Interstellar

Can We Travel to Other Stars?

Small self-replicating probes could be launched on interstellar journeys. Creating a galactic Internet may yield even greater benefits

by Timothy Ferris

Living as we do in technologically triumphant times, we are inclined to view interstellar spaceflight as a technical challenge, like breaking the sound barrier or climbing Mount Everest—something that will no doubt be difficult but feasible, given the right resources and resourcefulness.

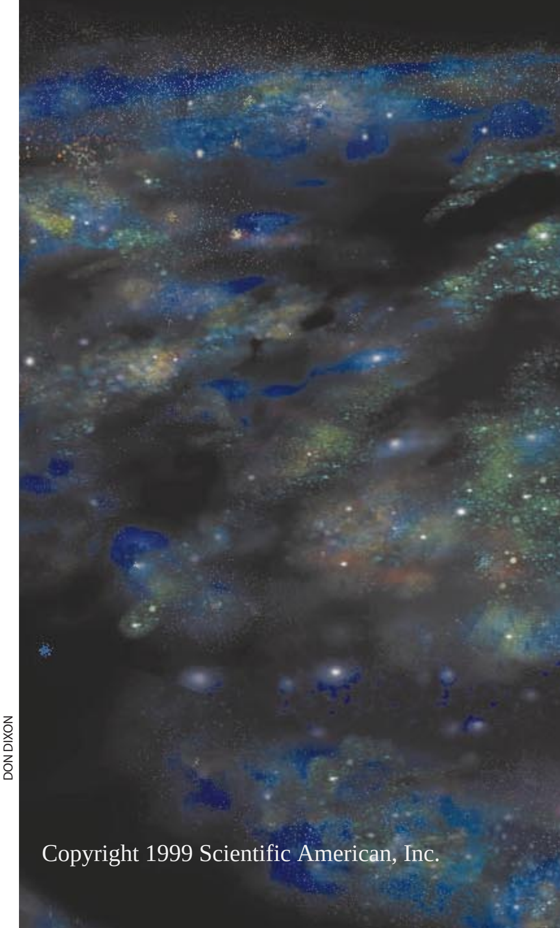
This view has much to recommend it. Unmanned interstellar travel has, in a sense, already been achieved, by the Pioneer 10 and 11 and Voyager 1 and 2 probes, which were accelerated by their close encounters with Jupiter to speeds in excess of the sun's escape velocity and are outward-bound forever. By interstellar standards, these spacecraft are slow: Voyager 1, the speediest of the four at 62,000 kilometers per hour (39,000 miles per hour), will wander for several tens of thousands of years before it encounters another star. But the Wright brothers' first airplane wasn't particularly speedy either. A manned interstellar spacecraft that improved on Voyager's velocity by the same 1,000-fold increment by which Voyager improved on the Kitty Hawk flights could reach nearby stars in a matter of decades, if a way could be found to pay its exorbitant fuel bill.

But that's a big "if," and there is another way of looking at the question: Rather than scaling a mountain, one can always scout a pass. In other words, the technical problems involved in traveling to the stars need not be regarded solely as obstacles to be overcome but can instead be viewed as clues, or signposts, that point toward other ways to explore the universe.

Three such clues loom large. First, interstellar space travel appears to be extremely, if not prohibitively, expensive. All the propulsion systems proposed so far for interstellar voyages—fusion rockets, antimatter engines, laser-light sails and so on—would require huge amounts of energy, either in the manufacturing of fusion or antimatter fuel or in the powering of a laser beam for light sails [see "The Way to Go in Space," page 58]. Second, there is no compelling evidence that alien spacefarers have ever visited Earth. Third, radio waves offer a fast and inexpensive mode of *communication* that could compete effectively with interstellar *travel*. What might these clues imply?

The high cost of interstellar spaceflight suggests that the payloads carried between stars—whether dispatched by humans in the future or by alien spacefarers in the past—are most likely, as a rule, to be small. It is much more affordable to send a grapefruit-size probe than the starship *Enterprise*. Consider spacecraft equipped with laser-light sails, which could be pushed through interstellar space by the beams of powerful lasers based in our solar system. To propel a manned spacecraft to Proxima Centauri, the nearest star, in 40 years, the laser system would need thousands of gigawatts of power, more than the output of all the electricity-generating plants on Earth. But sending a 10-kilogram unmanned payload on the same voyage would require only about 50 gigawatts—still a tremendous amount of power but less than 15 percent of the total U.S. output.

NEAREST STARS to the solar system are depicted in this view of the Milky Way galaxy as seen from 500 light-years above the galactic plane. The green lines between the stars (*inset*) represent high-bandwidth radio beams in a hypothetical communications network linking alien civilizations. Such an interstellar network would allow intelligent species to share knowledge without incurring the tremendous expense of traveling to other stars.



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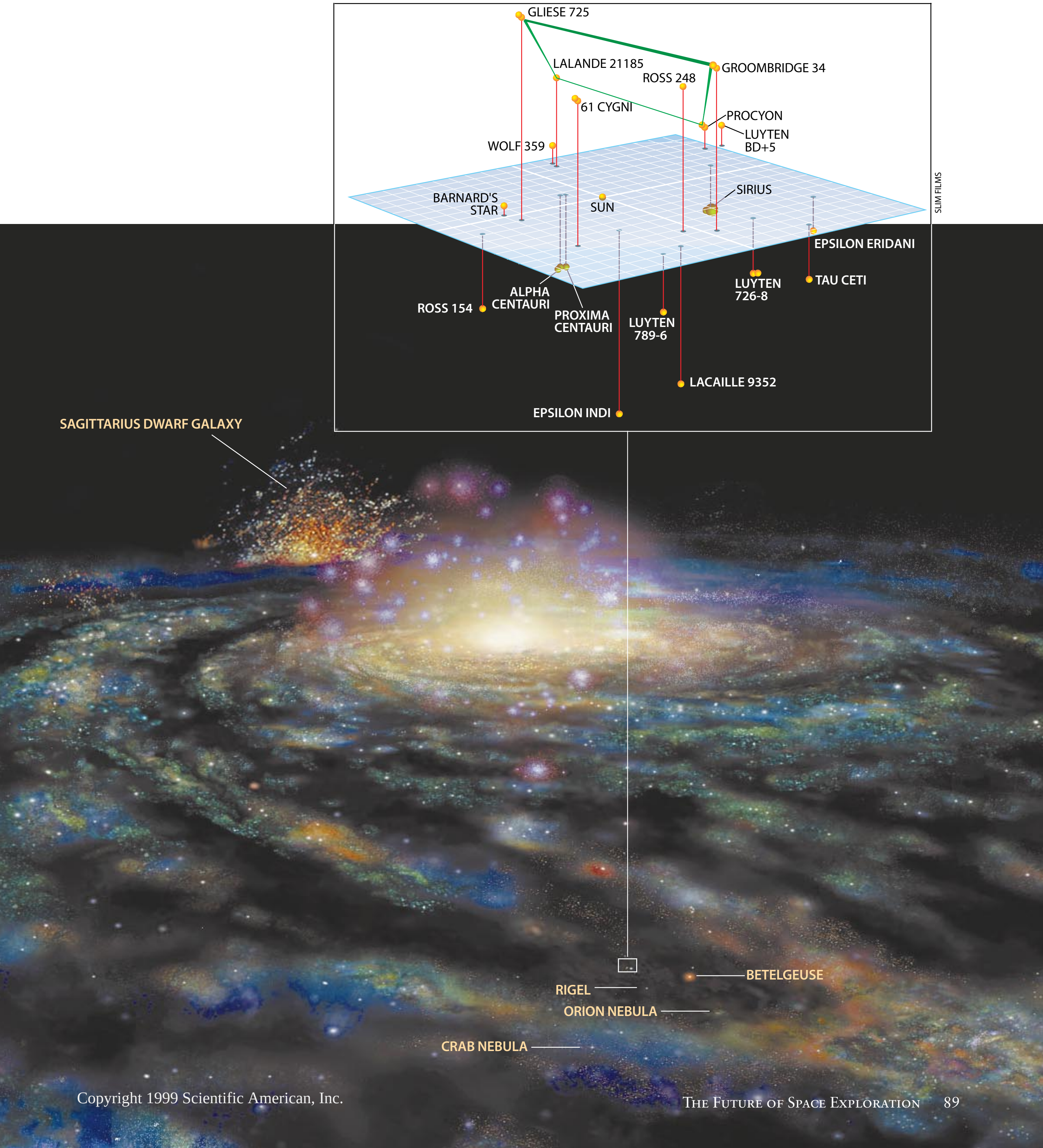

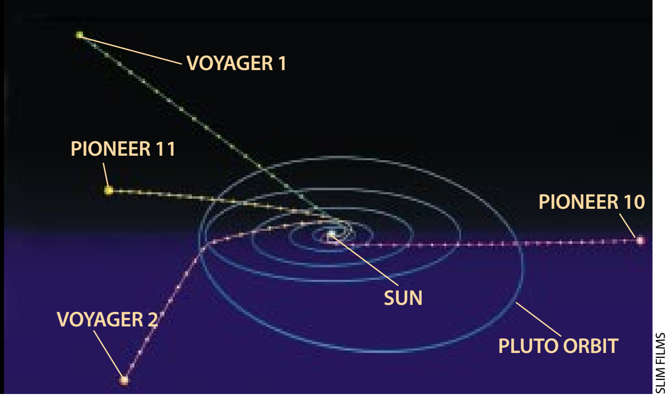

FIRST STARSHIPS are the Pioneer 10 and 11 and Voyager 1 and 2 probes, all launched in the 1970s. Voyager 1 has traveled the farthest of the four spacecraft; it is now 10.8 billion kilometers from the sun.

What can be accomplished by a grapefruit-size probe? Quite a lot, actually, especially if such probes have the capacity to replicate themselves, using materials garnered at their landing sites. The concept of self-replicating systems was first studied by mathematician John von Neumann in the 1940s, and now scientists in the field of nanotechnology are investigating how to build them. If the goal is exploring other planetary systems, one could manufacture a few small self-replicating probes and send them to nearby stars at an affordable cost. Once each probe arrived at its destination, it would set up long-term housekeeping on a metallic asteroid. The probe would mine the asteroid and use the ore to construct a base of operations, including a radio transmitter to relay its data back to Earth. The probe could also fashion other probes, which would in turn be sent to other stars. Such a strategy can eventually yield an enormous payoff from a relatively modest investment by providing eyes and ears on an ever increasing number of outposts.

If colonization is the goal, the probes could carry the biological materials required to seed hospitable but lifeless planets. This effort seems feasible whether our aim is simply to promote the spread of life itself or to prepare the way for future human habitation. Of course, there are serious ethical concerns about the legitimacy of homesteading planets that are already endowed with indigenous life. But such worlds may be outnumbered by "near-miss" planets that lack life but could bloom with a bit of tinkering.

One of the intriguing things about small interstellar probes is that they are inconspicuous. A tiny probe built by an alien civilization could be orbiting the sun right now, faithfully phoning home, and we might never learn of its existence. This would be especially true if the probe were engineered to keep a low profile—for instance, if its radio antenna were aimed well away from the ecliptic, or if it were programmed to turn off its transmitters whenever the beam came near a planet. And that is just how such probes would presumably be designed, to discourage emerging species like ours from hunting them down, dismantling them and putting them on display in the Smithsonian National Air and Space Museum. Similarly, a biological probe could have seeded Earth with life in the first place. The fact that life appeared quite early in Earth's history argues against the hypothesis that it was artificially implanted (unless somebody out there was keeping a close eye out for newborn planets), but such an origin for terrestrial life is consistent with the evidence currently in hand.

Where Are the Aliens?

From the second clue—that aliens have not yet landed on the White House lawn—we can posit that our immediate celestial neighborhood is probably not home to a multitude of technologically advanced civilizations that spend their time boldly venturing to other star systems on board big, imposing spacecraft. If that were the case, they would have shown up here already, as they evidently have not. (I am, of course, discounting reports of UFO sightings and alien abductions, the evidence for which is unpersuasive.) By similar reasoning we can reach the tentative conclusion that wormholes, stargates and the other faster-than-light transit systems favored by science-fiction writers are not widely in use, at least out here in the galactic suburbs.

Admittedly, one can poke holes in this argument. Perhaps the aliens know we exist but are courteous enough not to bother us. Maybe they visited Earth during the more than three billion years when terrestrial life was all bugs and bacteria and quietly departed after taking a few snapshots and carefully bagging their trash. In any event, it seems reasonable to conclude that if interstellar interstates exist, we are not living near an exit ramp.

The third clue—that radio can convey information much faster and more cheaply than starships can carry cargo—has become well known thanks to SETI, the search for extraterrestrial intelligence. SETI researchers use radio telescopes to listen for signals broadcast by alien civilizations. The SETI literature is therefore concerned mostly with how we can detect such signals and has little to say about how electromagnetic communications might be employed among advanced civilizations as an alternative to interstellar travel. Yet just such a path of speculation can help explain how intelligent life could have emerged in our galaxy without interstellar travel becoming commonplace.

When SETI was first proposed, in a paper published in *Nature* by Giuseppe Cocconi and Philip Morrison in 1959, the main method of electronic communication on Earth was the telephone, and the objection most frequently raised to the idea of interstellar conversation was that it would take too long. A single exchange—"How are you?" "Fine"—would consume 2,000 years if conducted between planets 1,000 light-years apart. But, as Morrison himself has noted, conversation is not essential to communication; one can also learn from a monologue. Eighteenth-century England, for instance, was deeply influenced by the ancient Greeks, although no English subject ever had a conversation with an ancient Greek. We learn from Socrates and Herodotus, although we cannot speak with them. So interstellar communication makes sense even if using it as a telephone does not.

In 1975, when I first proposed that long-term interstellar communications traffic among advanced civilizations would best be handled by an automated network, there was no model of such a system that was familiar to the public. But today the Internet provides a good example of what a monologue-dominated interstellar network might be like and helps us appreciate why extraterrestrials might prefer it to the arduous and expensive business of actually traveling to other stars.

Experientially, the Internet tends to collapse space and time. One looks for things on the Net and makes use of them as one pleases. It does not necessarily matter whether the information came from next door or from the other side of the planet, or whether the items were placed on-line last night or last year. E-mail aside, the Internet is mostly monologue.

Suppose the Internet had been invented several thousand years ago, so that we had access not only to the books of Aristotle and Archimedes but also to their sites on the World Wide Web. What a boon it would be to surf such a web, downloading the lost plays of Sophocles and gazing at the vivid mosaics of Pompeii in colors undimmed by time. Few, I think, would

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INTERSTELLAR INTERNET might include informational sites similar to the hypothetical home page shown above. Alien civilizations could archive their histories, scientific discoveries and literatures on the network, leaving a permanent record of their existence.

trade that experience for a halting phone conversation with someone from the past.

The same may also be true of communications between alien worlds. The most profound gulf separating intelligent species on various star systems is not space but time, and the best way to bridge that gulf is not with starships but with networked interstellar communications.

The gulf of time is of two kinds. The first is the amount of time it takes signals to travel between contemporaneous civilizations. If, as some of the more optimistic SETI scientists estimate, there are 10,000 communicative worlds in the Milky Way galaxy today, the average time required to send a one-way message to one's nearest neighbor—across the back fence, so to speak—is on the order of 1,000 years. Therefore, it makes sense to send long, fact-filled messages rather than "How are you?"

The Interstellar Internet

The other gulf arises if, as it seems reasonable to assume, communicative civilizations generally have lifetimes that are brief by comparison with the age of the universe. Obviously, we do not even know whether alien societies exist, much less how long they normally stay on the air before succumbing to decay, disaster or waning interest. But they would have to last a very long time indeed to approach the age of the Milky Way galaxy, which is more than 10 billion years old. Here on Earth, species survive for a couple of million years on average. The Neanderthals lasted about 200,000 years, *Homo erectus* about 1.4 million years. Our species, *H. sapiens*, is about 200,000 years old, so if we are typical, we may expect to endure for another million or so years. The crucial point about any such tenure is that it is cosmologically insignificant. Even if we manage to survive for a robust 10 million years to come, that is still less than a tenth of 1 percent of the age of our galaxy.

Any other intelligent species that learns how to determine the ages of stars and galaxies will come to the same sobering conclusion—that even if communicative civilizations typically stay on the air for fully 10 million years, *only one in 1,000 of all that have inhabited our galaxy is still in existence*. The vast majority belong to the past. Is theirs a silent majority, or have they found a way to leave a record of themselves, their thoughts and their achievements?

That is where an interstellar Internet comes into play. Such a network could be deployed by small robotic probes like the ones described earlier, each of which would set up antennae that connect it to the civilizations of nearby stars and to other network nodes. The network would handle the interstellar radio traffic of all the worlds that know about it. That would be the immediate payoff: one could get in touch with many civilizations, without the need to establish contact with each individually. More important, each node would keep and distribute a record of the data it handled. Those records would vastly enrich the network's value to every civilization that uses it. With so many data constantly circulated and archived among its nodes, the interstellar Internet would give each inhabited planet relatively easy access to a wealth of information about the civilizations that currently exist and the many more worlds that were in touch with the network in the past.

Intelligence brings knowledge of one's own mortality—and at the same time, provides a means to transcend it—so the desire for some kind of immortality is, I suspect, widespread among intelligent beings. Although some species may have limited themselves to physical monuments, such as the one erected by Percy Bysshe Shelley's Ozymandias, these must eventually weather away and would in any event require long journeys to be seen and appreciated. Surely most species would elect to contribute to the interstellar Internet, where their thoughts and stories could career around the galaxy forever.

If there were any truth in this fancy, what would our galaxy look like? Well, we would find that interstellar voyages by starships of the *Enterprise* class would be rare, because most intelligent beings would prefer to explore the galaxy and to plumb its long history through the more efficient method of cruising the Net. When interstellar travel did occur, it would usually take the form of small, inconspicuous probes, designed to expand the network, quietly conduct research and seed infertile planets. Radio traffic on the Net would be difficult for technologically emerging worlds to intercept, because nearly all of it would be locked into high-bandwidth, pencil-thin beams linking established planets with automated nodes. Our hopes for SETI would rest principally on the extent to which the Net bothers to maintain omnidirectional broadcast antennae, which are economically draining but could from time to time bring in a fresh, naive species—perhaps even one way out here beyond the Milky Way's Sagittarius Arm. The galaxy would look quiet and serene, although in fact it would be alive with thought.

In short, it would look just as it does. SA

Timothy Ferris is the author of *The Whole Shebang: A State-of-the-Universe(s) Report*, *Galaxies*, *Coming of Age in the Milky Way* and other best-selling books. In 1977 he produced the archival phonograph record carried on the Voyager probes. He is currently emeritus professor of journalism at the University of California, Berkeley.