

Humankind in Outer Space. Gonzalo Munevar

When we explore space we challenge our science in new and profound ways, leading to new scientific and technological discoveries. The natural serendipity of exploration creates fundamental progress in all the main areas of space science, including planetary formation and evolution, fundamental physics, and astrobiology, as described in my book *The Dimming of Starlight: The Philosophy of Space Exploration* (Oxford University Press, 2023). I will discuss how humankind in outer space can add greatly to this progress. Beyond the exploration of Mars and other planets, this goal requires large space ships with artificial gravity, e.g. O'Neill's "colonies," sent to other star systems at near the speed of light. Some physicists erroneously believe that Einstein's mass equation would make that practically impossible, but the proper approach is his velocity-addition formula. To get around the problem of the amount of fuel, we could scoop hydrogen ions from space. Whitmire's catalytic nuclear ramjet might succeed. Using Wheeler wormholes to travel faster than light is mired in time-travel paradoxes. Alcubierre argued that an engine that contracts spacetime in front of the starship and expands spacetime behind it (General Relativity) would allow the starship to travel faster than light. Unfortunately, he does not have a proper mechanism. But gigantic ramjets may allow us to reach nearby star systems in a few years and to terraform some of their planets. More ships can be built in those systems and sent to explore other star systems, and so on.