Chapter 1

Exploration of Star Systems

Is space exploration of other star systems possible? The idea dominates much of science fiction. The old *Star Trek* television series popularized the idea of interstellar flight during the years leading up to the Apollo space missions to the moon. Ten years later there came the *Star Wars* movie, which brought an upsurge in public interest with space travel after a nadir in its popularity following the cancelled Apollo program. There followed a spate of science fiction movies involved with star travel, where most of them were of poor quality. Star travel persists in our imaginations, but the currently prospects appear very remote. The only space missions that might be considered as star travel are the Pioneer and Voyager probes which have left the solar system. They will never send any data back concerning planetary systems around other stars, where it will also take tens of thousands of years for them to reach distances comparable to those between stars. However, this does not mean that star travel is impossible.

Spacecraft are sent into the solar system at velocities 15–20 km/sec. This speed, while fast by most considerations, is far smaller than the speed of light $c = 299,997$ km/sec. It consequently takes one of our spacecraft about 15–20,000 years to travel a light year. This is due to limits of our current state of rocketry. Chemical rockets can only send a craft to a maximum velocity of around 30 km/sec. The Voyager spacecrafts had to use a gravitational slingshot approach, where they absorbed some angular momentum and energy as they flew past Jupiter, in order to exit the solar system. Nuclear propulsion will do better, rating at around 100 km/sec, but this again falls very short of reaching velocities approaching the speed of light. So our space systems are far too sluggish to reach other stars.

By measuring the Doppler shift of stars extrasolar planets have been detected, and a few imaged. Most of these are gas giant planets similar

to Jupiter. Some extrasolar systems have been found to have several gas giant planets arrayed in various orbits. There is a rich variety of stellar system structure that has been discovered. Optical interferometers may soon image these planets with considerable detail. They may further image smaller terrestrial planets similar to Venus or Earth. We may explore other star systems in the near future by such means from near Earth space. However, with some 145 extrasolar system identified so far with planets, and potentially thousands waiting to be found, there is the prospect that a planet might be found with optical signatures similar to Earth. If a planet of this sort is detected it will confirm Carl Sagan's thesis that life exists elsewhere in the universe. However, there is no way that such remote detection will ever reveal to us the nature of life on this planet. A scientific premium would be placed upon sending a spacecraft to this star system to examine this life in detail.

The major thesis of this book concerns sending space probes to other stars. Exuberant ideas of large interstellar spacecraft with people on board are not likely to obtain, at least not any time in the foreseeable future. The physics and technology required to send an un-piloted probe to another star at some significant fraction of light speed are formidable challenges in of themselves. It has to be honestly admitted that manned spaceflight is also very expensive and tends not to produce the same measure of real results obtained with space probes. Unfortunately it appears that other planets in our solar system offer little for us humans, who are these squishy watery complexes of biomass. The same may well be the case for other planetary systems. So schemes of colonizing other planets are at best problematic. Further, an extrasolar planet identified as biologically active might be a serious biohazard to any human being stepping forth onto its surface. In fact we may find this to be the case for the planet Mars. In addition this risks contaminating Mars with earthly bacteria. So it is a certainty that the first of spacecrafts to reach other stars will be un-piloted robotic craft, where it may be unlikely that humans will ever directly travel to another star except by the sort of virtual reality seen from our probes sent to planets in our solar system.

Many science fiction portrayals of star travel invoke warp drives and other schemes designed to short circuit the limitation of light speed. The classical laws of gravitation turn out to predict such spacetime structures, such as wormholes and warp drives. However, mass-energy couples to spacetime in general relativity and gravity very weakly. It requires the accumulation of large amounts of mass in order to create an appreciable gravity

field. By the same reasoning it is very difficult to imagine how a system can be readily devised that is able to engineer spacetime curvatures. There are also problems with these exotic types of spacetime solutions as well. They violate the energy conditions of general relativity established by Hawking and Penrose. Consequently quantum fields which act as the source for spacetime curvature suffer serious pathologies. This will be discussed further on. It is unlikely that starships will ever be constructed with warp drive capability.

The preliminary answer to the opening question of this introduction, is yes. However, this yes has qualifications, as it is an affirmative answer to a possibility. If interstellar probes are sent into space it will likely be at least a half century or more from today. The duration for these missions will be measured in decades as well. Much can happen here on Earth in the mean time. Such stellar exploration can only happen if we manage to tackle a fair number of problems we face. These include, energy and resource depletion, global public health and pandemics, nuclear war, population pressures and the long term prospect of a global ecological collapse. This is a major qualifier, for stellar exploration depends upon a stable global situation lasting for at least another century. It further depends upon either some breakthroughs in our understanding of quantum field theory, or a future ability to construct large systems in space. In the first case this means that large amounts of anti-matter needs to be generated, or some way that conservation laws violated to convert mass directly to energy. If this is physically realistic a photon propelled relativistic rocket is possible. In the second this is required to construct large solar collectors and photon sail ships. As seen further on this requires construction in space on a very large scale. Substantive hurdles have to be overcome for either of these approaches to work.

So with this tentative affirmation I will proceed to illustrate the basic problems here. If such stellar exploration is never conducted at least I intend for this book to be a basic overview of basic mechanics and special relativity. These matters are here discussed in an entertaining format that differs from most books on elementary physics.