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ASTRONOMY FOR SCIENCE FICTION WRITERS: STARS

By
Michael McCollum

Since the beginning of time, human beings have gazed up in the sky and marveled at the bright points of light they see there. Indeed, those of us who were born after the invention of the electric street lamp have little appreciation for the glorious spectacle the starry vault of the heavens presented to our distant ancestors. For most of human history our ability to light up the night has been extremely limited, and as a result, the stars in the sky were about all anyone had to look at on a moonless night. As a result, our ancestors didn't need classes in astronomy. They knew the sky as intimately as we know our local neighborhoods, and imagination being what it is, they populated their sky with fanciful creatures.

The human brain is built in such a way that it will attempt to make sense out of any light pattern that happens to fall on our retinas. Even when we gaze upon a collection of random dots, our brains strive mightily to turn those dots into a meaningful pattern, to extract order from out of randomness. This ability is innate and instinctual, and the source of numerous newspaper stories whenever the daily quota of blood and gore falls short of the necessary number of column-inches. Usually these stories take the form of someone who has seen the image of Jesus Christ in the water stain on their ceiling, or of Elvis in the form of a particularly misshapen potato. Nor are these the most common examples. This inherent "connect the dots" bias of the human brain caused Percival Lowell to see canals on Mars, and all of us to see the face of a man superimposed on the craters of the Moon. Our ancestors had this ability as well, and they saw the outlines of beasts and people in the diamond points of light in the night sky.

Even though they had no way to judge the scale of the dark universe above them, ancient men and women realized that they were looking at something far greater than themselves. Thus, it was easy for them to imagine the sky as the home of the gods, the playground of the capricious pranksters and malicious super beings who made life on Earth so difficult. From these imaginings they invented entire religions, and eventually, the "science" of astrology.

Astrology is built on the belief that the stars above the horizon at the moment of birth somehow control a person's destiny throughout their life. It is easy to see how such a belief got started. If the sky is the home of the gods, then knowing the stars that were in the sky at the moment of your birth will tell you which gods were looking down on you at that most crucial event of your life. This idea is simple and powerful. It is a testament to astrology's power as an idea that there are probably more astrology adherents alive today than at any time in history. Nor has astrology always been the purview of the pseudoscientific. Sir Isaac Newton was, among a great many other things, official astrologer to the English court.

Eventually, astrology gave way to a true science that also attempts to explain the mysteries of the night sky. This is the science of astronomy. Astronomy studies the stars as physical objects rather than merely as a pattern of lights in the black velvet vault overhead.

Astronomers measure the size of stars, determine their mass, delve deeply into their composition, and theorize about their origins. They make no claims as to being able to predict the future of individual human beings, although they do predict the ultimate fate of things on a grander scale — that of the Sun, the Earth, and the Universe.

Of the two schemes for attempting to make sense of the night sky, science fiction writers find astronomy to be of more use than astrology (this rule doesn't necessarily hold for fantasy writers). Even so, astronomy has its own built-in biases that limit its usefulness for those of us who would travel between the stars, if only in our imaginations.

Look in any book on astronomy and you will find charts and tables that give you the precise position of far more stars than are visible in the night sky. This data is calculated down to the nearest arc-second. The charts also show you the outlines of the mythical people and animals with which our ancestors populated the sky. We call these patterns "constellations" and we use them as navigational aids for sailing the celestial stygian sea.

The bias that limits astronomy's usefulness to science fiction writers is that it is, of necessity, based on Earth-centered observations. The star positions that astronomers plot are positions of stars with respect to one another *as they appear to those of us here on Earth!* We science fiction writers are less interested in where the stars are with respect to Earth-bound observers than we are in their true positions with respect to one another. In other words, SF writers prefer a more universal viewpoint than can be found in most astronomy books. We are more interested in the true topology of the sky than in its constellations. In this we are probably unique in all the world.

That, then, is the subject of this series of articles dedicated to Astronomy for Science Fiction Writers. Don't tell us where to point our telescopes, but rather where to point our starships! But before we can attempt to cross the interstellar gulf in our imaginations, we must learn some basic concepts. The first concept is the most basic of all:

Just What Is A Star, Anyway?

Several years ago a friend of mine, a fellow engineer, shocked me when he betrayed the fact that he didn't know the difference between a star and a planet! So, to make sure that we are all on the same wavelength, let's take an in-depth look at stars; what they are and what they are not.

In addition to being Earth-centered (of necessity, for the moment), astronomers also have a bias towards objects that glow brightly in the dark sky. Most of these objects are stars.

A star is simply a big, glowing ball of gas with a thermonuclear furnace at its heart. This furnace generates energy that heats up the gas at the star's interior to temperatures in the millions of degrees. (The temperature at the middle of the sun is estimated to be 14 million degrees C.) Once generated, this energy bubbles up out of the interior of the star, often taking thousands of years before it reaches the outer shell of the gas that comprises the visible surface of the star. Although considerably cooler than the interior, the outer layers of a star are still hot enough that they radiate energy in the wavelengths we humans refer to as "visible light." This is the reason we see the stars as points of light in the sky. They emit photons to which our eyes are sensitive.

Stars form when mutual gravitational attraction causes the collapse of interstellar gas clouds. As gas clouds coalesce into "lumps" in the vacuum of space, the pressure and temperature at their interior rises. If the gas cloud is sufficiently massive, the pressure and temperature at its interior will eventually rise to the point where the nuclei of hydrogen atoms (protons) will begin to stick to one another when they collide. When protons "stick" together they form a new element (helium) and release a huge quantity of energy in the process. This is known as hydrogen fusion. It is the same reaction that takes place when a hydrogen bomb is detonated.

Stars are the largest objects we know about. They have to be. For a star to "light off," the pressure/temperature in its middle must be sufficient to sustain a hydrogen fusion reaction. And the conditions within the collapsing gas cloud are controlled by only a single factor – the mass of the cloud! If the cloud is below "critical mass," then the star will be stillborn. The nuclear furnace will not light off to generate the energy that causes a star to burn so brightly.

Have we ever seen such stillborn stars? Yes, we have. In fact, you can go outside and look up in the sky to see two such could-have-been stars (assuming that they are above the horizon at the time). The two largest planets in the Solar system, Jupiter and Saturn, are stars that didn't get up to minimum size. Although among the brightest objects in our sky, Jupiter and Saturn don't glow with inner light. Rather, we see them because they reflect back the light of the sun. That is the basic difference between a star and a planet. Stars glow by their own light and planets glow by reflected light.

"Jupiter is a star?" you ask. No, but it could have been. Had Jupiter been approximately 10 times more massive than it is, its interior temperature would have reached the critical threshold level where a hydrogen fusion reaction would have begun. Had that occurred, Jupiter would have been a tiny star in its own right. If a factor of ten seems a lot, remember that Sol (our sun) is 1000 times more massive than Jupiter. In reality, Jupiter came close to minimum mass for a star.

Had Jupiter and Saturn made it to minimum star size, then we would have inhabited a system with one large and two small stars in it. If this sounds strange, it shouldn't. Multiple star systems are more common than are single star systems in the universe. Systems with multiple stars (2, 3, 4, 5, or 6) abound throughout the galaxy. The pattern in multiple star systems is very like that of the Solar System: a single massive star at the center, with one or more tiny stars circling it in planetary-style orbits.

I first learned about multiple star systems in 1962 when I attended a lecture in which an astronomer pointed out that the prevalence of multiple star systems in the universe is strong evidence that planetary systems are common throughout space. He pointed out that this is only logical since we very nearly became a tri-star system ourselves. Since that time, we have discovered other evidence, including infrared photographs of matter shells around nearby stars and the discovery of several planet-like objects of the Jupiter-class circling other suns than our own.

Not all stars are like our own sun. In fact, stars like Sol (the Latin name for the sun, and its official name in most science fiction stories) are a distinct minority in the universe. Stars come in a large variety of sizes and colors, depending on their mass. Their life spans vary greatly, and they face different fates when they finally run out of fuel and die. And since science is primarily a method for classifying things, astronomers long ago developed numerous classification systems for stars. The most common such system classifies stars by their spectra, and is known as the Harvard Classification System. If you are going to be a science fiction writer, it is important that you know the differences between the various kinds of stars.

Otherwise, you are liable to commit a blunder by putting your hero's planet around a star that is wholly unsuited to human life.

The Classification of Stars

Stars are classified by letter designation, depending on their color, which is one characteristic that is easy to observe. The various letters can be remembered with the following simple mnemonic: "Wow! Oh Be A Fine Girl, Kiss Me Right Now, Susie." This allows you to remember the sequence of the classifications W, O, B, A, F, G, K, M, R, N, and S. (The classification was originally intended to be alphabetical, but like a lot of good intentions, got screwed up along the way.) The categories are further subdivided by adding a number to the letter designation. The numbers come in ten steps between zero and nine, with 0 being the hottest in a category and 9 being the coolest. Thus, an F9 star is slightly hotter than a G0, which is hotter than a G9, which is hotter than a K0.

The following discusses each type of star and gives you some idea of what it is like physically. Caution! The differences between various stars are much more complicated than the spectral classification system indicates. However, for the purpose of science fiction writing, the following is a good first approximation of reality:

<u>Type W Stars – The Wolf-Rayet Stars</u>

Even though these are the most luminous of all stars, the Wolf-Rayet stars are very rare and far away, making them appear dim to astronomers on Earth. They are very hot, with surface temperatures up to 80,000°C. Only about 150 Wolf-Rayet stars are known in the galaxy (out of 100 billion stars). Most of these are surrounded by shells of gas that have been ejected and are moving away from the star at speeds on the order of 3000 km/sec. Conditions surrounding a Wolf-Rayet star are not conducive to the evolution of life as we know it, or even its survival. If you want to plant your civilization around a Wolf-Rayet star, think about living in a microwave oven, or swimming in the cooling pool of your local nuclear reactor.

<u>Type O Stars – The Big Blue Bruisers</u>

Type O stars are typically big and hot, with surface temperatures between 35,000 and 40,000°C. They are blue-white in color and expend energy at a prodigious rate and are therefore, relatively short lived. Gamma Velorum is an example of a Type O star. They can be seen across thousands of light-years, so they make good beacon stars. If you visit one, be sure to pack your SPF 10 million sunscreen. An O-star planetary system is not a good place to live. And because they don't live very long, the bright O-stars aren't going to be around long enough to allow your aliens time to evolve.

<u>Type B Stars — The Other Big Blue Bruisers</u>

The B stars are only slightly less energetic than the O stars. They range from 12,000 to above 25,000°C and are blue-white to white in color. Rigel and Spica are both B-class stars. Because of the rate at which they expend energy, they are relatively short lived and have too much ultraviolet in their spectrums to be healthy for life based on organic molecules. Like their O big brothers, they are pretty to look at, but of limited use to humans.

Type A Stars – White Sub-Giants

The A stars are still energetic, but much less so than the O's and the B's. Their surface temperature ranges from 8,000 to 10,000°C. Sirius, Vega, and Altair are all Class A stars and are popular places to put colonies in science fiction novels. The sunlight would be very strong, requiring protection from ultraviolet, but you can at least build a good story for life existing on planets circling these stars – especially if you make them distant planets.

Type F Stars – Yellow-White Stars

The F stars are hotter than Sol, but not dangerously so. Their surface temperatures range from 6000 to 7500°C. Their spectra are rich in calcium lines. Examples of F stars include Procyon and Polaris. It is easy to convince readers that human beings are colonizing F-class star systems since Sol was very nearly an F-class itself.

Type G Stars – Yellow Stars

We human beings have a particular fondness for G-class stars because we evolved beneath the rays of one. Sol is generally classified as a G2, which means that it is on the hotter end of the G spectrum and just below F. They come in both dwarf (Sol) and giant size (Capella). G-class stars range in temperature from 5,000 to 6000°C (dwarf) and 4200-5500°C (giants) and their spectra are rich in metals. You can't do better than plant your colony around a Type G star, except of course, that there aren't all of that many of them close by. The closest truly Sol-like stars to us are Tau Ceti (K0, 11.9 light-years), and Epsilon Eridani (K0, 10.7 light-years).

Type K Stars – Orange Stars

Cooler than the G Class, but still a viable candidate for interstellar civilizations are the K-class of stars. Arcturus, Aldebaran, and Pollux are all K-Class stars. The class has a surface temperature range of 4000-5000°C (dwarfs) and 3000-4000°C (giants). K-stars have the advantage to the science fiction writer in that they are the most numerous star type in the galaxy. As indicated by the fact that we searched for signs of extraterrestrial intelligence around Tau Ceti and Epsilon Eridani for several years using our radio telescopes, K-class stars pose little problem to the interstellar colonist.

Type M Stars – Red-Orange Stars

Class M stars are very cool compared to the sun, having surface temperatures of 3000°C for the dwarfs and 3400°C for the giants. A lot of very effective science fiction scenes have been written with the big red ball of a planet's sun hanging in the background. One of the advantages of inhabiting a world in an M-class star system would be that you could gaze at the sun without worrying about damaging your eyes. Some M-class stars are also variables (Mira Ceti). It is unlikely that any planet around a variable star would have conditions suitable for the development of life. If life did develop, the pulsing of the star would make for an interesting environment. Betelgeuse and Antares are examples of M-class giant stars. Both of these are very bright in the night sky, both because of proximity and inherent luminosity. Proxima Centauri, the closest star to Sol, is a Class M dwarf. Proxima Centauri is one of those small stars in orbit about a larger star, Alpha Centauri.

Type R Stars – Red Giant Stars

Class R stars are cooler than even M class, and composed entirely of giants. Their temperatures are approximately 2600°C. Type R stars are very old and represent a stage of evolution in the life of a star that was once very like Sol. Indeed, our own sun will run out of fuel in approximately 4.5 billion years. When it does so, it will expand into a red giant phase where it will definitely wipe out all life on Earth. It will remain a red giant for approximately 100 million years (not a long time when considering that Sol will then be 9 billion years old) and then collapse until it becomes a white dwarf.

Type R-class stars are V Arietis and T Lyrae. Because they are stars in their dotage, red giants are good places to look for lost civilizations and advanced alien technology. Their blood red color also adds an alien look to outdoor scenes. Think about what a snowfield must look like beneath an R-class star.

Type N Stars – Cooler Red Giant Stars

Type N stars bear many of the characteristics of the Type R brethren. Their surface temperatures are 2600°C. Typical N stars are R Leporis and V Aquilae.

Type S Stars – Deep Red Giant Stars

Type S stars have surface temperatures of 2600°C. Examples include the variable stars Chi Cygni and R Cygni.

The differences between R, N, and S stars involve peculiarities in their spectra and are mostly of interest to astronomers. Science fiction writers can treat all three classes the same. They are all big, red balls that used to be small bright stars. They are all into the helium-burning phase (which follows the hydrogen-burning phase) and which signifies that a star is nearly at the end of its life.

Other Star Types

The classifications discussed above are primarily for what are called "Main Sequence Stars." The main sequence referred to involves the Hertzsprung-Russell Diagram, in which astronomers discovered that the various classes of stars represent a continuum of star types that depend on mass. In other words, if you know how much mass the gas cloud that will eventually form a star contains, you can predict precisely what kind of a star will result, its life, and its evolution from a large, dimly glowing protostar to whatever it will eventually become.

White Dwarf Stars

The main sequence does not show all of the kinds of stars there are, however. I noted earlier that the sun will eventually become a white dwarf. When it eventually runs out of fuel (after passing through the red giant phase) the thermonuclear fire inside the sun will go out. and the sun will collapse in upon itself. When it collapses, the pressure will build to the point where the electrons of the sun's material will be squeezed almost down into the atomic nuclei. The result will be a star with the mass of the sun, but the diameter of the moon. In other words, the density will skyrocket to nearly unimaginable levels. The matter in a white dwarf is so dense that a teaspoon of star-stuff weighs millions of tons.

Neutron Stars

White dwarfs only happen if the initial star was approximately the size of the sun. If it was much larger, then when the sun runs out of fuel, it collapses until the atoms are packed nucleus to nucleus. In effect, the hydrogen atom electrons are squeezed down into the protons of the nucleus to form a neutron. These neutrons are more dense even than the white dwarf material. A neutron star possesses all of the mass of the star that formed it, but is only a few kilometers in diameter. Since angular momentum is conserved during a collapse, neutron stars spin very quickly. The original star's magnetic field is also compressed, which means that the rotating star often generates a beam of radio waves that rotates as the star spins. The result is what we call a "pulsar." The fastest pulsars rotate a few thousand times each second, sweeping the universe with their radio beams much as a lighthouse sweeps the horizon with its light.

Black Holes and Supernovae

For really massive stars, the end of thermonuclear burning brings with it a massive collapse and then an explosion. For a few days the star can radiate more energy than all the other stars in a galaxy combined. And when it collapses, such a star is too massive to stop at the neutron star stage. The density rises to the point where the star "falls" out of the universe altogether. It forms a black hole, a point with a gravitational pull so hard that nothing can escape it, not even light.

Astronomy for Science Fiction Writers

As noted in several of the discussions of spectral type, it isn't enough to pick a star at random and tell your readers that it is the capital star of an alien interstellar civilization. Doing so blindly will get you laughed at, and more importantly, will cause you to get endless letters from readers pointing out your mistake. This isn't fatal for a science fiction story, but it helps to at least convey that you understand the subject when you are writing. (Larry Niven had the Earth rotating the wrong way in the first edition of Ringworld and hardly anyone noticed. Even so, a technical science fiction writer should strive for accuracy, if for no other reason than professional pride.)

When deciding to people the stars with humans and other intelligent beings, be sure to pick a star that is at least believable. Remember that many stars are not as hospitable to life as our own Sol. Some are big and bright, and have a high concentration of ultraviolet in their spectra. As everyone who has ever been sunburned knows, ultraviolet is hazardous to your health. The reason for this is fairly straightforward. Photons in the ultraviolet wavelengths have sufficient energy to break the bonds of carbon atoms when they hit an organic molecule. Since we humans are built from organic molecules, anything that tends to break these bonds is ultimately harmful. Your interstellar colonies are going to have enough problems fighting off the bug-eyed monsters. Don't handicap them with terminal sunburns as well!

Nor are all stars as stable as Sol. Many of them oscillate wildly in their power output. Over a period of days, weeks, months, or years, a variable star's output can increase hundreds of times. While this cycle of increasing and decreasing brightness must be interesting to watch, it will play hell on the lives of any animals that happen to inhabit a planet in the system. So when choosing your star, try not to pick a well-known variable such as Mira.

So you see, choosing a star isn't as easy as looking in the encyclopedia and picking an exotic sounding name. In fact, most stars that have names aren't good candidates for interstellar colonies. Many of our star names come to us from Arab astronomers (Aldebaran, for example) and a good rule of thumb for the selection of stars is this: If a star is bright enough to have been named by people who hadn't yet invented the telescope, then it is probably too bright to make a good site for a colony. We humans prefer the small, dim stars – like Sol. And because they are small and dim, they probably don't have names yet.

A science fiction writer solves this problem simply by assigning his own names to these stars. After all, we are gods to the people we create in our fiction, and one of the perks of being a god is the right to name the stars, isn't it?

Knowing a star's classification in the Harvard Classification System is a good first start to choosing it as the locale for your latest story or novel. It is not the only consideration, however. There is also the star's location. Is it in the right place in the sky to satisfy the needs of your plot? If so, use it. If not, find another. The subject of where the stars are in the sky with respect to one another is the subject of the next article.

Why don't you go outside tonight, look up into the sky, and marvel at all there is to see there? You may discover that our ancestors weren't as handicapped as you thought by their lack of prime time television programming.

Table 2: The Nearest Stars To Sol					
Name	Position		Distance (L-Y)	Spectral Class	Remarks
	Right Ascension*	Declination*			
Proxima Centauri	14h 26.3m	-62.28°	4.3	Me	Centauri is a triple star system. Changing relationship between A &B will make life interesting.
Alpha Centauri A	14h 36.2m	-60.38°	4.3	G4	
Alpha Centauri B	14h 36.2m	-60.38°	4.3	K5	
Barnard's Star	17h 55.4m	+04.33°	5.8	M5	
Wolf 359	10h 54.1m	+07.20°	7.6	M8	
Lalande 21185	11h 00.1m	+36.18°	8.1	M2	
Sirius A	06h 42.9m	-16.39°	8.7	A0	Sirius, the dog star
Sirius B	06h 42.9m	-16.39°	8.7	dA	White dwarf companion
UV Ceti A	01h 36.4m	-18.13°	8.9	M6e	
UV Ceti B	01h 36.4m	-18.13°	8.9	M6e	
Ross 154	18h 46.1m	-23.53°	9.5	M6	
Ross 248	23h 39.5m	+43.56°	10.3	M6	
Epsilon Eridani	03h 30.6m	-09.38°	10.7	K0	Very "Sol-like" star
Ross 128	11h 43.5m	+01.06°	10.8	M5	
Luyten 789-6	22h 35.7m	-15.36°	10.8	M7	
61 Cygni A	21h 04.7m	+38.30°	11.2	K5	Double star system
61 Cygni B	21h 04.7m	+38.30°	11.2	K7	
Epsilon Indi	21h 59.6m	-57.00°	11.4	K5	
Procyon A	07h 36.7m	+05.21°	11.4	F5	See "Procyon's Promise."
Procyon B	07h 36.7m	+05.21°	11.4	—	White dwarf companion
Sigma 2398 A	18h 42.2m	+59.33°	11.5	M4	
Sigma 2398 B	18h 42.2m	+59.33°	11.5	M5	
Groombridge 34 A	00h 15.5m	+43.44°	11.6	M1	
Groombridge 34 B	00h 15.6m	+43.44°	11.6	M6	
Lacaille 9352	23h 02.6m	-36.09°	11.7	M2	
Tau Ceti	01h 41.7m	-16.12°	11.9	K0	See "Sails of Tau Ceti."
Luyten's Star	07h 24.7m	+05.29°	12.3	M5	
Lacaille 8760	21h 14.3m	-39.04°	12.5	M1	
Kaptayn's Star	05h 09.7m	-45.00°	12.7	M0	
Kruger 60 A	22h 26.3m	+57.27°	12.8	M4	
Kruger 60 B	22h 26.3m	+57.27°	12.8	M6	

* Star position is measured in Right Ascension and Declination. These are polar coordinate measurements that measure the angle to the star in the plane of Earth's equator, and at right angles to the equatorial plane. Right Ascension is the angle measured from a fixed point to the star in the plane of the Earth's equator. It is the star's longitude. RA is measured in hours and minutes rather than degrees because the RA measurement has historically been taken using the Earth's rotation (one hour equals 15 degrees of rotation). Declination is the angle measurement of the star's "elevation" in the sky. It is the star's "latitude." Declination is measured from the equator, with positive angles representing stars in the northern hemisphere and negative angles representing stars in the southern hemisphere. Polaris, the pole star, has a declination of +90 degrees

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The End

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3. Antares Dawn - US$4.50

When the super giant star Antares exploded in 2512, the human colony on Alta found their pathway to the stars gone, isolating them from the rest of human space for more than a century. Then one day, a powerful warship materialized in the system without warning. Alarmed by the sudden appearance of such a behemoth, the commanders of the Altan Space Navy dispatched one of their most powerful ships to investigate. What ASNS Discovery finds when they finally catch the intruder is a battered hulk manned by a dead crew.

That is disturbing news for the Altans. For the dead battleship could easily have defeated the whole of the Altan navy. If it could find Alta, then so could whomever it was that beat it. Something must be done…

4. Antares Passage - US$4.50

After more than a century of isolation, the paths between stars are again open and the people of Alta in contact with their sister colony on Sandar. The opening of the foldlines has not been the unmixed blessing the Altans had supposed, however.

For the reestablishment of interstellar travel has brought with it news of the Ryall, an alien race whose goal is the extermination of humanity. If they are to avoid defeat at the hands of the aliens, Alta must seek out the military might of Earth. However, to reach Earth requires them to dive into the heart of a supernova.

5. Antares Victory – First Time in Print – US$7.00

After a century of warfare, humanity finally discovered the Achilles heel of the Ryall, their xenophobic reptilian foe. Spica – Alpha Virginis – is the key star system in enemy space. It is the hub through which all Ryall starships must pass, and if humanity can only capture and hold it, they will strangle the Ryall war machine and end their threat to humankind forever.

It all seemed so simple in the computer simulations: Advance by stealth, attack without warning, strike swiftly with overwhelming power. Unfortunately, conquering the Ryall proves the easy part. With the key to victory in hand, Richard and Bethany Drake discover that they must also conquer human nature if they are to bring down the alien foe …

6. Thunderstrike! - US$6.00

The new comet found near Jupiter was an incredible treasure trove of water ice and rock. Immediately, the water-starved Luna Republic and the Sierra Corporation, a leader in asteroid mining, were squabbling over rights to the new resource. However, all thoughts of profit and fame were abandoned when a scientific expedition discovered that the comet’s trajectory placed it on a collision course with Earth!

As scientists struggled to find a way to alter the comet’s course, world leaders tried desperately to restrain mass panic, and two lovers quarreled over the direction the comet was to take, all Earth waited to see if humanity had any future at all…

7. The Clouds of Saturn - US$4.50

When the sun flared out of control and boiled Earth's oceans, humanity took refuge in a place that few would have predicted. In the greatest migration in history, the entire human race took up residence among the towering clouds and deep clear-air canyons of Saturn's upper atmosphere. Having survived the traitor star, they returned to the all-too-human tradition of internecine strife. The new city-states of Saturn began to resemble those of ancient Greece, with one group of cities taking on the role of militaristic Sparta...

8. The Sails of Tau Ceti – US$4.50

Starhopper was humanity's first interstellar probe. It was designed to search for intelligent life beyond the solar system. Before it could be launched, however, intelligent life found Earth. The discovery of an alien light sail inbound at the edge of the solar system generated considerable excitement in scientific circles. With the interstellar probe nearing completion, it gave scientists the opportunity to launch an expedition to meet the aliens while they were still in space. The second surprise came when *Starhopper's* crew boarded the alien craft. They found beings that, despite their alien physiques, were surprisingly compatible with humans. That two species so similar could have evolved a mere twelve light years from one another seemed too coincidental to be true.

One human being soon discovered that coincidence had nothing to do with it...

9. Gibraltar Earth – First Time in Print — $6.00

It is the 24th Century and humanity is just gaining a toehold out among the stars. Stellar Survey Starship *Magellan* is exploring the New Eden system when they encounter two alien spacecraft. When the encounter is over, the score is one human scout ship and one alien aggressor destroyed. In exploring the wreck of the second alien ship, spacers discover a survivor with a fantastic story.

The alien comes from a million-star Galactic Empire ruled over by a mysterious race known as the Broa. These overlords are the masters of this region of the galaxy and they allow no competitors. This news presents Earth's rulers with a problem. As yet, the Broa are ignorant of humanity's existence. Does the human race retreat to its one small world, quaking in fear that the Broa will eventually discover Earth? Or do they take a more aggressive approach?

Whatever they do, they must do it quickly! Time is running out for the human race…

10. Gibraltar Sun – First Time in Print — $7.00

The expedition to the Crab Nebula has returned to Earth and the news is not good. Out among the stars, a million systems have fallen under Broan domination, the fate awaiting Earth should the Broa ever learn of its existence. The problem would seem to allow but three responses: submit meekly to slavery, fight and risk extermination, or hide and pray the Broa remain ignorant of humankind for at least a few more generations. Are the hairless apes of Sol III finally faced with a problem for which there is no acceptable solution?

While politicians argue, Mark Rykand and Lisa Arden risk everything to spy on the all-powerful enemy that is beginning to wonder at the appearance of mysterious bipeds in their midst…

11. Gridlock and Other Stories - US$4.50

Where would you visit if you invented a time machine, but could not steer it? What if you went out for a six-pack of beer and never came back? If you think nuclear power is dangerous, you should try black holes as an energy source — or even scarier, solar energy! Visit the many worlds of Michael McCollum. I guarantee that you will be surprised!

Non-Fiction Books

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13. The Art of Writing, Volume II - US$10.00

This collection covers the Art of Writing articles published during 1998. The book is 62,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

14. The Art of Science Fiction, Volume I - US$10.00

Have you missed any of the articles in the Art of Science Fiction Series? No problem. The first sixteen articles (October, 1996-December, 1997) have been collected into a book-length work of more than 70,000 words. Learn about science fiction techniques and technologies, including starships, time machines, and rocket propulsion. Tour the Solar System and learn astronomy from the science fiction writer’s viewpoint. We don’t care where the stars appear in the terrestrial sky. We want to know their true positions in space. If you are planning to write an interstellar romance, brushing up on your astronomy may be just what you need.

15. The Art of Science Fiction, Volume II - US$10.00

This collection covers the *Art of Science Fiction* articles published during 1998. The book is 67,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

16. The Astrogator's Handbook – Expanded Edition and Deluxe Editions

The Astrogator's Handbook has been very popular on Sci Fi – Arizona. The handbook has star maps that show science fiction writers where the stars are located in space rather than where they are located in Earth's sky. Because of the popularity, we are expanding the handbook to show nine times as much space and more than ten times as many stars. The expanded handbook includes the positions of 3500 stars as viewed from Polaris on 63 maps. This handbook is a useful resource for every science fiction writer and will appeal to anyone with an interest in astronomy.

