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Introduction

Humans have, since our beginning, looked at the stars and asked the big questions: "Who am I?" "Why am I here?" "What or who is out there?" We are close to being able to answer some of these questions as our species continues its exploration of space and prepares to take the first steps toward the stars. The stars are more than beautiful points of light in the night sky. Far, far away, they harbor new worlds. It is difficult to believe that until the early 1990s the only planets we knew (scientifically) existed in the universe were those orbiting our sun. With the growing list of known exoplanets, some of which appear to lie in the habitability zones of their parent stars, there are many beginning to wonder about how we might someday travel there to explore them. Despite the optimism of the early Space Age, our progress toward this goal has been slower than many anticipated. This is not just for lack of trying; the challenges are daunting.

The nearest star, Proxima Centauri, is about 4.2 light-years away. That is, it takes light, traveling at about 186,000 miles per second (~300,000 km/sec), over four years to make the journey. For most people, this is a meaningless measurement; how many of us can truly relate to the speed of light? To illustrate the difficulty, consider distances much closer and the challenges we face in traversing them. The Voyager spacecraft, launched in 1977, are the most distant emissaries yet launched from Earth.

Voyager 1 is roughly 156 astronomical units (AU) away as of this writing, 156 times the sun-to-earth distance of ~93 million miles, and it has taken it more than forty-four years to get there. For up-to-date information about Voyager's location, check out the NASA website https://voyager.jpl.nasa.gov/mission/status/. If the Voyagers were traveling in the correct direction, then it would take them about 70,000 years to reach Proxima Centauri—and that is the *nearest* star. The duration of a viable interstellar journey must be measured in years, not millennia, for such missions to be undertaken.

Propulsion is not the only challenge. How would such a spacecraft communicate across such vast distances? Far away from any star, how can the craft be powered on its journey through the darkness between the stars? Traveling at the speeds necessary to shorten the trip time will increase the risk of damage to the craft from collision with interstellar dust—a potentially catastrophic event when traveling at a significant fraction of the speed of light.

Fortunately, nature appears to allow rapid interstellar travel without having to invoke new physics. Propulsion technologies based on nuclear fusion, antimatter, and laser-beamed energy all appear to be physically possible—but the engineering of systems of the scale required is well beyond today's capabilities.

If we are to undertake this ultimate voyage, we must first inhabit much of our own solar system. Interstellar travel will require new technologies, a new ethical framework for exploration that will enable us to avoid repeating the mistakes of the past, and a visionary mind-set that is reminiscent of the construction of the great cathedrals of Europe—the notion that a project begun today may not be complete for many generations to come.

And then there is the question of why. Why should we travel to the stars? For that matter, why should we explore space at all?

In the first fifty-plus years of the Space Age, we now have compelling and nearly universally accepted reasons for the exploration and development of space near Earth and in Earth orbit. Weather satellites allow meteorologists to provide fairly accurate weather forecasts days and weeks into the future. They also help us predict the paths of hurricanes and cyclones, saving lives. Communications satellites knit the world together, allowing us to know what's happening all over the world in real time. They relay our television channels and some cell phone conversations, while large constellations of communication satellites are beginning to provide broadband Internet accessible everywhere around the globe. Spy satellites help keep the peace by allowing countries to monitor one another's military activities, nearly removing the possibility of surprise attacks—an important part of strategic safety in our nuclear weapons–armed world. Global Positioning System satellites allow us to navigate to new places and are essential to keeping our highly interdependent world and global economy functioning. Space near Earth is now indispensable to our daily lives and well-being.

Many advocates believe that the next logical step is the development of cis-lunar space, the region between Earth and the moon. With NASA and other countries planning to send people to the moon in the coming years, there is an expectation that new products and services will arise there just as they did in Earth orbit. The argument is then extended out into the solar system and, ultimately, to the stars.

As a scientist, I believe there is a valid reason for exploring space, including space beyond our meager solar system, that has nothing to do with economics or tangible return—to learn more about the universe, what's out there, and how it works. *All* of the engineering we use to keep our twenty-first-century lives functioning stemmed from scientists in earlier eras asking similar fundamental questions that, at the time, may or may not have had an obvious economic return or application. Expanding human knowledge is as valid a reason as any other.

There are objections to these views and some sticky ethical questions that arise when thinking about our expansion into space and then on to the stars. (Many of these are addressed in chapter 3, "Putting Interstellar Travel into Context.")

Interstellar travel is possible—just extremely difficult. Are we willing to accept the challenge?

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