spacing of the bands gives a direct measure of the speed with which the light has traveled through the experimental mechanism. By using his interferometer, Michelson concluded that the speed of light is 300,000 kps.

It was not long before Michelson thought up another interesting thing to do with his interferometer. Because he and the other nineteenth century scientists believed that both light and the Earth travel through this universal medium called ether, he came up with an idea for measuring the speed of the Earth with respect to the ether. He reasoned that light beams coming in from different directions would have the Earth's relative velocity imposed on them. That is, the velocity of light beams coming from the point in the sky toward which the Earth is moving would have a velocity of c *plus* V_{EARTH}, while those at right angles to the Earth's motion would have a velocity of c. By combining both beams in an interferometer, he would obtain light and dark bands that would allow him to directly measure the Earth's velocity through the ether.

However, when Michelson and a colleague, Edward Morley, performed the experiment, they discovered that the velocity of the Earth with respect to the ether was precisely *zero*. He and Morley performed the experiment hundreds of times, pointing their interferometer in every direction they could think of, and no matter what, they always came to the conclusion that the Earth was stationary with respect to the universal ether. In other words, just as the ancient philosophers had surmised, *the Earth was indeed the central benchmark of the universe.*

Needless to say, this conclusion did not sit well with the scientists of the time. After all, they had learned enough about the structure of the universe to realize that the sun and Earth were about as ordinary as it was possible to get. The thought that the universal ether just happened to be pinned to our local piece of dirt seemed preposterous. Yet, no one could

figure out any other conclusion to the Michelson-Morley experiment, which always came up negative!

The Michelson-Morley experiment was one of the most important in history. Over 20 years it had two important results. The first of these was to discredit the ether theory and force scientists to realize that while light exhibits wavelike attributes, it is actually a particle phenomenon. That is, rather than being waves in the ether, electromagnetic radiation is due to tiny particles known as photons that stream outward from the light source. (Why particles have wavelength is beyond the scope of this book. That they do is one of the most important underpinnings of modern physics.)

The second direct result of the Michelson-Morley experiment was the publication of Einstein's Special Theory of Relativity in 1905. What if, Einstein asked, the velocity of light is always the same *regardless of the velocity of an observer?* What would the universe look like then?

The measure of Einstein's intellect lies in the fact that once he had asked the question, he did not flinch from the answer. For the velocity of light to be a constant regardless of the velocity of an observer, then space, time, and mass must all be variable with respect to velocity. (Specifically, if you are traveling at 50% of *c* and observing light coming in from directly ahead of you, then a unit length (such as a meter stick) in that direction must appear foreshortened sufficiently that the additive nature of your velocity and that of the light are canceled out. Also, although time appears normal to an observer traveling at a large percentage of the speed of light, time outside his ship must appear to be running faster. This is called “time dilation” effect and is very well documented by experiment. While we cannot come anywhere close to traveling at light speed ourselves, we can produce subatomic particles in our particle accelerators that approach the speed of light quite closely. What we see are that unstable particles with half-lives measured in millionth's of a second tend to fly twice as far as they ought to (when their velocity equates to a time dilation constant of 2).

Nor is it only time that slows. As velocity increases, mass increases and depth contracts. As a spaceship approaches the speed of light, time aboard the ship grinds nearly to a halt, its mass approaches infinity, and it becomes an immaterial wavefront spread across light-years of space. Not that these changes have any effect on the crew. They perceive the inside of the ship as they always have, although the universe outside takes on a decidedly odd appearance.

It is the time dilation effect, as well as the increase in an object's mass, that prevents anything from exceeding the speed of light. As the velocity of a material object reaches *c*, time freezes and mass becomes infinite. To accelerate an infinite mass even one micron per second faster requires infinite energy, and that is one thing the universe does not possess. As powerful as all the stars in the universe are, their energy remains finite.

If all of this seems needlessly obscure to you, don’t worry about it. Einstein’s Special Theory of Relativity is a subject with which some of the smartest people humanity has yet produced have struggled. For a science fiction writer it is only necessary to know that the Einstein Barrier is very real. Nothing can ever exceed the speed of light.

So here we are, fellow science fiction writers, stuck in a universe of inconveniently long distances with a speed limit that is a veritable crawl on the scale we are writing about. Do we limit ourselves to the surface of the Earth, or voyages between the nine small worlds of our own system? Not by a long shot! We break through the Einstein Barrier using

technologies as novel as they are fictional. However, in so doing, we try to avoid writing unintentional comedy by betraying our ignorance of the whole problem.

"But how can we violate one of the basic laws of the universe?" you ask. That will be the subject of the next chapter. The various methods for violating the light speed limitation are time honored and ingenious, and who knows, they might actually be possible in the future. Stick with me and we will have your ships zooming through the firmament faster than you can say Warp Factor Nine!

Table 1: The Effect Of Velocity on Mass and Time

Percent of Light Speed	Mass Increases By X Times	Time Slows Down By X Times
0%	1.000	1.000
10%	1.005	1.005
20%	1.020	1.020
30%	1.048	1.048
40%	1.091	1.091
50%	1.155	1.155
60%	1.250	1.250
70%	1.400	1.400
80%	1.667	1.667
90%	2.294	2.294
95%	3.202	3.202
99%	7.089	7.089
99.9%	22.36	22.36
99.99%	70.71	70.71
99.999%	223.6	223.6
99.9999%	707.1	707.1
99.99999%	2236	2236

The End

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The Makers searched for the secret to faster-than-light travel for 100,000 years. Their chosen instruments were the Life Probes, which they launched in every direction to seek out advanced civilizations among the stars. One such machine searching for intelligent life encounters 21st century Earth. It isn't sure that it has found any...

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Three hundred years after humanity made its deal with the Life Probe to search out the secret of faster-than-light travel, the descendants of the original expedition return to Earth in a starship. They find a world that has forgotten the ancient contract. No matter. The colonists have overcome far greater obstacles in their single-minded drive to redeem a promise made before any of them were born...

3. Antares Dawn - US$4.50

When the super giant star Antares exploded in 2512, the human colony on Alta found their pathway to the stars gone, isolating them from the rest of human space for more than a century. Then one day, a powerful warship materialized in the system without warning. Alarmed by the sudden appearance of such a behemoth, the commanders of the Altan Space Navy dispatched one of their most powerful ships to investigate. What ASNS Discovery finds when they finally catch the intruder is a battered hulk manned by a dead crew.

That is disturbing news for the Altans. For the dead battleship could easily have defeated the whole of the Altan navy. If it could find Alta, then so could whomever it was that beat it. Something must be done…

4. Antares Passage - US$4.50

After more than a century of isolation, the paths between stars are again open and the people of Alta in contact with their sister colony on Sandar. The opening of the foldlines has not been the unmixed blessing the Altans had supposed, however.

For the reestablishment of interstellar travel has brought with it news of the Ryall, an alien race whose goal is the extermination of humanity. If they are to avoid defeat at the hands of the aliens, Alta must seek out the military might of Earth. However, to reach Earth requires them to dive into the heart of a supernova.

5. Antares Victory – First Time in Print – US$7.00

After a century of warfare, humanity finally discovered the Achilles heel of the Ryall, their xenophobic reptilian foe. Spica – Alpha Virginis – is the key star system in enemy space. It is the hub through which all Ryall starships must pass, and if humanity can only capture and hold it, they will strangle the Ryall war machine and end their threat to humankind forever.

It all seemed so simple in the computer simulations: Advance by stealth, attack without warning, strike swiftly with overwhelming power. Unfortunately, conquering the Ryall proves the easy part. With the key to victory in hand, Richard and Bethany Drake discover that they must also conquer human nature if they are to bring down the alien foe …

6. Thunderstrike! - US$6.00

The new comet found near Jupiter was an incredible treasure trove of water ice and rock. Immediately, the water-starved Luna Republic and the Sierra Corporation, a leader in asteroid mining, were squabbling over rights to the new resource. However, all thoughts of profit and fame were abandoned when a scientific expedition discovered that the comet's trajectory placed it on a collision course with Earth!

As scientists struggled to find a way to alter the comet's course, world leaders tried desperately to restrain mass panic, and two lovers quarreled over the direction the comet was to take, all Earth waited to see if humanity had any future at all…

7. The Clouds of Saturn - US$4.50

When the sun flared out of control and boiled Earth's oceans, humanity took refuge in a place that few would have predicted. In the greatest migration in history, the entire human race took up residence among the towering clouds and deep clear-air canyons of Saturn's upper atmosphere. Having survived the traitor star, they returned to the all-too-human tradition of internecine strife. The new city-states of Saturn began to resemble those of ancient Greece, with one group of cities taking on the role of militaristic Sparta...

8. The Sails of Tau Ceti – US$4.50

Starhopper was humanity's first interstellar probe. It was designed to search for intelligent life beyond the solar system. Before it could be launched, however, intelligent life found Earth. The discovery of an alien light sail inbound at the edge of the solar system generated considerable excitement in scientific circles. With the interstellar probe nearing completion, it gave scientists the opportunity to launch an expedition to meet the aliens while they were still in space. The second surprise came when *Starhopper's* crew boarded the alien craft. They found beings that, despite their alien physiques, were surprisingly compatible with humans. That two species so similar could have evolved a mere twelve light years from one another seemed too coincidental to be true.

One human being soon discovered that coincidence had nothing to do with it...

9. Gibraltar Earth – First Time in Print — $6.00

It is the 24th Century and humanity is just gaining a toehold out among the stars. Stellar Survey Starship *Magellan* is exploring the New Eden system when they encounter two alien spacecraft. When the encounter is over, the score is one human scout ship and one alien aggressor destroyed. In exploring the wreck of the second alien ship, spacers discover a survivor with a fantastic story.

The alien comes from a million-star Galactic Empire ruled over by a mysterious race known as the Broa. These overlords are the masters of this region of the galaxy and they allow no competitors. This news presents Earth's rulers with a problem. As yet, the Broa are ignorant of humanity's existence. Does the human race retreat to its one small world, quaking in fear that the Broa will eventually discover Earth? Or do they take a more aggressive approach?

Whatever they do, they must do it quickly! Time is running out for the human race…

10. Gibraltar Sun – First Time in Print — $7.00

The expedition to the Crab Nebula has returned to Earth and the news is not good. Out among the stars, a million systems have fallen under Broan domination, the fate awaiting Earth should the Broa ever learn of its existence. The problem would seem to allow but three responses: submit meekly to slavery, fight and risk extermination, or hide and pray the Broa remain ignorant of humankind for at least a few more generations. Are the hairless apes of Sol III finally faced with a problem for which there is no acceptable solution?

While politicians argue, Mark Rykand and Lisa Arden risk everything to spy on the all-powerful enemy that is beginning to wonder at the appearance of mysterious bipeds in their midst…

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Where would you visit if you invented a time machine, but could not steer it? What if you went out for a six-pack of beer and never came back? If you think nuclear power is dangerous, you should try black holes as an energy source — or even scarier, solar energy! Visit the many worlds of Michael McCollum. I guarantee that you will be surprised!

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The Astrogator's Handbook has been very popular on Sci Fi – Arizona. The handbook has star maps that show science fiction writers where the stars are located in space rather than where they are located in Earth's sky. Because of the popularity, we are expanding the handbook to show nine times as much space and more than ten times as many stars. The expanded handbook includes the positions of 3500 stars as viewed from Polaris on 63 maps. This handbook is a useful resource for every science fiction writer and will appeal to anyone with an interest in astronomy.

