Introduction

As a child in the late 1960s and early 1970s, I was fascinated by astronomy. I haunted the local library and read every book they had on the subject. I pestered my parents to plan trips to the planetarium, or to the local college when the astronomy department gave talks for the public. When I was twelve, my father purchased a high-powered telescope for me. That Celestron 8 machine saw a great deal of use over the next decade. Forty years later it is still in my possession, although (alas) I now live in a part of the country where city lights make star-gazing impractical.

I can't be sure whether my life-long love for science fiction is a cause or an effect of that fascination with the universe around us. I grew up on stories by Asimov, Clarke, and Heinlein, and watched *Star Trek* re-runs at every opportunity. I was enthralled by stories of men and women *going* to the places I read about in my astronomy texts, discovering new worlds and meeting the strange people who lived there. I was particularly struck by authors who "showed their work" with respect to the physical environment. Authors like Poul Anderson, Hal Clement, or Larry Niven could make the settings of their stories both plausible and compelling.

At some point I discovered the world of *conflict simulation games,* sophisticated tabletop games that were designed to emulate various real-world political or military struggles. Most such games focused on historical conflicts, such as the American Civil War or the Second World War. A few, though, ventured into the realm of science fiction.

Almost by accident, my father brought home one such game for me, and it proved quite the revelation. This was the game *Starforce*, released by Simulations Publications, Incorporated in 1974.

Starforce was a simulation of human expansion into interstellar space, beginning in the twenty-fourth century. Redmond Simonsen, the game's designer, meticulously worked out the technologies, the social and political conditions, and a complete "future history" for the game. In particular, he did careful research to build a map of space within about 20 light-years of Sol. His map included dozens of stars that could only be found in obscure astronomical catalogs, every one accurately placed.

Be it admitted, *Star Trek* has never worried very much about the real geography of the galaxy. Some of my favorite literary authors have done a much better job. But the fact that this game map existed – that we *knew enough* about our galactic neighborhood to make it *possible* – set my imagination alight. I spent years poring through what sources I could find, making lists of nearby stars, studying everything that was known about them, drawing maps and imagining what worlds might actually be out there.

One tool that came to my hand was another game. My father (again) came across the classic roleplaying game *Traveller*, and brought home a copy of the core rules for me. That game, published in 1977 by Game Designers' Workshop, was the first to include a semi-random process for the design of star maps and worlds as settings for play. The world-building rules in the core game were very simplistic, but in the *Scouts* supplement (1983) a more sophisticated version appeared. This version took into account the properties of a world's primary star, which made it possible for me to apply the system to the *real* stars I had been studying.

One result was the first original space-opera universe I ever designed – one which is never likely to be published, since it's a little too obviously the result of an immature imagination. Another was a growing awareness that the *Traveller* rules were incomplete. To be sure, the designers produced a remarkable achievement, versions of which are still in use among *Traveller* players to this day. Still, they *had* oversimplified some details for ease of use, and the system included a few outright errors.

I set out to learn how to do better. In a sense, I've spent most of my adult life in that quest: a study of the universe around us, for the purpose of educating my creative imagination.

Years later, I spent about a decade writing and doing editorial work for the game publisher Steve Jackson Games. Ironically, this was at a time when they held a license to publish materials for the *Traveller* game and its fictional universe. That gave me the opportunity to design and publish three world-building systems of my own, which appeared in the books *GURPS Traveller: First In* (1999), *GURPS Traveller: Interstellar Wars* (2006), and *GURPS Space, Fourth Edition* (2006).

The last of these was the most comprehensive. It was published after the first discovery of *exoplanets*, worlds actually known to be circling other stars. It made an honest attempt to take into account some of the things we had already learned about the structure of planetary systems other than our own. Even so, in the years since its publication it has become dated with startling speed. In particular, the launch of the *Kepler* observatory in 2009 led to the discovery of *hundreds* of new exoplanets in just a few years. It's become clear that the model of planetary formation I've used in the past was naïve at best, hopelessly wrong at worst.

Fortunately, as of this writing, the astronomical community seems to be converging on a new model, similar to the old but considerably refined. This model accounts for the great variety of exoplanets we've discovered, while still explaining most of the known features of our home planetary system. There is still a great deal of work to be done, and we're likely to be surprised by what we learn in the years to come. Still, it seems possible to build a new set of world-building guidelines for the creative imagination, one which once again takes into account all that we've learned about the universe.

Purpose of this book

This book is intended as a resource for authors, game designers, game referees, readers, and fans of science fiction. It presents an overview of scientific concepts that might be applied to high-level design of a space-based fictional setting: the placement of stars, the arrangement of planetary systems, and the properties of individual worlds. It also presents a set of procedures for such design, allowing the reader to generate regions of space suitable for science fiction stories or games. The results should at least be plausible, given our present understanding of the universe.

More personally, this book is a collection of all the research I've done over the past thirty-five years, ever since I was first inspired by those games I enjoyed as a teenager. Over the decades I've picked up many world-building tricks to apply in my own game writing and literary work, which I hope will be of use to others.

Mathematical background

The scientific background in this book will be presented in a qualitative manner, with very little in the way of mathematical symbolism. Unfortunately, it's impossible to *apply* real-world science without using

mathematics. If the reader intends to use the world-building procedures described here, he will need to be able to call on mathematics at about the (American) high-school level:

- Reading, interpreting, and solving algebraic formulae
- Exponents and simple roots
- Logarithms
- Trigonometric functions

You will *not* be required to apply calculus or advanced statistics. Wherever possible, I will do that work for you, and present you with a reasonable approximation that can be computed at the level of high-school mathematics.

Many of the world-building procedures described in this book will require the generation of random numbers. You will need two sets of dice:

- One set of three six-sided dice. These are the familiar cube-shaped dice, with their faces marked with one to six spots. Six-sided dice will be referred to in the text as "d6," and you may be instructed to roll one (1d6), two (2d6), or three (3d6) six-sided dice. You may also be instructed to add or subtract some number from the result on the dice, or to multiply the result by some number. For example, if you are instructed to roll "3d6+5," this means to roll three six-sided dice, total the faces showing, add five to the result, and use the final total.
- One set of two ten-sided dice, with one die a different color than the other. Ten-sided dice are available from most game and hobby shops, and usually have faces marked "0" through "9." These dice will be referred to in the text as *percentile dice* or "d%." To roll the percentile dice, designate one of the two ten-sided dice for the "tens" digit, the other as the "ones" digit, and roll them together to generate a two-digit number between 00 and 99.

Please note that selecting options at random is *never required*. If you wish, the random-generation tables and procedures can be taken as a description of the options that are available and their relative likelihood. If you have your own vision for a specific case, feel free to select an option that will fit without rolling the dice!

Standard units

Throughout this book, most quantities will be expressed in the International System of Units (SI), or "metric" to my American readers. Hence we will be using meters, kilograms, and so on.

The measure of temperature is most likely to be unfamiliar. Temperatures will be given in *kelvins* (K), which are based on an absolute scale. Absolute zero is, by definition, at 0 K. The melting point of water is at about 273 K, and its boiling point at sea-level pressure is at about 373 K. Humans are most comfortable in temperatures ranging from about 288 K to 300 K.

The SI units are sometimes inconvenient for measuring quantities on an astronomical scale. We will therefore supplement the SI measures with several other units.

The *astronomical unit* (AU) is defined as equal to the average distance from the Sun to Earth, or about 150 million kilometers. Astronomical units are a convenient unit to use when describing distances within planetary systems.

The *light-year* (ly) is defined as the distance light travels in a vacuum in one year. It is equal to about 9.46 trillion kilometers, or 63,200 astronomical units. Light-years are a convenient unit to use when describing interstellar distances. Astronomers often prefer a unit called the *parsec* (pc), which is equal to about 3.26 light-years. We will not use parsecs in this book, but it should be a simple matter to convert from parsecs to light-years when reading any other source material on astronomy.

We will define the *Earth-mass* (Em) (as one might expect) as a mass equal to that of the planet Earth. It is equal to about 5.97 times 10^{24} kilograms. Earth-masses are a convenient unit to use when describing the properties of planets and moons.

We will define the *solar mass* (Sm) as a mass equal to that of the Sun. It is equal to about 1.99 times 10^{30} kilograms, or about 333,000 Earth-masses. The solar mass is a convenient unit to use when describing the properties of stars.