

STARGÅTE: Hard Reboot

“Mr. President, for the past seven years the United States Air Force has been sending teams to other planets, by means of an alien device known as the Stargate.”

“Haha! That’s funny! That’s very funny.”

– General Francis Maynard and President Henry Hayes, **Inauguration**

The *Stargate SG-1* television series was a highly successful but somewhat underrated science fiction franchise. While earning praise for its character chemistry and clever (and self-aware) writing, it is perhaps most notable for its intriguing premise and mythology, and the resulting philosophical and cultural themes it explored. This treatment reimagines these ideas from a *hard SF* perspective, replacing space operatic and fantastic concepts from the series with plausible ideas based on current scientific knowledge and reasonable extrapolations.

Premises

We summarize here the basic ideas behind the *Stargate SG-1* setting, [along with commentary on how each idea could be adapted to a hard SF universe](#).

Basic Principles

- An ancient civilization created a network of interstellar portals (*stargates*) connected by wormholes, which contemporary humans rediscover and use to explore the Galaxy.

[Most forms of FTL either violate relativity or can trivially be used for time travel. Wormholes offer at least some semi-plausible mechanisms to avoid closed timelike curves. In the hard-SF *Stargate* reboot, all FTL travel would be via stargates.](#)

- Members of high-tech civilizations have used stargates to visit Earth in antiquity and prehistory, where they were viewed as sorcerers or gods by primitive humans.

[This is Clarke’s Third Law at work, and a central theme of the series is exploring connections between aliens and Earth myths, religions, and spiritual traditions. Note, however, that in a hard SF scenario, even “magical” technology should have at least some nod towards a plausible physical mechanism.](#)

- As a result of these visits, ancient humans were conscripted or otherwise transplanted to other planets.

[There is abundant fossil evidence that humans evolved on Earth from indigenous life. It would be fantasy to imagine that independent evolution could produce biologically-compatible aliens, or even superficially similar ones. All humanoid aliens must ultimately have come from terrestrial stock.](#)

[Furthermore, since this would likely require not just transporting humans but *terraforming* suitable planetary environments, this process must have begun in prehistoric times – although there may have been subsequent waves of human migration.](#)

- An antagonistic alien race, the Goa’uld, live as parasites in human hosts: they can control the hosts’ bodies, assimilate their thoughts and memories, and survive for centuries by hopping to new hosts.

[As noted above, it is implausible that an organism from an alien ecosystem would be biologically compatible with terrestrial life: parasites must normally co-evolve with their hosts. Given the timescales involved and the exotic abilities of Goa’uld symbiotes, they are likely the product of biological engineering rather than natural evolution.](#)

Later Developments

- The original gate-builders (*Ancients*) were eventually revealed to be anatomically identical to modern humans: later in the series they were presented as human beings from another galaxy (*Alterans*) who recreated all life in this Galaxy, including terrestrial humans, after a great plague.

This is inconsistent with paleontological evidence, unless one supposes that the Ancients fabricated a fake fossil record along with recreating all life – which leads down a rabbit hole of Cartesian skepticism and Young Earth creationism. The intent of this hard SF treatment is to reconcile esoteric ideas (e.g. ancient astronauts and pseudoarchaeology) with established empirical facts, not to undermine the very notion of empirical reality by invoking deceitful omnipotent beings. This plot point must be discarded or heavily modified: see p. 3.

- The Ancients were part of a group of four older civilizations, at least three of whom were humanoid, who preceded the Goa'uld.

Since humans evolved on Earth, these races would most naturally be the result of human emigration after contact with the gate-builders. Humanoid Ancients might be either human acolytes of the actual gate-builders, or the gate-builders themselves in human *guise* (see p. 3). Since the Goa'uld are best imagined as the result of bioengineering, they might have originated among any of these groups, before forming their own faction.

- Eventually many of the Ancients, along with some members of other races, underwent *ascension*, abandoning their physical bodies for forms of pure energy.

In the series, ascension is presented variously as a spiritual, biological, or technological process, or some hybrid of the above. In hard SF the obvious analogue is *mind uploading*. While ascended beings would technically still require *some* physical substrate, as software-based entities they could freely transition among various instantiations, effectively making them incorporeal.

- Among ascended beings there is philosophical conflict and outright war between the aloof Others and the dogmatic Ori, with breakaway sects seeking an enlightened and benevolent middle ground.

The philosophical and ethical questions evoked by beings on a “higher plane of existence” readily carry over to software-based entities. The central question in either case is the proper relationship between “higher” and “lower” beings: dispassionate observation (analogous to wildlife zoologists), well-intentioned intervention (animal rescuers), authoritarian mastery (pet owners), or exploitation (ranchers, hunters, etc.). This is compounded by the near-omnipotence of beings that have crossed the technological singularity, and their ability to wreak havoc on the Universe unless they exhibit exceptional restraint.

The series canonically presents the Ori as tapping their followers’ free will as a form of energy to increase their own power, while falsely holding out the promise of ascension. This is both overtly mystical and cartoonishly evil; some more plausible (and interesting) motivations are considered on p. 9.

Proposed Backstory

It is noteworthy that the foundational character of the *Stargate* franchise was not a captain, adventurer, or inventor, but an *archaeologist*. Many of the heroes' challenges were solved through cultural, historical, or linguistic insights rather than combat or technological wizardry. The interweaving of alien civilizations with Earth mythology, religion, and history is the defining feature of the series.

Here we give further details of the revised hard-SF background, expanding on the points noted above.

Ancients and the Four Great Races

"Sir, the odds against any alien life forms we encounter looking remotely human are... astronomical."

"Yeah, well. We'll see."

– Capt. Samantha Carter and Col. Jack O'Neill, 200

The *Stargate* backstory provides a plausible justification for encountering humans and humanoid races among the stars, but nonhuman extraterrestrials also play a necessary role. Clearly the stargates themselves are the product of an advanced technological civilization; however, an indigenous industrial society in Earth's prehistory would have left unmistakable paleontological and geochemical evidence. Hence, aliens.

The *Ancients* were an extraterrestrial civilization that first contacted humans in prehistoric times. Whether they invented or inherited stargate technology, the Ancients were the main builders of the stargate network in our region of the Galaxy: traveling from star to star at relativistic but sublight speeds, leaving stargates as they went. They should be viewed as a *culture*, not an alien species; indeed it is not clear whether the Ancients who arrived on Earth were even biological beings. More broadly, "Ancients" include the group of humans known as *Alterans* ("High Earthlings"), who left Earth to join Ancient society.

The Ancients arrived on Earth some 100,000 years ago near the end of the last interglacial period. They established a stargate and a small outpost, made contact with humans, and inducted the Alterans into their community. After a (geologically) short time, the Ancients (and Alterans) left through the stargate to other worlds, and subsequent glaciation wiped away or buried nearly all signs of their brief presence on Earth.

Over time, four distinct groups of extraterrestrial humanoids descended from these original emigrants, maintaining a loose confederation known as the Alliance of the Four Great Races.

Alterans: This was the original group of humans to join Ancient society. Over the subsequent millennia, they initiated many terraforming efforts in our region of the Galaxy, and developed advanced hibernation and stasis techniques to allow them to pursue such long-term endeavours. Eventually, some tens of thousands of years ago, they became dissatisfied with embodied life, and Ascended, leaving behind many relics and projects to continue unsupervised.

Note: In the original *SG-1* series, Alterans were presented as humanoids from another galaxy who recreated terrestrial humans in their image. As noted in the *Premises* p. 2, this is incompatible with the paleontological record, and will not be included in this setting.

At least three distinct societies spun off from the Alterans, and coexisted with them for some time in a loose alliance.

Ansur: This is the most advanced humanoid civilization as of the time of the main *Stargate* plotline. The Ansur have visited Earth on and off over the millennia, and their interactions with their primitive cousins have ranged from indifference to meddlesomeness to protectiveness.

In the *Stargate* mythology, the "Asgard" (technically, *Aesir*) are beings who presented themselves as guardians or gods to early Nordic and Germanic societies on Earth; whereas other pagan deities are mostly connected to Goa'uld. There is no definite reason for this (it's not as if the Norse gods were exceptionally peaceful or benevolent). For this reason we have adopted a more archaic form of the name (with cognates *Ansuz* in proto-Germanic, *Anghu* or *Ahura* in Zoroastrianism, *Asura* in Sanskrit, and others besides) to suggest that the Ansur could also stand in as deities in other religions.

Like all humanoids, they originally descended from terrestrial humans, likely branching off from the Alterans at some point after they left Earth. Since then, they evolved a distinct *gracile* physiology (think

Roswell Greys), with large heads, big eyes, and underdeveloped torso and limbs – all characteristic of their dependence on high technology and propensity towards low-*g* and microgravity habitats. Ansur no longer produce offspring, but will occasionally clone new bodies for themselves, imprinting their personality and memories on the newly-grown brain (see *Reincarnation*, p. 30). While technologically capable of ascension, they have generally chosen to remain embodied in biological forms, with minimal cybernetic augmentation. Because of their lack of population turnover, Ansur society is relatively static.

Nox: A very different relationship with technology was adopted by the Nox. This race is anatomically quite similar to humans, and has eschewed any overt changes to their physiology. Most Nox live in small bands or family groups, pursuing simple hunter-gatherer lifestyles. They *do* have access to advanced technology far beyond present-day Earth, but keep it hidden in the background. In particular, they have access to advanced biotechnology and medical technology, which they use to live long and healthy lives; and superlative cloaking devices, which they use to conceal their technological infrastructure (as well as themselves when needed). Their usual response to any external threat is to hide until it goes away. The Nox have had little or no interaction with humans on Earth.

See p. 25 for more details on various cloaking systems. The mode of operation will be quite different from what the Nox displayed in the *SG-1* series, but will accomplish the same ends.

Furlings: These are the most enigmatic of the Four Great Races. Even their appearance is not shown in the TV series. It is not known whether they survive to this day, or what happened to their civilization. Unlike the Alterans, their ruins and relics are few and scattered, but show a level of technological advancement that in some cases surpasses even the gate-builders.

Plot point: It has been speculated (in non-canon material) that the Furlings may have been the creators, and perhaps thus the first victims, of the Goa’uld. This would make Furlings the original “first hosts” or *Unas*. In the rebooted background, Unas/Furlings would be humanoids, descended from Alterans, but evolved for physical strength and robustness, to complement the cognitive enhancements provided by the Goa’uld symbiote. A yeti-like appearance would be a nod towards the preconception (based on their name) that they ought to be furry. They would likely have better fine manipulation ability than the lizardlike Unas depicted in *SG-1*.

Goa’uld

“The System Lords can’t be trusted either as a group or individuals. They’re posturing egomaniacs driven by an insatiable lust for power, each one capable of unimaginable evil.”

“See, why should I be nervous? Sounds like an average day at the United Nations.”

– Daniel Jackson and Elizabeth Weir, *New Order*

The Goa’uld are a parasitic species of snake-like symbiotes that take humans (and other humanoid races) as hosts. There are several distinct characteristics that make them unlike most mundane real-world parasites:

- They are intelligent, and can exert complete control over the host’s body, *and* access its memories.
- Their own memories are passed on genetically to their offspring.
- They give their host body increased strength, stamina, and healing ability.
- Nonetheless, they regularly outlive their host, and survive for centuries by moving from host to host.

While these are fairly run-of-the-mill traits for SF “puppet-master” parasites, what is often glossed over in these sources is how *incredibly unlikely* it would be for these traits to evolve naturally, especially for a species that did not co-evolve with its host. Furthermore, these traits are more clearly aimed at *perpetuating the individual* than maximizing reproductive utility. From a hard-SF point of view, it is clear that Goa’uld symbiotes are the product of deliberate biological engineering.

Origins

Why would one want to create a Goa'uld? The obvious purpose would be as a repository of memory and a way to preserve and perpetuate one's identity. A symbiote need not have *any* intrinsic intelligence or personality, but would simply be a biological memory storage and retrieval system that integrates with the host's central nervous system. It would start out as a blank slate, copying the memories and personality of its host. When passed on to a new host, it would assimilate that host's memories and personality into a gestalt entity. At least for a while, this might be a true mutualistic symbiosis, blending the wisdom and knowledge of the previous host(s) with the will and selfhood of the new. This is the situation with the Tok'ra (p. 6), as well as similar symbionts in SF, such as *Star Trek's* Trill.

This idealized scenario breaks down, though, when one considers the sheer weight of memory that would build up in the symbiote over many lifetimes. Eventually the symbiote's personality would completely dominate that of the host. This would be accelerated if the first blendings prioritized leaders or other influential people in society, who would tend to be particularly strong-willed, even egotistical. A gestalt built of competitive Type A personalities might easily veer into megalomania, with the current host having little or no influence.

Biology

Goa'uld symbiotes reproduce asexually, with a complete set of memories passed down "genetically" to the offspring. A parent may voluntarily produce blank memory-less offspring, but cannot pick and choose specific memories to pass on or withhold (due to the holistic nature of human memory).

Symbiotes take about 7 years to mature before they can blend with a host. Outside of a host, a symbiote has only basic instinctive survival behaviour: its genetic memory payload only manifests when integrated with a host's nervous system. Prior to their first blending, larval symbiotes are not considered "people", and may be culled as needed to maintain a sustainable population of backup copies.

A symbiote may be implanted surgically in a host, or it can instinctively make an incision with its teeth to enter at the back of the neck or throat. It immediately releases a healing factor to seal the wound, and extrudes tendrils to interface with the host's central nervous system. Within a few hours, the host will begin to have access to the symbiote's stored memories: at this point an assertive Goa'uld personality will typically overwhelm the host and take control. Full integration of the *host's* memories takes a bit longer, on the order of days.

Note: The Goa'uld of *SG-1* can seize control of their host almost instantly, giving them a tremendous advantage as spies and infiltrators. Realistically, given the complexity of interfacing with the central nervous system, even a few hours is starting to stretch credulity. Clandestine Goa'uld agents are certainly still possible, but host "assets" would need to be covertly abducted and then reinserted after blending. (Goa'uld rarely pursue such a strategy in any case, as it goes against their natural egomania.)

A blended symbiote is almost impossible to remove forcibly, but can withdraw from a host voluntarily, usually to move to a new host or to enter a spawning phase. Mature Goa'uld can produce a brood of a dozen or so larvae every few years. An individual symbiote can survive for several centuries if it has access to new hosts.

When a symbiote withdraws, the host's original personality may reassert itself. Former hosts will remember their experiences, and will have superficial reflected memories of what they thought about while blended, but will no longer have direct recollection of the symbiote's genetic memories. Hosts abandoned after prolonged blending may be functionally insane, unable to separate their "own" memories from the hazy residual impression of memories from the symbiote.

In addition to its cognitive augmentation, a Goa'uld symbiote significantly enhances the host's endocrine and immune systems, providing increased strength, vitality, stamina, immunity to most diseases, and rapid healing. Normal human hosts will be cured of most ailments and can easily live to more than a century. Withdrawal of the symbiote, however, often results in a backlash and collapse of the host's immune system.

Note: In the *Stargate* movie, the antagonist, Ra, was portrayed with glowing eyes and a "flanged" voice. In the TV series these were elaborated as abilities that the Goa'uld could invoke voluntarily to impress or intimidate their subjects. No physiological explanation was given, and none seems immediately plausible. In the hard-SF setting, these will *not* be natural abilities of the symbiote, though the Goa'uld may employ technological devices to achieve the desired dramatic effect.

History

The reason for creating Goa'uld as bioengineered organisms, rather than cybernetic implants, was likely so that they could continue to function and provide backup copies even in the absence of technological infrastructure. This does indeed seem to have been important in their early history: the earliest genetic memories that the Goa'uld recount are of a primitive existence, and they apparently have no memory of the advanced civilization that created them.

Plot point: If the creators of the Goa'uld were the Furlings (p. 4), then it may be that the development of the Goa'uld led to conflict and collapse of their civilization. The fact that the Goa'uld have no memory of this suggests that all current Goa'uld descend from an individual or group of “blank slate” symbiotes that took hosts after the collapse. Another hypothesis is that the Goa'uld may have been initially developed by a third-party civilization and then deployed among primitive humanoids. Or, the Goa'uld might simply be lying or repressing their earliest memories, unable to tolerate the idea that they are the creation of mere hosts.

The earliest Goa'uld civilizations date back roughly 10,000 years, when they spread from their initial homeworld after learning how to use its stargate. The limited number of native hosts (*Unas*) constrained their migration, until they discovered Earth around 6,000 BCE. The increased supply of hosts allowed their numbers to multiply, and they spread human hosts and slaves across many worlds (the product of earlier Alteran terraforming projects). Among the Four Great Civilizations, only the Ansur actively opposed them, and then only to protect planets in which they has a particular interest. The Goa'uld soon became the dominant technological society in this region of the Galaxy.

Around 1,000 BCE, the main stargate link to Earth was shut down amid discord and rebellion. By this time the Goa'uld were preoccupied with their broader empire, and had a sufficient population of extraterrestrial humans to sustain it. The Earth gate remained buried and inactive until modern times (though at least one other gate in the Solar system has allowed for intermittent visits by other races).

From its inception, Goa'uld society has been a feudal-like arrangement of self-interested warlords gathered into shifting factions and alliances, ruling much larger populations of human slaves. The total population of (mature, blended) Goa'uld is only several thousand scattered across a few hundred worlds, with slave populations of order a thousand times larger. The top dozen or so Goa'uld form a loose council of *System Lords* that, ostensibly, addresses issues of common policy or external threats (but in fact mostly serves as a platform for boasting and grandstanding). The Goa'ulds' notorious ruthlessness is both a strength and weakness: their empire is held in check mostly by its internal rivalries and conflicts.

Because of their relatively small population and conservative egoistic outlook, Goa'uld are markedly lacking in scientific innovation and other cooperative ventures; nevertheless they have built up a significant high-tech civilization over the millennia. They are technological scavengers, taking advantage of high-tech relics, or assimilating the knowledge of host populations that they conquer.

Tok'ra

Despite their heritage of common memories, Goa'uld do exhibit individual personalities, due to their varying experiences and the subtle influences of different hosts. While stereotypical Goa'uld are near-caricatures of egomania, they are also quite knowledgeable and intelligent, and many have strong personal codes of honour. Some even truly believe they are benefactors to their lowly subjects.

One group of symbiotes in particular has eschewed the usual pattern of self-centred behaviour, and strives for the original model of an equal partnership between symbiote and host. These are the *Tok'ra* (“Against Ra”), so-named because they descend from a rebel against Ra, the chief System Lord at the time. The Tok'ra blend only with willing hosts, and refrain from overwhelming the host's identity: the symbiote's gestalt personality will deliberately repress itself at times to give the host's own personality equal control.

The Tok'ra movement began some 3,000 years ago with an individual, Egeria, who came to the conclusion that the customs of the Goa'uld and the System Lords were both morally repugnant and ultimately self-destructive. It spawned a generation of blank-slate symbiotes, recruited carefully-selected hosts, and indoctrinated this new cohort with the ideals of cooperation and individual dignity. By starting with blank symbiotes, Egeria essentially “reset the clock” on the emergence of a domineering gestalt personality, and hoped that the new ideology, infused with the attitudes of hosts selected for selflessness, would keep such egomaniacal tendencies in check.

Jaffa

Immature Goa'uld larvae normally live as aquatic parasites, like a leech or lamprey. For a spacefaring society on the go, carting around aquaria can be inconvenient, so after encountering Terrestrial humans, the Goa'uld devised an alternative solution. Using genetic engineering they created a modified humanoid race with a marsupial-like pouch, capable of protecting and sustaining a larval symbiote. Although immature larvae cannot blend with their host's mind, they *do* still provide immune system augmentation, giving Jaffa the same health benefits as a Goa'uld host. A side effect, though, is that Jaffa are very likely to become immunologically dependent on the symbiote (which incidentally makes it difficult for renegade Jaffa to extricate themselves from Goa'uld society).

Ascended Beings

“There are many planes of existence between human existence and Ascension.”

– Jim, *Threads*

In *Stargate* canon, ascension is an evolutionary and spiritual process by which people shed their physical body to live as energy on a “higher plane of existence”. The hard-SF analogue, *mind uploading*, is a process of transcribing an individual's thoughts and identity into software, allowing them to transcend the limitations of their biological form.

While mind uploading is a technological procedure, it would ideally be accompanied by spiritual or psychological development: a rigorous mental preparation to adapt to the expanded capabilities of incorporeal existence. Many of our basic motivations are grounded in pursuing our physical needs and pleasures, securing our lives and livelihoods, and caring for our kin. If one has the ability to live forever, spawn millions of offspring every second, and simulate any pleasure or luxury imaginable, one should cultivate other aspirations to avoid a dangerous mental spiral. Nonetheless, there is no *requirement* that ascension must coincide with moral or spiritual enlightenment.

Those who have made the transition to incorporeal existence naturally think of themselves as “higher beings”; in the *Stargate* mythology, they refer to those still subject to biological imperatives as “lowers”. As noted in the quotation above, there may be many degrees of ascension, which, in our hard-SF interpretation, could mean three things: 1. to what extent the entity *depends* on a specific physical instantiation; 2. to what extent the entity *cares* about the affairs of the physical world; and 3. to what extent the entity's behaviour is *understandable* to ordinary sophonts. These will tend to be related. “Low-level” ascended beings might be like Greg Egan's Gleisner robots: embodied in distinct physical forms, in order to have immediate and authentic interaction with the material Universe (including corporeal life). “High-level” beings, on the other hand, could be wholly committed to immaterial existence, live in solipsistic virtual realities on robust cosmic information networks, and have mental schema and motivations that are entirely alien: their interactions with our reality might be either too subtle to notice or too vast to comprehend.

Ascended beings might also develop aspects of superintelligence, whether through straightforward increases in speed and mental capacity, or through the development of radically new forms of information processing. There may even be distinct levels or stages of superintelligence beyond human-level cognition, but if so, these would likely be unfathomable to us.

Unlike the telekinetic energy beings of *SG-1*, a realistic ascended being must have some material form if it is to interact with the physical Universe – though it is not *restricted* to that form. Some possible constitutions are given below.

- **Incarnate:** The being can create a biological body, imprinting its personality and *some* of its memories into the organic brain. This allows for genuine relations with other biological races, but a “higher” ascended being may have to choose which aspects of itself will fit into the form's neural anatomy.
- **Cybernetic:** The being can create a biological body, but with artificial augmentation. In particular, a computer brain may be fused to an organic body, allowing most or all of the entity's personality to take up residence in the physical form.
- **Biomimetic:** The being can inhabit an artificial “robot” body, but with superficial features (living flesh, vital signs, etc.) that allow it to pass undetected as a biological creature. This permits substantially greater physical capabilities than a fully-incarnate or primarily organic cybernetic form.

- **Utilitarian:** The being can construct an artificial form suited to whatever task is at hand, without concern for appearances or passing itself off as a living creature.

Note that these categories are not discrete, but can blend into one another. One particularly versatile form that spans the biomimetic-utilitarian grades is a *nanomorph*; see the *Crawling Chaos*, p. 10.

Phama

“Oma concerns herself with the individual. She may have the best intentions, but then, so did the Ori when they first began.”

– Moros, *The Quest*

Phama are individual ascended beings who make (ostensibly) benevolent interventions with lowers, protecting them or guiding them towards ascension. They may also be referred to in various human cultures as tutelaries, daimones, yidams, spirit guides, or guardian angels. In the *SG-1* series, Oma Desala (Mother Nature), Orlin, and Ganos Lal (Morgan Le Fay) fit this profile; it is mentioned that Oma had followers with similar views.

Note: The Stargate franchise had no general term for tutelary ascended beings. The first such being encountered was normally referred to as Oma, said to derive from Tibetan ama or “mother”. On this basis we use the term phama, literally “parents”, to denote such beings in general.

Phama are presented as a fringe movement within ascended society, consisting of rare individuals who tread warily around the non-interventionist policies of the Others (below). While they respect the self-determination of corporeal beings, they are also willing to intervene, with the best of intentions, and sometimes with disastrous consequences. For this they are ostracized or otherwise punished by the rest of ascended society, and their interactions with lowers are monitored and restricted. This distinguishes Phama from the Ori, who are authoritarian, dogmatic, indifferent to the autonomy of lowers, and have an organization and power base that rivals the Others.

Among Earth spiritual traditions, these beings fit in well with religions that emphasize spiritual enlightenment and liberation from the physical world, such as Taoism, Buddhism, and Gnosticism (rather than, say, Abrahamic religions that prioritize faith and devotion to a deity). Their teachings and rituals focus on expanding one’s consciousness and rejecting materialistic desires, in preparation for a future existence as an independent incorporeal entity.

Others

“The Others of your kind destroyed the planet? Well they interfered too. Isn’t that breaking their own rule?”

“As a collective, they decided it was necessary to prevent a disaster that I was responsible for. I was forced to live on Velona after that.”

“Well, you couldn’t have known.”

“That’s why the rule exists.”

– Samantha Carter and Orlin, *Ascension*

The Others represent the bulk of ascended beings, who largely ignore the physical Universe, or who study it subject to a policy of non-intervention. The *Stargate* series explored reasons for this in several episodes, and these reasons carry over quite well to software-based entities.

The moral case for remaining uninvolved is the risk of a slippery slope when near-omnipotent beings identify too strongly with one or another mortal race or cause. Even acting with benign intentions, the meddlers would be responsible for the consequences of their interventions, leading to further involvement. An idealistic pursuit could end up significantly refashioning the Universe according to one favoured group’s view of Utopia, without regard for the autonomy or will of other creatures. To prevent this, the Others collectively restrain and sanction individual ascended beings whose interventions cross a vaguely-defined line that would “significantly alter the fate” of any corporeal species.

Another reason cited by ascended beings for their aloofness is the utter insignificance of mortal affairs in the grand cosmic scheme. The moral imperatives of lower life forms are simultaneously outside of the Others’ jurisdiction *and* beneath their concern, and ascended beings who obsess over such matters are seen as

irresponsible eccentrics. If ascended beings are superintelligent, they would likely see ordinary sapient races the way we do simple animals: as creatures to be studied but not empathized with. But even human-level software intellects might have concerns that are unimaginably larger than ours in *scale*. A virtual reality running on a sufficiently advanced substrate (e.g. a neutron star converted to femtomachinery) would allow more sapient beings to live full and productive lives in one minute, than have ever existed in the flesh over the history of the known Universe. To such a community, the fate of one mortal species, or even an entire galaxy, might be inconsequential. Advances in fundamental sciences could even give ascended beings access to other *physical* realities, among which our entire observable Universe is a negligible speck.

Ori

“What is a god? What power is great enough to make you bow down in humble reverence?”

– *Prior of the Ori, **The Powers That Be***

The Ori are a community of ascended beings that actively commands the worship of lowers, through the religion known as Origin. Within the *SG-1* series, it is stated that the Ori hold out the *false* promise of ascension for their followers, while instead drawing out their spiritual energy to increase their own power. As noted on p. 2 of the *Premises*, this mystical energy is difficult to reconcile with a hard-SF outlook; and furthermore, “soul-sucking vampire” seems a rather trite motivation for a transcendent superhuman being.

It is worth noting that the accusation that Ori do *not* ascend their followers is only made by rival ascended beings who openly oppose the Ori, so even within *Stargate* canon there is no guarantee that these allegations are truthful. Notably, the Oracle of the Ori acknowledges that they channel the energy of their worshipers, but explains that this “unselfish act of giving” is part of the process of salvation and ascension.

If we dispense with the notion of magical “life force”, then the most straightforward explanation in our proposed backstory is that the Ori *do* ascend at least some of their followers, but only those who have sufficiently demonstrated their selfless devotion. The ultimate purpose of Origin, then, would be to recruit and select candidates who would make good and stable ascended beings. In this they are not so different from the Phama. However, while the Phama’s philosophies promote spiritual self-awareness and self-actualization, the Ori call for piety and surrender of free will. To the Ori, self-determination is inextricably linked to self-interest, which is a dangerous trait for an omnipotent being. Only through giving up one’s selfhood to a greater cause can one prove worthy of apotheosis.

The Ori could well argue that they are charting a path of prudent benevolence between the callous Others, who hoard their knowledge of ascension, and the reckless Phama, who ascend lowers with inadequate vetting. However, these noble-sounding ethics become problematic when combined with a cosmic perspective that trivializes mortal affairs. To the Ori, the interests and lives of lowers are of small concern when weighed against the importance of elisting worthy disciples for ascension; and the Ori’s followers are notorious for their aggressive proselytizing and genocidal religious crusades. It should be noted, though, that the Ori are in fact remarkably restrained compared to what they are *capable* of. Perhaps they are kept in check by the threat of escalating conflict with the Others, or they recognize some limits to promoting virtue through coercion, or they have other motives that are not readily apparent to lowers.

In the proposed backstory, the Ori would most naturally be an offshoot of Alterans, which would explain their particular concern with the human races in our Galaxy. Pre-ascended Alterans, being human, would almost certainly have had ideological divisions over authoritarianism versus self-determination; after ascending, the schism would have become more acute, dividing the Ori from the rest of ascended society.

Plot point: While the *Stargate* franchise regularly cast aliens in the role of pagan gods, it generally refrained from giving Abrahamic religions a similar treatment, perhaps for fear of alienating viewers. Nonetheless, the Ori are clearly modeled on mediaeval Christianity. What if this connection was made explicit? The Ori might present themselves to the humans of Late Antiquity and the Middle Ages as manifestations or messengers of an almighty God, creator of the Universe, and work through the Church to recruit candidates for ascension. The sacraments of Communion and Extreme Unction could be ceremonial cover for technological interventions needed to obtain a mental upload (see *Nondestructive ascension*, p. 30). And what if the Reformation and Enlightenment reflected a realignment in the ascended domain, and the withdrawal of the Ori from this part of the Galaxy? Modern churches might be maintaining doctrines and rituals established by the Ori, but without the technological backing that would lead to actual salvation!

Priors

The Priors of the Ori are their high priests and chief evangelists, greatest and most powerful of their non-ascended followers. In the series they are presented as having been artificially evolved along the path to ascension, having many telekinetic and healing powers. In a hard-SF setting, their abilities would be technological or cybernetic, rather than biological. See the *Technology* section for ideas on what is or is not plausible. Priors are fanatically devoted and fearless, confident that they will ascend upon their own death.

Replicators

The *shapeshifter* and the *devouring swarm* are two visceral horrors depicted across human cultures. In *SG-1* they are manifested in the Replicators, one of the three primary adversaries of the series (along with the Goa'uld and the Ori). In a hard-SF setting, Replicators, particularly the “human-form” Replicators, are machine intelligences, and therefore qualify as ascended beings – ones who have chosen to incarnate in a particularly adaptable physical form. In the proposed setting, this form is a *nanomorph assembler*: a mass of molecular machinery capable of assuming an almost unlimited range of configurations and of fabricating nearly any artifact, including copies of itself.

While the most basic Replicators might earn Greg Egan’s reproach as “bacteria with spaceships... knowing no better, having no choice”, the more sophisticated Replicators, like other ascended beings, would presumably have more elaborate (and possibly inscrutable) motivations. It should be noted that *any* ascended being might choose to manifest as a nanomorph: the flexibility and utility of this form would make it a popular physical instantiation. However, humanity’s perspective will be forever tainted by their first encounter with a being of this form – the Lovecraftian nightmare known as the Crawling Chaos.

Crawling Chaos

The Crawling Chaos is a malevolent entity in nanomorph form, known for manipulating, tormenting, and sometimes devouring sapient beings. Unlike the Goa'uld, the Crawling Chaos does not seem to be motivated by egomania – it often presents itself as an agent of even more remote and unfathomable Powers. Nor does it seek out endless replication, slavish submission, or wanton destruction – though it would certainly seem capable of achieving these things! Instead it seems to take joy in deluding, abusing, and driving others to madness: a sadistic trickster and sower of discord.

In its raw form, the Crawling Chaos is a protean mass of grey goo, pieces of which can break off, merge, and reshape themselves at will. It has no discrete internal structure: any separated part can sense, move, or think on its own. It can change its shape and appearance, including texture and colour, sculpting its surface to microscopic precision. Thus a human-sized piece could adopt a human appearance down to the finest visual or tactile scrutiny (though it would not stand up to surgical or chemical analysis). Alternatively, it can form its body into other utilitarian configurations (e.g. a multi-limbed serpent or a flattened parafoil), or reshape appendages into tools or weapons with molecularly-fine edges. Separated pieces retain the being’s overall personality and memory, though with lesser “focus” or precision; combined pieces seamlessly merge their memories and experiences.

Additionally, the Crawling Chaos is a nanomorph *assembler*, made up of universal molecular constructors. It can synthesize a wide variety of gadgets from raw elements, including more of its own substance, at a rate of 5% of its mass per day: if it wished, and had enough material, it could double in mass every two weeks. Other technological artifacts can be assembled at a similar rate (e.g. a 100 kg piece of Crawling Chaos could assemble a 1 kg device in just under 5 hours).

The Crawling Chaos can also *disassemble* objects that it touches, its constructors tearing through matter like ultra-strong acid. It is capable of scanning the objects that it disassembles, storing an atomic-level schematic for analysis or future assembly. Most disturbingly, it can disassemble and scan *people*, creating a mental upload for ongoing study. Thus the Crawling Chaos will sometimes devour an individual and reshape itself into their Döppelgänger, with access to the original’s memories and personality. This personality is under the complete and total control of the Crawling Chaos’s own psyche: unlike the Goa'uld, it does not form a gestalt personality.

There are some physical limits to the Crawling Chaos’s powers. It is made of ordinary matter, so its strength and durability are not supernaturally high: roughly equivalent to carbon-nanofibre-reinforced

tungsten. Its self-repairing nanomechanical structure allows it to reform or repair itself quickly, even if shattered into tiny shards, but it cannot withstand being melted or vapourized. Its powers of assembly are also finite. It cannot create energy (in the form of fuel, for instance), though it could certainly assemble a refinery or power generator. It cannot directly fabricate a living organism, but it would be able to assemble a nanosurgery pod (p. 30) or similar biotech device that in turn *could* grow such an organism.

In the *SG-1* series, the most effective weapon against the Replicators was a device that attacked them at the software level. This is certainly a reasonable possibility, but would require an intimate knowledge of their computational system, at the level of whatever beings created them. See the *Sangrail* (p. 34): the Crawling Chaos is fundamentally an ascended being, and would need to be dealt with as such.

Plot point: The true motives of the Crawling Chaos, like other ascended beings, are best left enigmatic. Certainly the in-universe characters will have no clear understanding of them, and beyond the concrete description above, we would not want to overly constrain future story-writers. However, we present one *possible* and *partial* explanation for the Crawling Chaos's behaviour. What if it, or the beings it serves, are interested in examining diverse and resilient new ways of thinking? This would certainly be an important pursuit to stave off solipsism or spiritual nihilism. Such a study might well involve "stress-testing" sapient minds to the point of destruction (i.e. insanity), and then absorbing and analyzing the results.

Other Races

Most extraterrestrial societies in our region of the Galaxy are humans or humanoids, descended from Alterans (who left Earth around 100,000 years ago) or Goa'uld slave populations (starting some 8,000 years ago). There is a good reason for this: the chances that two independent ecosystems, evolving over billions of years, would produce technological civilizations close enough in time to allow meaningful peer interrelations, is remote. Thus, essentially all extraterrestrial civilizations in the hard-SF backstory will be either human-derived, or will exist in a mode that changes over much longer timescales than human society, or both.

The total population of extraterrestrial humans is only a few tens of millions, many of them serfs serving Goa'uld masters, or *former* serfs of Goa'uld that were killed in internecine conflicts. Because of the Goa'uld's wide diaspora and loose organization, it is not uncommon for orphan colonies to go unnoticed and unclaimed for centuries, allowing the locals to build their own society; most of the worlds visited by SG teams were of this type. Typically, such societies would still be bronze age through mediaeval in development, with populations in the tens of thousands. Some have reached industrial levels of development, and populations of a few million. And a very few have equaled or surpassed Earth's technology (see below) – though not its population! Often, a world may develop independently for a century or more, only to be "reclaimed" by a Goa'uld, who proceeds to eradicate its civilization and bring the population to heel.

Perhaps surprisingly, a small but significant *bourgeoisie* of unblended unenslaved humans exists within the Goa'uld empire, who trade in goods and services useful to the Goa'uld "aristocracy", and whose existence is therefore tolerated. Their population is scattered across a few dozen developed worlds. While they have access to Goa'uld-level technology, the Goa'uld keep their independent industrial capacity in check, lest they develop into a threat to the System Lords.

Nonetheless, the Goa'uld, preoccupied with their own perpetual discord, have allowed a few human civilizations to develop into powers that rival their own.

Tau'ri

We would be remiss if we did not at least mention Earthlings (Tau'ri) in our backstory! Earth is the ancestral homeland of all humans in the Galaxy, and despite the human diaspora, still contains the overwhelming majority of the human population. Abandoned and overlooked by the System Lords for millennia, Tau'ri civilization has progressed significantly: while technologically inferior to the Goa'uld, it has immense industrial capacity, and has been developing far more rapidly than the other less populous worlds in the Galaxy. Combined with a few fortuitous discoveries and alliances, this allows the "primitive" Tau'ri to challenge their more advanced rivals.

Tollan

The Tollan are one of the most advanced unascended societies in this region of the Galaxy. In the *SG-1* series they are shown as being capable of building stargates (p. 15) and phase-shifting devices (p. 32). Conveniently for story-writers (but inconveniently for our protagonists), they have an absolute ban on sharing their technology with less-advanced societies, claiming that their first such attempt at philanthropy resulted in the primitive beneficiaries *destroying their own world*.

From their name, one can infer that the Tollan were transplanted from Mesoamerica some 2,000 years ago. (The name *Tollan* refers to the birthplace of humanity in some Mesoamerican mythologies, and is also an epithet of certain pre-Columbian cities, principally Teotihuacan.) While anthropologist Daniel Jackson speculated (in the episode *Enigma*) that the Tollan may have advanced further than the Tau'ri by avoiding Europe's Dark Ages, this seems an inadequate explanation: the original transplanted population would likely have numbered tens of thousands at most, growing to perhaps a few million today, which is barely enough to support an industrial revolution, much less a modern technological civilization. Furthermore, while the Tollan regularly use (and perhaps can manufacture) particular items of *miraculous* technology, their overall society and way of life seems little different from the Tau'ri. These facts would suggest that, for all their admonition against sharing technology with primitive cultures, the Tollan are likely not a self-made civilization, but are themselves clients of an advanced patron.

The identity of this patron would certainly be an interesting plot point to explore. An obvious candidate from the original series would be the Giant Aliens seen in the episode *Crystal Skull*, who took the role of Mesoamerican deities and also had phase-shifting devices as their signature technology. The portrayal of the Giant Aliens suggests that they are in all likelihood a group of Phama.

Aschen

The Aschen are another uncharacteristically advanced human civilization, depicted as being more than a match for the Goa'uld. Their name (German for "ashes"), and the Gothic writing system used by some worlds in their confederacy, suggest an origin story (possibly a harrowing one) based in late Mediaeval Europe. This is long after the Goa'uld abandoned Earth, indicating that another stargate-using society, possibly Ansur or Ori, may have been responsible for relocating them.

As with the Tollan, there is the puzzle of how the Aschen developed an advanced technological civilization starting from a (presumably) small founding population. A possible answer is suggested by another characteristic Aschen trait: their staid humourlessness. Much of the Aschen population might be like the "Azi" of C. J. Cherryh's *Alliance-Union* universe. These are artificially-gestated mass-produced humans, raised and educated using sophisticated psychoneurological conditioning rather than conventional parenting and socialization. This allows the society to expand its workforce and industrial base much faster than traditional child-rearing, producing adults with specialized expertise but limited emotional range. (We point out that the Ansur also use cloning for reproduction, albeit for different reasons.)

The signature technological achievements of the Aschen are in biotechnology – a fact that meshes well with the speculation above. Aschen destroy their enemies and subjugate their vassal states, not by military conquest, but through insidious and often surreptitious bioweapons (e.g. covertly sterilizing 90% of a target population to collapse its civilization).

Precisely *who* transplanted the Aschen (and gave them their initial infusion of biotechnology), and why they were subsequently left to develop independently, is for future storytellers to determine.

Reetou

Rounding out our list of extraterrestrial societies is one genuinely *alien* race, indeed one of the few non-humanoid aliens from the original series. The Reetou are a vaguely insectoid species, described as being "180° out of phase" from ordinary matter, rendering them invisible. In the proposed reboot, the Reetou would be native inhabitants of a *mirror phase* universe coexisting with ours: see *Parity Reverser*, p. 32.

Mirror matter would be invisible *and* intangible to ordinary-phase matter, but the Reetou are able to use *Transphase Enhancement Regions*, either innately or in the form of artifacts, to *purposefully* interact with normal matter. See p. 34 for more discussion on the capabilities of TER devices.

Although Reetou are native to mirror-matter worlds, their TER capabilities allow them to function on normal-matter planets, as well as operate stargates. This may be the main attraction of normal-matter worlds to them: lacking stargate technology of their own, the Ancients' network allows them rapid transit across the Galaxy. However, within the mirror-phase Galaxy, stargate devices would effectively be located in interstellar space (far from mirror-matter stars or planets), suggesting the Reetou must combine stargate travel with at least some interstellar capability in their own phase. This would imply that Reetou have a stable and tranquil culture capable of operating on centuries-long timescales.

Individual Reetou, of course, may diverge from this peaceful stereotype.

Languages

"Scene 23 takes place on another planet, so you think aliens eat apples?"

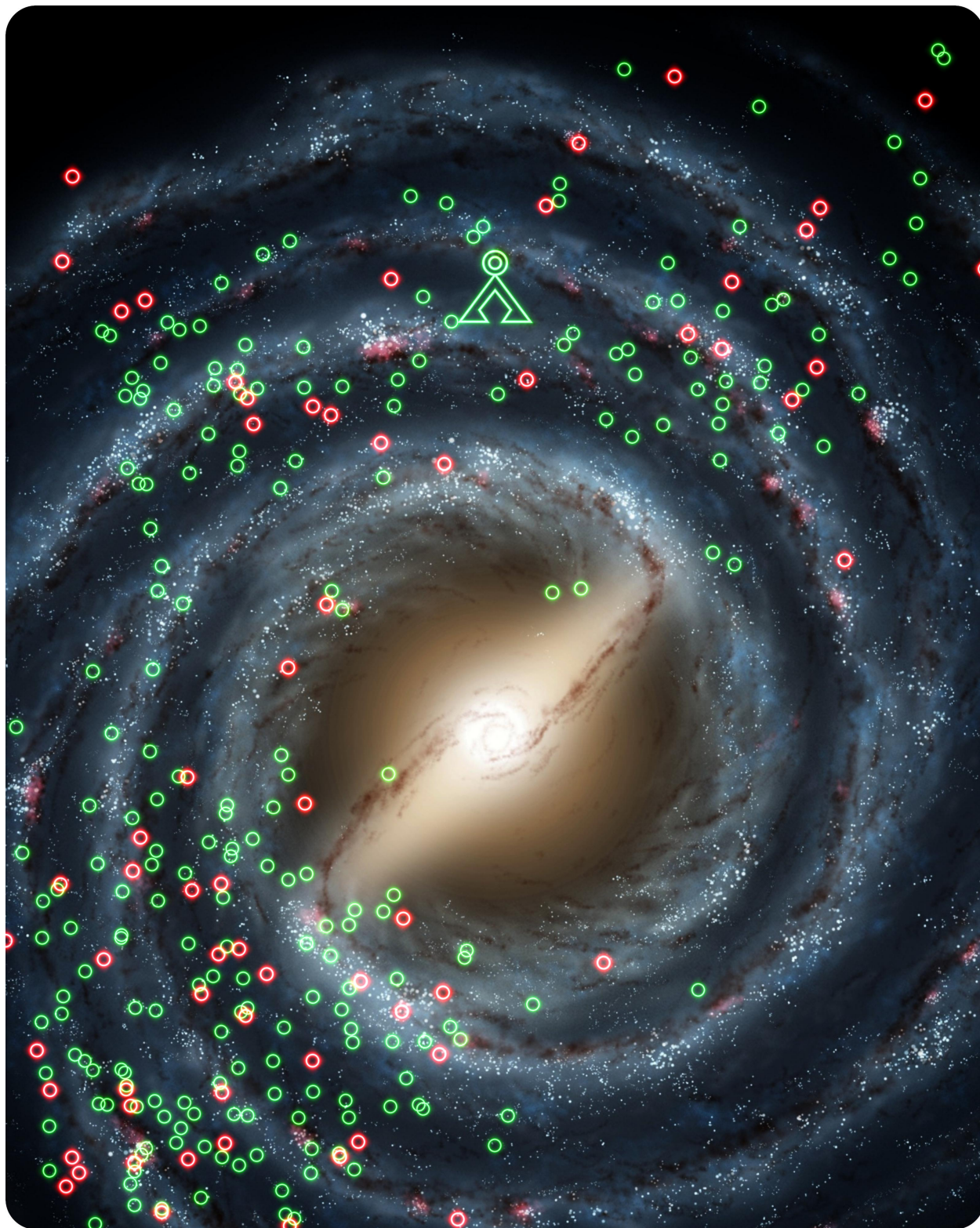
"Why not? They speak English."

– Martin Lloyd and Prop Master, ***Wormhole X-treme!***

The *Stargate* backstory provides a natural justification for Earthlike planets (Alteran terraforming projects) and humanoid extraterrestrials (Alteran and Goa'uld migrants). English-speaking aliens, however, do not follow logically. The original feature film and several episodes explore the challenges of communicating with new contacts, and emphasize the importance of having a polyglot linguist/anthropologist on the advance team. Other episodes have not been so realistic.

It is understandable that portraying the contact team laboriously establishing communication with each episode's society-of-the-week could detract from an action-packed storyline, and creating believable alien languages is also a significant task for story-writers. There are, however, a few factors that would help to mitigate this.

- Most Goa'uld-disseminated cultures will speak some variant on the Goa'uld *lingua franca*, which can be portrayed as ancient Egyptian (either because Goa'uld introduced the proto-Afro-Asiatic language family to Earth, or because the sudden assimilation of so many hosts from this region led the Goa'uld to adopt the hosts' common tongue as their own). Once the team is fluent in this language, they can quickly establish communication with a majority of human-populated worlds.
- Most *other* cultures dispersed around or after this time spoke languages known to modern linguists. To first approximation, the archaic form of these languages can be used for communication. Again this brings the slightly-cinematic abilities of the team's linguist to the forefront of these missions.
- Human societies that diverged from *earlier* times belonged to the Alteran diaspora and/or Alliance of Four Great Races. Given their advanced technology and (in the case of the Ansur) continued interest in Earth, these races presumably *could* communicate with us in English, if they wished. (Or other Earth languages, depending on the time and place of contact. For instance, *SG-1* depicted the language of the Ancients as being similar to Mediaeval Latin, but this may have been the result of Ori interactions with early Christianity: "original" transcriptions of Ancient were in fact Latin *translations*.)
- We will not dictate precisely how these languages are *portrayed* in a dramatization: whether ancient languages will be reconstructed, modern languages substituted, or dialogue being notionally "dubbed" into English in situations where the *characters* are mutually intelligible. Nonetheless we would encourage the use of appropriate narrative techniques to make it clear that, in most cases, the *actual* language being spoken is *not* English.



Technology

In science fiction, gadgets and technology are as important as backstory in establishing a believable setting. Having items whose operating principles are thought out in a coherent manner makes all the difference between a random episodic plot device and an authentic element of the fictional universe. This is especially true with hard SF, where these operating principles must be broadly consistent with what is known about our own Universe.

Ultimately, in an episodic series with many writers and a Galaxy-spanning backdrop, no prior list of gadgets such as this one can be exhaustive. It can, however, serve as a set of concrete examples to establish the scope of technological abilities. It is up to the showrunners and/or technical consultants to ensure that individual storylines do not overrun the boundaries of what is possible (or at least plausible) in the setting.

When discussing a society's technical proficiency, it's worth noting that technology is a complex web of interrelated theoretical concepts and industrial capabilities, and is not captured by a single overall "tech level" (or even a branching "tech tree"). Nonetheless it is useful from a dramatic perspective to have a general idea of which societies are more or less advanced, and what devices they might have access to. In these discussions we will use the following approximate categories:

- ① **Contemporary:** What our Earth protagonists have access to at the start of the story (other than the stargate itself). This can be actual modern-day devices or plausible "secret research projects".
- ① **Near-Future:** Technologies that are foreseeable within the next few decades... or sooner, if spurred on by the protagonists' adventures.
- ② **Mature Spacefaring:** A technological plateau typical of most spacefaring societies encountered by the adventurers, including the Goa'uld and their rivals. It covers a wide range of technologies that have reasonably well-understood operating principles but no obvious development timeframe, making it difficult to subdivide this level further.
- ③ **Advanced Spacefaring:** Any of several technologies that represent *optimistic* improvements from the previous level. This level would be typical of more sophisticated spacefaring societies, such as the Ansur, that can readily hold their own against the Goa'uld.
- ④ **Breakthrough:** Technologies that go beyond physical laws as they are currently understood, while not being *inconsistent* with them. This might be typical of Priors or low-ascended beings, who may have access to Ancient knowledge but lack their industrial foundation.
- ⑤ **Miraculous:** Technologies of the Ancients, such as stargates.

Realistically, the interdependencies of technologies means that it takes significant time and investment across many fields to achieve significant progress: very rarely can a lone inventor, genius scientist, or singular alien artifact cause an immediate broad-based technological advance. In a dramatization we can take some artistic license, but a hard-SF setting should limit this to something believable. *Near-future* technologies could reasonably emerge during the story arc, while occasional *mature spacefaring* devices might be reproduced from a working model by Earth scientists as one-off prototypes, though without the high-tech industrial base for mass production. (But see *Autofactories*, p. 31.)

Note that lower-tech societies may also have access to *individual* higher-tech artifacts, either as gifts, trade items, recovered relics, or plunder. The iconic example is the stargate network, which is clearly the product of *miraculous* technology.

Stargates ⑤

The eponymous stargate devices are obviously central to the setting. We begin by explaining how stargates could function in reality.

Theory

A stargate is a device that opens a wormhole connecting two portals separated by (usually) interstellar distances: travelers can simply step through the portal and bypass the intervening space. Unlike the devices

in the original *Stargate* franchise, a realistic wormhole has no “event horizon” and is bidirectional, allowing light or matter to pass freely in both directions.

According to special relativity, it is straightforward to convert a faster-than-light communication or transit system into a time machine. In the case of a pair of stargates, if the two ends can be brought close enough together, the round-trip time through the portal and back through regular space can be made small or even *negative*: a phenomenon known as a “closed timelike curve” (CTC). However, it is possible for the system to detect when a CTC is about to occur and sever the link. There is some theoretical indication that this may even occur spontaneously: an imminent CTC could amplify quantum noise circulating around the loop, in a manner loosely analogous to the way a microphone connected to a nearby speaker can convert background static into a steadily-rising tone. In principle the energy buildup might automatically break the wormhole connection just before a CTC is formed.

Thus, stargates offer a plausible hard-SF mechanism for interstellar travel *without* having to deal with time travel, greatly facilitating their use as a plot device.

Realistically, stargates would not dial each other to establish a *new* wormhole. Rather, a pair of gates would have a *pre-established*, though possibly microscopic, wormhole joining them. Connecting to the other gate involves *inflating* the wormhole to a traversable size, by flooding it with exotic negative-energy *contramatter*. The existence of contramatter is a prerequisite for stargates (or any other form of faster-than-light travel).

The raw masses and energies involved in inflating a traversable wormhole are immense, typically on the order of thousands of times the mass of the Earth. However, matter and contramatter are finely balanced, so the *net* energy required can be arbitrarily small. We assume that stargate technology has been refined to the point that the energy imbalance that must dissipated is within safe tolerances – say about 500 MJ per activation. This represents inefficiencies on the order of 1 part in 10^{36} .

Design

The simplest type of wormhole is a *spherical excision wormhole*, formed by removing two spherical regions of space at either end of the wormhole and connecting the surface of one sphere to the other. Figure 1(a) shows an “embedding diagram” for such a wormhole, where conventional 3-dimensional space is represented as a 2-dimensional surface, which frees up the vertical direction to illustrate the connection of the wormhole openings through higher-dimensional “hyperspace”. Figure 1(b) shows what one would see looking at and through such a wormhole. Contramatter, shown in blue in these images, is concentrated around the surface of greatest curvature. (The *real* appearance of contramatter, if it exists, is unknown.)

The sharp curvature at the “throat” of the wormhole presents some challenges, as it will cause lengths and angles to be distorted as one passes through. Flexible structures may not have any problems, but rigid

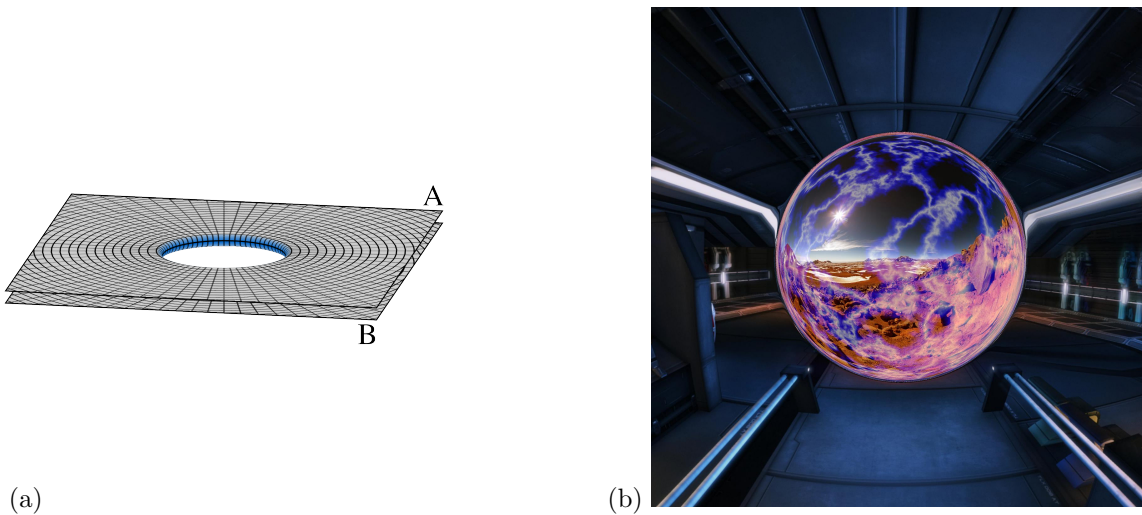
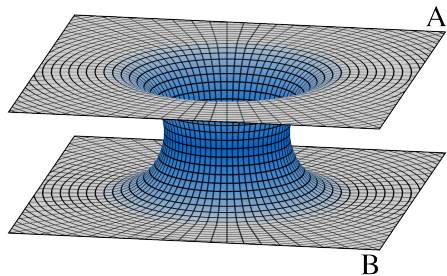
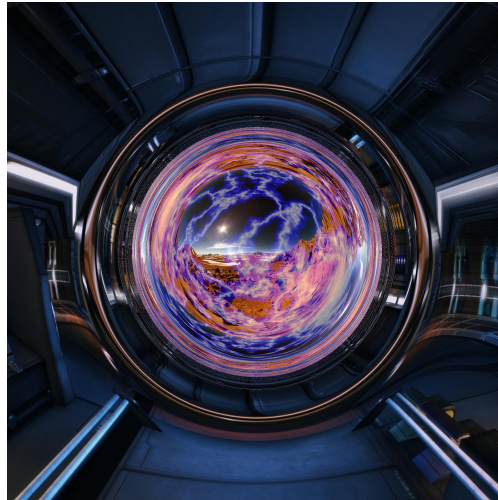


Figure 1: (a) Embedding diagram and (b) illustration of a simple spherical excision wormhole.

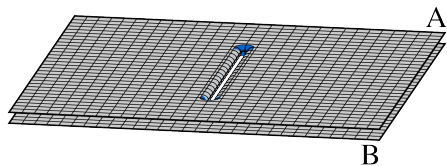


(a)



(b)

Figure 2: (a) Embedding diagram and (b) illustration of a smoothed spherical wormhole.



(a)



(b)

Figure 3: (a) Embedding diagram and (b) illustration of a flattened disk wormhole.

objects (including the skull and bones of living travelers) will be stressed and may break. The dimensionless *strain* at the throat of the wormhole is on the order of $\sim (l/R)$, where l is the size of the object and R is the size of the wormhole throat. Safe passage may require wormholes many times larger than the people or objects traversing them. The wormhole shown in Figure 2 smooths out some of this curvature: the strain in this case is of order $\sim (l/R)^2$.

Both simple excision and smoothed wormholes still require the traveler to pass through a contramatter-filled region of significant curvature. Some conceptualizations of contramatter suppose that it disintegrates ordinary matter on contact: if so, then it would be preferable to avoid regions of curved space altogether. The safest and most convenient wormhole geometry involves pushing the contramatter field out to a circumference and flattening the throat from a sphere to a disk, as shown in Figure 3. So long as travelers avoid the edge of the gateway, they will not experience any distortion effects or direct exposure to contramatter. Flat stargates are both bidirectional *and* two-sided: passing through either side of either gate causes one to emerge from the corresponding side of the other gate.

A flat wormhole can also be *polyhedral*, with contramatter “struts” along the edges of the polyhedron. However, among all the different geometries, a disk-shaped gateway is both the simplest and the easiest to visualize; from here on we will assume that stargates are circular when inflated.

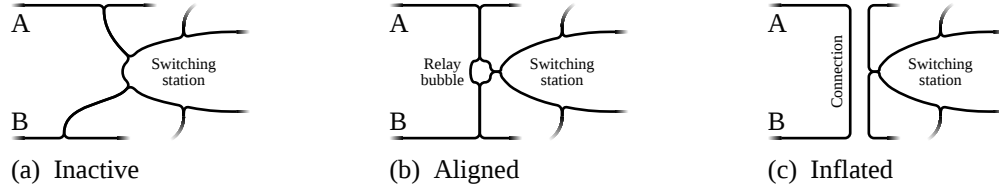


Figure 4: Dialing and connecting stargates A and B through a switching station.

Stargate Networks

Each wormhole connects two specific gates. To allow one departure gate to access multiple destinations, one would have to set up a waypoint or “switching station” where many wormhole termini are brought together in close proximity, allowing one to hop from the departure point to the switching station, then immediately through another gate to the desired destination. In many fictional portrayals, the traveller must physically navigate some interdimensional space to enter the correct destination gate: as with, for instance, the “wood between the worlds” in C. S. Lewis’s *Narnia* setting, the Galactic “Grand Central” from Arthur C. Clarke’s novelization of *2001: A Space Odyssey*, or the more recent depiction of “ring space” in the novel and television series *The Expanse*. The *Stargate* network, by contrast, handles this switching automatically by “dialing” the remote gate before “establishing a connection” (inflating the wormhole).

The process is sketched out conceptually in Figure 4. An inactive stargate has a microscopic wormhole connecting it to the switching station (a), through which it can signal a desired destination. Machinery in the switching station then aligns the termini within a pinched-off “pocket universe” (b), before inflating the wormhole throats (c). The result is a near-seamless connection between the two stargates, with only a microscopic branch linking the wormhole throat to the switching station. Thus, the existence and nature of the switching system would be largely hidden from most travelers.

To add new gates to the network, a wormhole would be created with each end held in a transport unit. One end would be sent to the switching station and added to the switching mechanism, while the other would be sent to the desired target in the Galaxy, possibly using the preexisting network. Note that taking a stargate through another stargate does *not* leave one wormhole “threaded” through the other: the openings are connected through hyperspace, *not* through real space. This is illustrated in Figure 5.

There may well be equipment at the switching station to create and incorporate new wormholes into the network, but, as explained above, this might escape the notice of a casual user of the gate network.

Operation

As in the *Stargate* movie and TV series, to initiate a transit from a starting gate, the traveler would use some form of dialing interface to enter a code uniquely identifying the destination gate. The switching station aligns and inflates the pair of wormholes as described above, allowing the traveler to pass through. After a timeout or explicit instruction, the wormholes would re-contract, closing the gateway.

Unlike the film and TV series, a dialing “address” identifies a specific gate rather than a spatial location: there is no way for the switching station to know the physical position of each gate. The initial deployment and assignment of addresses might have followed some regular pattern, allowing one to predict gate locations from addresses or vice versa, but this would not account for subsequent movement (typically of order 0.1 lightyears per millennium). By the same token, connections would not require “spatial drift correction” as described in the series: dialing a stargate’s address would access it wherever it is located.

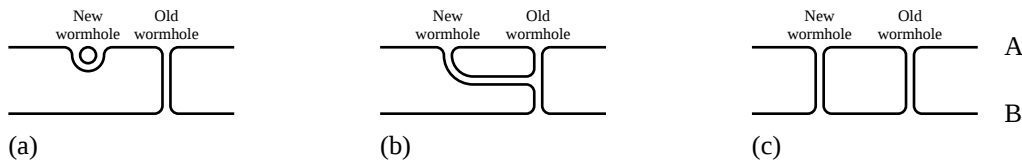


Figure 5: Transporting a wormhole mouth through another preexisting wormhole.

One of the more cinematic features of gate-dialing in the *Stargate* franchise is the “kawoosh”, or unstable vortex, that accompanies the opening of the gate. This actually has a plausible counterpart in realistic stargates! Inflating the wormhole throat involves filling it with contramatter, which would expel or even disintegrate ordinary matter in order to open the gateway. The sphere of contramatter would then be spun out to the perimeter, flattening the gateway and leaving its centre clear. An animation of a realistic wormhole inflation can be viewed at <https://www.youtube.com/watch?v=uZOYmibfzzc>. However, unlike previous *Stargate* canon, burying the stargate or installing a protective iris is unlikely to have any effect: if the kawoosh can push air aside, then from the standpoint of fundamental physics, a mere thousand-fold increase in density from air to rock is unlikely to make a difference. (But see the *Plot Points* below.)

Also, as noted above, once inflated the wormhole presents a direct (and two-way) physical connection between the two gateways, not an “event horizon” that dematerializes and rematerializes travelers. An iris could certainly be closed (*after* the kawoosh) to impede transit, but it would be simply a physical barrier, subject to physical attack. If there is a pressure differential across the gateway, one would have to contend with gale-force or stronger winds (up to near-sonic speeds if connecting to a gateway in a vacuum). And if one were to connect to, say, a gate on the ocean floor, the backwash of water at a thousand atmospheres of pressure would cause devastation in the vicinity of the gateway. Cautious users will need to take care when building their gate facilities!

In the revised hard-SF backstory, we will assume that Earth’s stargate was found deactivated in Egypt, and is now operated from a secure underground facility able to contain significant pressure differentials (including total evacuation of air from the embarkation room). A second gate elsewhere in the Solar system provided some degree of access after the first gate was deactivated over 3,000 years ago. Most advanced civilizations will take similar precautions, and many will locate their stargate facilities in orbit or on barren moons. Primitive worlds may have unguarded gateways exposed on the surface, and would have little defense against high-tech invaders in any case.

Plot Points

A few more operational considerations, that could be turned into individual storylines:

- Inflating the wormhole requires the active involvement of devices at both ends, which has operational and security implications. Plotlines can explore the initial discovery of how to *activate* an inactive gate (as well as how to engage the “dialing sequence”); how to *deactivate* a stargate, to prevent or terminate hazardous connections; whether there are override codes that the switching station can use to open a stargate in a soft-inactive state; whether there are hard-deactivation mechanisms – short of destruction – to lock down local inflation completely (similar to “burying the gate” in *SG-1* parlance); and various other attempts to access low-level functionality of the gate network and switching station.
- Even a “deactivated” stargate maintains a microscopic wormhole link, which can in principle be used for communication at sufficiently short wavelengths. From a plot perspective, this would be similar to communication through an iris-sealed gateway in the *SG-1* series. It could also be a mode of directed energy attack, similar to the Ancient weapon in the episode *Redemptions*. The only way to sever this basic connection is to release the wormhole entirely, irrevocably disabling the gate.
- Destroying a stargate could in principle trigger a significant energy release. From a fundamental physics perspective, the relevant energy scale is anywhere from the energy of a Planck-scale black hole (around a kiloton TNT-equivalent yield) to the energy of a black hole a few metres across (enough to incinerate much of the Solar system); the actual energy release would depend on the precise properties of contramatter and how it combines with ordinary matter to shape the wormhole. For dramatic purposes, we will assume an energy release comparable to the rest mass of the *ordinary* matter making up the device: a few thousand kilograms, or about 100 *gigatons* TNT-equivalent yield (enough to leave a crater a kilometre across and cause major devastation within a hundred kilometres or so).
- The stargate network would initially be deployed using slower-than-light interstellar seed ships. These might be automated vessels as portrayed in *Stargate Universe*, only relativistic rather than FTL. Note that realistically there is *no* distance restriction on connecting stargates: an intergalactic gate could be dialed just as easily as an in-system gate, once its address is known.

Spacegates

The preceding depiction of stargates brings them in line with currently-understood physics principles, while maintaining the “feel” of the *SG-1* series: in particular, the motif of heroes embarking from a secret Earth-based facility and arriving promptly at the scene of action, with minimal time and effort spent in transit.

But we live at the dawn of a new age of space exploration, so a modernistic or near-futuristic *Stargate* update might benefit by foregrounding realistic hard-SF space travel technologies (p. 26). This is particularly suitable if the setting must be developed independent of Metro-Goldwyn-Mayer *Stargate* properties (p. 41).

To move *Stargate* into the New Space Age, simply add one or more of the following assumptions:

1. A stargate must be in a hard vacuum (no more than a few nanograms per cubic metre) in order to inflate. Most stargates will be in outer space or on airless worlds, though high-tech civilizations (such as Earth’s) might have specialized stargate facilities on the homeworld.
2. A stargate must be in freefall or microgravity to inflate. In this case, all operational stargates will be in orbit, like the “spacegates” of *Stargate Atlantis*.
3. There is no automatic “switching station” or dialing sequence as described on p. 18. The gates might not even require inflation: they could be permanently open. Travellers must physically transit through one or more extraplanetary network “hubs” to reach their destination gate, adding anywhere from hundreds of metres to millions of kilometres to their journey.

A benefit of options 1 and/or 2 is that they immediately resolve one of the greatest hazards of gate travel: namely, the risk of opening a gate between a habitable environment and vacuum (or the ocean floor, or the core of a gas giant...). Contact with inhabited worlds will typically involve both space and gate travel. This makes space travel an integral part of most plotlines, but also significantly slows down the pacing, adding hours or days of travel time between stargates and the inhabited worlds they serve.

Option 3 presents some interesting story possibilities, along with challenging strategic considerations. Dense hubs with closely-spaced portals would be natural targets for empires or cartels wishing to dominate gate travel; by contrast, far-flung network junctions would be harder to monopolize, but slower to transit. These issues must be carefully explored to maintain a believable setting.

Overall, options 1 and 2 make a clear narrative and thematic break from the *SG-1* franchise, while also averting some possible catastrophes in gate travel. Option 3 represents an even greater stylistic shift, but potentially introduces new plot pitfalls.

Matter Transporters ⑤

“This one won’t dial multiple addresses, and it will only create a wormhole once and probably burn out.”

“And you ordered the materials online.”

“Mostly. Sorry, but you’re going to have a pretty big credit card bill this month. Oh, and you’re going to need a new toaster.”

– Orlin and Samantha Carter, *Ascension*

Stargates are not the only technology used to “transport” travelers in the *Stargate* setting. Ring transporters, beaming technology, and other variations make their appearance in both the feature film and TV series. From a hard-SF point of view, matter transporters can be broadly grouped into two categories:

Transporters that maintain local integrity of the traveler. Basically, this means wormholes. Note, however, that they need not be used solely for interstellar travel: one can set up gateways within the same system or even on the same planet. These might be connected to the full stargate network, or they might make up an independent local transit network, or they might be dedicated pairs of gateways without the complication of a switching station.

Transporters that convert the traveler to information. This includes *all* transporters in the original *Stargate* franchise, including the stargates themselves (which ostensibly dematerialized the traveler before beaming them through the wormhole). Realistically, this technology is on a par with mind uploading: in converting a traveler into energy, you are essentially Ascending them and then reincarnating them at their destination. But at that point, you could just as easily, in fact *more* easily, keep them in Ascended form!

In the hard-SF *Stargate* setting, transporters will be based on traversable wormholes connecting established endpoints – i.e. stargates or variations on them. As noted, stargates *per se* are those that comprise an interstellar network, while other devices might be part of a local network or dedicated link. Technologies that rely on dematerializing the traveler will *not* exist, except as a mode of transportation for Ascended beings.

Aside: Quantum physicists have been known to co-opt the term “teleportation” to refer to the transmission of quantum phase information between two systems. Writers of *Star Trek* and other fuzzy SF have obligingly adopted this terminology as the physical rationale for non-duplicative beaming technology. But *quantum teleportation is not actually teleportation!* In particular, for any macroscopic object, it would be *much* easier to simply scan and digitize it at the atomic level, and then store it, run it as software, or reconstruct a copy (or multiple copies) atom-by-atom. The only reason to invoke quantum information would be if preserving the identity of the traveler somehow relied on transmitting a coherent quantum state – a conceit that does not hold up to rational scrutiny. (In reality the quantum state of any individual is *continually* undergoing decoherence through interactions with the environment, on timescales of order 10^{-20} s: as far as the person’s quantum state is concerned, simply waiting a nanosecond is the same as creating a decoherent copy.)

Energy Weapons

Space opera stories typically introduce a variety of cinematic “ray guns” with generic effects and vaguely-specified operating principles. Sometimes, the idiosyncratic properties of a particular weapon become a significant (but usually inconsistently applied) plot point. *Stargate SG-1* notoriously had *zat’nik’tel* “zat guns” that would successively stun, kill, or disintegrate their target after consecutive shots – the latter capability being incongruously overpowerful, and was quietly dropped after the second season of the show. By starting out with a set of sound operating principles, one can hopefully avoid such embarrassments.

Pulse Lasers ①

A pulse laser is a *near-future* laser weapon that concentrates light emissions into short millisecond pulses. This is ideal for hand-held laser weapons, as it does not require the beam to be held in place on a moving target to burn a hole in it. Instead, the laser pulse produces a surface explosion as it vaporizes the outer layers of whatever it hits.

Although this concept is still in development in the real world, its effects on a target *might* resemble the cinematic blasts of “plasma weapons” (such as *Stargate*’s staff weapons). The appearance of the beam, however, would be quite different. In vacuum or clear atmospheres, it would be invisible. In haze or dusty air it would produce a brief flickering line of light connecting the weapon to its target. (Even if the laser emissions were infrared, they would heat any dust particles to incandescence.) This might be accompanied by a crackling sound, but the main report of the weapon would be the explosion at the target.

Particle Beams ②

A particle beam uses electromagnetic acceleration of electrons or ions, rather than stimulated emission of light, to deliver energy to the target. In principle this allows it to pack more energy into narrower or shorter “bolts” than a laser. However, particle beams tend to dissipate rapidly in space (due to electric repulsion) or in atmosphere (due to interaction with air), giving them shorter ranges than lasers. In an ordinary atmosphere, particle beams will be blocked by only a few metres of air.

A design optimized for use in an atmosphere would fire an ultraviolet laser pulse to ionize the air ahead of the beam. The resulting conductive ion channel would then keep the particle beam collimated over much longer distances.

The effect of a particle beam weapon would be similar to a pulse laser, only more energetic. The appearance of the beam would be like a perfectly straight lightning bolt due to the ion channel, and would make a similar crack of sound from expanding superheated air. Unlike cinematic “blasters”, the actual passage of the particle beam down the channel would be too fast to resolve with the naked eye.

Electrolasers ④

A weapon that can reliably subdue the heroes or important adversaries without killing them is a godsend to action/adventure writers. Of course reality is never so convenient: “non-lethal” weapons are either unreliable at incapacitating their targets, or carry a significant risk of serious injury, or both. However, devices based on electro-muscular disruption (EMD) have seen wide use in real life as “less-lethal” weapons. *Stargate*’s zat guns broadly fit this category.

An *electrolaser* is a plausible *near-future* EMD energy weapon that could be the basis of a realistic zat gun. It is essentially a taser without wires. As with particle beams (above), it uses an ultraviolet laser to ionize channels through the air, then delivers an electric current through those channels. The effect is similar to a lightning bolt, but passing along a straight line, and with controllable current.

Rather than having a strict sequence of effects on multiple hits, an electrolaser could be built with distinct settings controlling the current delivered (e.g. “set to stun” or “set to kill”). Of course the actual effects would be somewhat variable, and multiple hits would certainly increase the risk of serious injury or death. It’s also worth pointing out that the EMD effect would likely not penetrate any significant amount of body armour, or even light clothing that was specifically designed to counter it (e.g. incorporating a grounded conductive mesh). It *could* disrupt devices with unshielded electrical systems: in the real world it has sometimes been proposed as a vehicle-disabling weapon.

An electrolaser could be combined with a particle beam weapon, giving it a high-energy “blast” setting. The combination weapon would only need a single UV laser and focal array, making it more compact than two separate weapons.

Continuous-Beam Lasers ⑤

Real-life high-energy laser weapons behave almost nothing like their space opera counterparts. Their beams are continuous, nearly invisible, and are held on their targets for seconds at a time to burn through vital systems. In practice these are mounted weapons connected to automatic targeting systems, making them highly accurate, instantly aimable, and impossible to dodge or intercept. They are ideal for attacking maneuverable lightly-armoured targets at ranges up to hundreds of kilometres (i.e. space combat and point defense).

In the hard-SF *Stargate* setting, continuous-beam lasers (of various wavelengths) are the default weapons for ship-to-ship combat in space. They may also see use as area or point defense *interdiction fields* (p. 24). Apart from this, they are rarely employed as hand-held beam weapons.

Sonic devices ①

A multipurpose sonic tool could provide a plausible *near-future* hard-SF basis for the iconic Goa’uld “hand device” from the film and series (also known as a “kara kesh” or “ribbon device”). It would consist of a phased array of ultrasonic emitters/receivers, worn on a webbing spread across the user’s hand, and operating at millimetre wavelengths (frequencies of tens of kilohertz). It could in principle have a wide range of functions:

- **Ultrasound imaging:** The device can scan its surroundings, providing sonar/echolocation at ranges up to dozens of metres, and imaging the interiors of nearby objects.
- **Acoustic tweezers:** Precise control of the pressure field would allow levitation and manipulation of small or microscopic objects, without physically touching them (e.g. a sonic lockpick).

- **Sonic weapon:** At high intensities and close ranges, the device can attack the auditory pathway, causing pain, hearing loss, dizziness, and nausea. Underwater the effects would be further enhanced: a “corrosion beam” that can wear down surfaces with microscopic cavitation shockwaves.
- **Beamed audio:** By interfering narrow beams of ultrasound, at sufficiently high frequency to cause nonlinear mixing, human-audible sounds can be produced through acoustic heterodyning. This can be used to transmit messages that would be heard only by a specified target within a beam a few degrees wide, at distances up to dozens of metres.
- **Ultrasonic communicator:** The device could fill the role of wireless telecommunication over short ranges (hundreds of metres), in environments where traditional radio communication is impossible (e.g. underwater or in metal structures).

Note that the “kinetic pulse” and “psychic beam” functions of the original *kara kesh* from the series would *not* be plausible in a hard-SF setting, though the sonic weapon and beamed audio effects (above) might serve a similar purpose.

Microwave devices ①

Microwaves have similar wavelengths as ultrasound, so a microwave phased-array system could be integrated with a hand device (above). It would add the following functions:

- **Imaging radar:** This scanner has much greater range in air than sonar, but does not work underwater, nor will it image the interiors of objects.
- **Terahertz spectrometer:** By operating at shorter (submillimetre) wavelengths, the scanner *can* image the interiors of objects, to a depth of a few centimetres, and also perform chemical analyses through molecular spectroscopy.
- **Electronic disruptor:** The device could scramble unshielded electronics at short ranges, and produce voltage spikes in electrical systems.
- **Heat ray:** Also known as a “pain ray”, this mode emits microwaves with 3 mm wavelengths, which penetrate exposed skin to a depth of less than half a millimetre. This quickly heats the outer layer of skin and triggers heat and pain receptors, with little actual tissue damage. Thick clothing, or even thin clothing that incorporates reflective materials, will block the effect.
- **Radio communicator:** The system can act as a regular narrow-beam telecommunication device.

Defenses

As with offensive “ray guns”, science fiction abounds with generic defensive “shields” whose underlying mechanism is implausible or simply left to the imagination. Sadly for the sake of realism, there is no currently-known method of producing an “energy field” that is more solid than actual matter, making such shields at least of *breakthrough*-level technology, if not higher. Fortunately, however, *directed* energy defenses are plausible, in current use, and can potentially satisfy some of the flavour of defensive energy shields.

Directed-Energy Screens

This is a high-powered active phased array covering the surface of a vessel, which can operate both as a scanner and, at higher power, as a synthetic aperture directed energy weapon. The result is an integrated system that can detect targets as they approach within some specified distance, and instantly lock an energy beam onto them with pinpoint accuracy.

The capabilities of the system depend on the technology, wavelength, energy available, and *computing* power required for simultaneous tracking and interception of multiple targets. Defense may be omnidirectional or focused in a particular direction; a wide angle screen may also be *reinforced* or “angled” against particular threats, by concentrating limited energy or computing resources in a particular direction. A few general categories are listed below.

- **Microwave disruptor screen ①:** This millimetre phased array (AESA) can deliver a powerful burst of microwaves at incoming missiles or vessels, with enough energy to blind radar guidance and radio communication systems, and, at close ranges, even scramble unshielded electronics.
- **Laser disruptor screen ①:** A lidar system with enough power to dazzle optical sensors (including human eyes!) out to significant distances. At closer ranges it can act as a laser point defense system, burning off control surfaces or rupturing fuel tanks of incoming missiles or vehicles.
- **Interdiction field ②:** A higher-power phased-array version of a laser screen, this system can intercept and vaporize inbound objects, including kinetic projectiles, within some defined area. It may be overwhelmed by multiple fast-moving projectiles, or vessels with sufficient mass or armour to resist its attacks; it is also ineffective against energy weapons, or blast from explosions outside of its interdiction zone. While these systems broadly lie within the *mature spacefaring* technology level, capabilities can vary greatly between spacefaring societies or individual vessels, depending on deliverable energy (increasing range and stopping power), computational speed (improving tracking of multiple targets), and other factors.

The above systems are suitable for larger vehicles (especially spaceships) or fixed facilities. Smaller portable systems for battlefield use are typically one technology level more advanced. Thus, for example, one might have the following:

- **Personal protection field ③:** An interdiction field built by an *advanced spacefaring* society, and scaled for individual use, this device can ward off small arms fire and other projectiles: the user may also specify classes of object to be permitted to pass (e.g. people, slow-moving objects, items with a valid IFF tag, etc.). It can be carried as a hand-held shield, or, for greater coverage and convenience, may be incorporated into armour or clothing.

Regenerative Ablative Armour

Ablative armour absorbs and dissipates the energy of an attack by chipping or vapourizing away. It is typically lighter than other forms of armour for the same protection, and is particularly effective against energy-based attacks. While this doesn't sound as cool as high-tech "shields", *regenerative* ablative armour fills much the same tactical and dramatic role: it is effective against most weapons, can be overwhelmed by sustained attacks, but can be "recharged" without visiting a shipyard for repairs.

There are a variety of possible armour compositions and configurations, both current and proposed; the following constitute just a few of the possibilities.

- **Ablative foam armour ①:** A fast-curing foamed resin that can be sprayed onto structures or vehicles. As it is worn away, it can be "topped up" either by hand or by automatic systems. It is light but relatively thick, allowing for wide dispersion of the energy of a beam or impact. Simple versions produce a homogeneous foamed structure; more advanced formulations, which set in the presence of an electric or magnetic field, could have a layered structure that is highly effective against micrometeors and similar impactors (a *Whipple shield*). While still rather crude, such designs lead naturally to...
- **Magnetically-reinforced ablative armour ②:** This semi-fluid suspension contains high-temperature superconductors that can be "pinned" in place by an applied magnetic field. The result is armour that can flow around a vessel, then be locked into a rigid layer levitating some distance from the vehicle's surface. As the shell ablates away, more material can be added.
- **Living metal armour ③:** Superficially similar to magnetically-reinforced "liquid" armour, this material incorporates molecular-scale nanomachinery that actively weaves diamondoid fibres and refractory materials into a structure with immense tensile strength, rigidity, and thermal tolerance. Damage to the structure is repaired automatically. This armour may *also* include superconductors and magnetic reinforcement, especially if it is to be levitated with a gap between it and the surface to be protected. Advanced versions may also include aspects of contemporary *electric reactive armour*, storing large amounts of energy in microcapacitors in order to vaporize projectiles on impact.

Contramatter Shields ⑤

Contramatter could provide a defense similar to space-opera “shields”, though it would require *miraculous* technology. However, given the ability to create contramatter, the system itself is fairly straightforward, consisting of a shell of contramatter levitated around the shielded object. Material or energy attacks are *nullified* (absorbed) by the negative-energy contramatter, reducing it on a 1:1 mass-equivalent basis. The only limit to this defense is the quantity of contramatter that can be held in place (which could be immense), or the rate at which it can recharge after absorbing an attack.

Regenerating the contramatter shell after it has been depleted requires *dissipating* the equivalent amount of positive energy. For practicality, most of this energy must be in intangible forms (e.g. neutrinos or gravitational radiation), but early versions might allow some portion to escape as thermal radiation. This could plausibly justify some cinematic visual effects: shields that glow bright blue as they absorb attacks, fading to yellow, orange, red, and then pitch black as they build back to full strength.

Cloaking Screens

A cloaking device, that renders a vessel (or character) invisible and undetectable, is a science fiction staple that is actually somewhat plausible... with some modification. Specifically, while space opera “cloaking shields” are projected around the vessel, realistic stealth technology is incorporated into the hull or armour.

Some typical cloaking/stealth systems, at various levels of technological advancement, are listed below.

- **Camouflage and radar stealth ①:** These are simple passive forms of “cloaking”. Camouflage uses colour patterns to break up the target’s visual signature and blend in with the environment; stealth uses radar-absorbing materials and careful shaping of the surface to reduce radar reflections (the radar equivalent of black camouflage on a black background).

Interestingly, in the original *Stargate* franchise, only Earth teams were known to employ mundane camouflage: a fact that was explicitly called out in some episodes. In the case of Goa’uld and their armies, this was justified by the Goa’uld’s egotism: their regalia were meant to impress and intimidate rather than conceal. In a realistic setting, one can assume that other more pragmatic military organizations will adopt their own forms of camouflage.

- **Adaptive camouflage ①:** This consists of a set of cameras and a display screen wrapped around the “cloaked” object, presenting a changing image designed to blend in with its background. In principle it could show an exact image of whatever is behind it, but the illusion would only work for one chosen vantage point: in practice the system would be designed to generate a pattern matching the *general* shapes and colours of the environment, shifting to smooth out any movement of the cloaked object.

Demonstrations of such a system exist today, but practical versions are probably a *near-future* technology. Early versions would have rigid screens and be slow to adapt to motion of the object or its environment; improved versions would have flexible displays (perhaps actual *cloaks*) and faster response. The system could also have the option to display more garish colours or styles, in situations where stealth is not the objective.

- **Holographic cloaking ②:** The next step up from adaptive camouflage, “holocloaks” employ a mesh of phased-array lightfield emitters to replace the cloaked object with a 3d holographic image of its surroundings. By the nature of holography, this projection would work from any vantage point, causing the object to literally disappear. In practice, there might be subtle distortions or lags in the projection, particularly when confronted with rapid movement.

A visible-light cloaking system as described above would be *mature spacefaring* technology, but similar “spoofing” systems designed to fool radar exist today. As noted earlier, this system differs somewhat from space-opera “cloaking fields”, in that the projection is generated by the emitter mesh, and can only disguise objects *within* the mesh. As with adaptive camouflage, the system could also replace the object with *any* 3d image, so long as the projection also fits within the surface of the mesh.

- **Sonic cloaking ①:** A sonic version of the holographic cloak, this uses a phased array of sound emitters to cancel and deaden any sounds produced by the cloaked object. Versions of such a system for stealth submarines exist today, and more general-purpose vehicular systems would be *near-future* technology; a personal wearable device might be a *mature spacefaring* technology.

Scanners

Sensor technology is another area where generic space-opera depictions would benefit from some careful consideration of the underlying science. Standard phrases, such as scanning for “life signs” or “energy signatures”, sound compelling but obfuscate the actual capabilities of the instrument. What follows are some *realistic* (or at least plausible) sensing technologies at various technological levels.

- **Sonic array ②:** As described for *Sonic devices* (p. 22), this can provide passive sound detection and analysis, active echolocation (sonar) in air and water, and image the interiors of *soft* objects in its immediate vicinity (rigid-hulled vessels will be opaque).
- **Microwave array ②:** Passive and active imaging radar, as described for *Microwave devices* (p. 23).
- **Spectroscopic lidar ①:** Active infrared or visible-light laser scanner, like imaging radar but with higher precision. *Spectroscopic* lidar can determine the chemical composition of surfaces that it scans. At higher technology levels, this lidar system may be combined with laser-based defense screens (p. 23), comprising a single fully-integrated system.
- **Terahertz spectrometer ①:** Submillimetre radar can penetrate the outer layers of nonreflective objects, to depths of a few centimetres, providing some interior imaging capability. Molecular spectroscopy can also identify the chemical composition of objects that it scans.
- **Radiation imager ①:** An advanced passive radiometer for measuring a variety of high-energy (ionizing) radiation. Sensitivity, resolution, and discrimination will improve steadily with technology.
- **Gravimetric sensor ③:** An array of high-precision accelerometers that can measure the gravity of nearby masses, producing a detailed map of the mass density distribution around the detector. A *near-future* versions might detect the presence of nearby out-of-phase beings (see p. 32); an *advanced spacefaring* version (as given here) could provide resolution comparable to human vision, but capable of penetrating any barrier.
- **Neutrino imager ④:** The same *breakthrough* technology that gives *neutrino thrusters* (p. 28) would also permit high-resolution neutrino detectors. However, because ordinary matter is very nearly transparent to neutrinos, an object to be imaged would need a strong neutrino source on the *opposite* side from the detector, and only vague interior structures could be mapped. Neutrino sources (such as fusion reactors), neutrino absorbers (including other neutrino imagers), or other neutrino-based technologies, would stand out strongly.

Notably absent from this list is any sort of mystical “life signs” scanner, though imaging spectrometers might be able to detect and map out *biosignatures* (chemicals indicating the presence of living organisms).

Spacecraft Propulsion

Stargates allow our modern-day protagonists to begin their interstellar adventures *without* having access to space-opera starships. Indeed, for the first four seasons of *SG-1*, only alien adversaries and inconstant allies had spaceships of their own. The modified hard-SF setting adds the further constraint that even advanced extraterrestrials do not have FTL starships, relying on stargates for fast interstellar travel.

Nonetheless, high-tech civilizations *will* have in-system space travel, and, as stated in the section on *Stargates* (p. 19), many stargates are to be found in orbit around interesting worlds. Spaceflight technologies will be an important part of the setting, so long as they abide by physical law. We present the following partial list of possibilities, in order of technological advancement.

Atomic Rockets

A *Nuclear-Thermal Rocket* (NTR) is the only plausible orbital or interplanetary rocket technology that could be built with current technology *and* fit through a stargate. It is the default option for exploring systems whose stargate is not located on a convenient planetary surface.

An NTR uses a conventional nuclear reactor to heat propellant (typically hydrogen) to temperatures much greater than can be achieved through chemical combustion. The NERVA prototype from the 1960’s achieved effective exhaust speeds of 8.2 km/s with specific thrusts of 1.4 *g*, suitable for orbit-to-orbit interplanetary

travel. With present-day technology, a crash program could produce a rocket with single-stage-to-orbit capability, once one sidesteps the public relations problem of flying nuclear rockets around Earth. (While NTR exhaust is not radioactive, the engine itself is, especially since it would probably be built with just enough radiation shielding to protect its crew.)

For concreteness, we present two possible systems:

- **Advanced Nuclear Thermal Engine (ANTE) ⑩:** A plausible *contemporary*-technology atomic rocket, this has similar performance to NERVA but is more compact, due to advances in materials. It provides 250 kN of thrust with 8.5 km/s exhaust speed (870 s specific impulse), with a dry mass of 6 t (specific thrust of 4.2 g). It uses liquid hydrogen as propellant; the reactor requires refueling every few years.
- **Bimodal Airbreathing Nuclear Engine (BANE) ⑪:** A *near-future* nuclear propulsion system that can switch from internal propellant to an airbreathing turbo-ramjet mode. Nuclear ramjets offer performance advantages over airbreathing chemical rockets, in that the incoming airstream only needs to be heated and expelled, not used to burn onboard fuel: it can operate in any atmosphere regardless of oxygen content. A 250 kN engine weighs only 1.5 t and has an exhaust speed of 15 km/s in rocket mode; in atmosphere it requires *no* onboard propellant.

Fusion Rockets

A fusion rocket is the most advanced practical propulsion system that is allowed by physical law as we understand it today. In a typical fusion drive, a plasma consisting of hydrogen isotopes (and perhaps some heavier catalyst elements) is heated and compressed until it undergoes nuclear fusion to form helium. The reaction products are then expelled at exhaust speeds ranging from a few hundred km/s to a theoretical maximum of around 30,000 km/s. Achievable thrust is also a matter of speculation and technological sophistication: early models (with, say, late 21st-century technology) would be microgravity engines, while those produced by advanced extraterrestrials might manage many *g*'s.

Alternatively, fusion *pulse* rockets generate plasma in a series of discrete explosions: either by compressing small fusion fuel pellets with laser or particle beams, or by detonating actual thermonuclear bombs. These are more plausible near-future technologies, and (in the case of bomb pulse units) can generate significantly higher thrust, but their “fuel” must be *manufactured*, not simply refined.

Fusion rockets would be the default drive system for moderately-advanced alien civilizations for interplanetary travel, and would make slow interstellar hops at least somewhat feasible.

The exhaust of a fusion drive is extremely hazardous: a rocket with 10 kN of thrust (enough to move a 1 t vehicle at 1 *g*), with the optimal 30,000 km/s exhaust speed, would be releasing energy at the equivalent rate of a 1 kt nuclear explosion every 15 seconds. (In the case of an Orion drive, below, this exhaust would consist of *actual* 1 kt bombs detonating behind the vessel.) A *variable* fusion rocket could operate in a lower-efficiency mode, achieving the same thrust with lower exhaust speed and energy release, but the jet would still be quite destructive. If the vehicle is to operate in an atmosphere, a secondary drive would be advisable, at least for takeoff and landing.

- **Orion drive ⑫:** This *contemporary*-technology nuclear pulse rocket uses full-sized thermonuclear bombs in the kiloton range for propulsion. Plasma from a shaped ablative shell around the warhead expands against a massive “pusher plate” to generate thrust. It could be built today, although it would be quite expensive and *extremely* unpopular (not to mention illegal under international conventions). It is more likely to be seen among reckless or desperate extraterrestrial civilizations at a comparable technology level to ours. A minimal system would mass 100 t, and could produce 2,000 kN of thrust with an effective exhaust speed of around 200 km/s (detonating a 1 kt bomblet every 5 seconds).
- **Fusion micropulse drive ⑬:** A more practical *near-future* drive, this uses particle beams to compress and detonate fusion fuel pellets of a few grams each. A 500 kg drive unit might produce only 4 kN of thrust (0.8 *g* specific thrust), but with an effective exhaust speed of 600 km/s.
- **Magnetic containment fusion drive ⑭:** A classic *mature spacefaring* fusion rocket. A 100 t engine might generate only 10 kN of thrust, but with an exhaust speed of 3,000 km/s (1% *c*).

- **Variable fusion torch ③:** An optimistic but still physically reasonable drive for *advanced spacefaring* civilizations. In *high-thrust mode*, a 200 kg engine could produce up to 50 kN of thrust (specific thrust of 25 *g*), with an effective exhaust speed of 3,000 km/s. In *high-efficiency mode*, that same engine would produce only 10 kN of thrust, but exhaust speed increases to 15,000 km/s (5% *c*).

Neutrino Thrusters

A neutrino drive represents a *breakthrough* technology (going beyond physical laws as we currently understand them, while not *inconsistent* with them). The theoretical underpinning presumes a device capable of changing the relative strengths of weak and electromagnetic interactions within its reaction chamber: particle annihilations are manipulated so as to preferentially produce neutrinos rather than photons, which are directed into a collimated beam. Once they leave the reaction chamber, neutrinos resume their usual intangible state, resulting in “reactionless” thrust with no apparent exhaust.

Early versions of a neutrino thruster might produce high-energy (GeV-scale) neutrinos, whose interactions with matter are not *entirely* negligible, and would give a measurable radiation dose to someone standing directly in the exhaust stream: around 1 rad/day per kN of thrust (for comparison, occupational dose limits are around 5 rad/year, and a lethal radiation dose is around 400 rad). More advanced neutrino thrusters convert the stream to lower-energy (~ 1 eV) neutrinos within the reaction chamber, through the weak equivalent of an electromagnetic shower cascade; at these energies the exhaust is detectable only by the most sensitive instruments.

To produce significant thrust, neutrino thrusters must be powered by total conversion of mass, such as matter-antimatter annihilation. We may assume that such an advanced civilization will also have mastered the safe bulk storage of antimatter (e.g. as frozen antihydrogen); nonetheless, the result of a containment breach would be cataclysmic: 1 kg of antimatter would create the equivalent of a 43-megaton nuclear explosion. Alternatively, if we are already contemplating the capability of manipulating fundamental particle interaction fields, it is not that much more of a leap to imagine a technology that could convert baryons to lighter particles without the need for antimatter. Such a thruster could be powered for extended periods with minuscule amounts of ordinary matter.

Two possible “models” of neutrino thruster are given below. Both are *breakthrough* technologies, but the second requires *two* theoretical breakthroughs (as well as “mundane” improvements in thrust-to-weight).

- **Basic thruster ④:** A 2 t thrust unit producing 40 kN of thrust (2 *g* specific thrust), powered by 150 g of antihydrogen and a similar amount of hydrogen per full day of operation. Standing in the direct path of the exhaust gives a radiation dose of 40 rad/day to a typical human.
- **Advanced thruster ④:** A 5 kg thrust unit producing 40 kN of thrust (800 *g* specific thrust), powered by the conversion of 300 g/day of any matter (garbage, spare parts...). Radiation dose is negligible.

Contramatter Drives ⑤

For civilizations advanced enough to build a stargate, the ultimate propulsion technology would be a contramatter reactionless drive system. This presumes the technological capacity to distill or otherwise procure arbitrary amounts of matter and contramatter at will, as would be needed to inflate a stargate. (This incidentally also gives such a civilization access to unlimited free energy.)

A contramatter-driven vehicle contains precisely enough contramatter to cancel the mass of the rest of the vehicle, so that it can achieve any acceleration with *no* external force, and no expenditure of propellant or energy. It is a truly reactionless drive, whose thrust is generated purely by static internal forces between matter and contramatter. Precise trim would be maintained by shedding positive or negative mass in the form of harmless neutrinos or their contramatter analogues. These features make it safe to use in any type of vessel or environment, from surface vehicles to relativistic starships.

Contramatter drives, like stargates, represent a level of technology best left in the hands of departed Ancients rather than contemporary civilizations. Size and thrust are limited only by the designer’s preference: if they are capable of building a stargate, they are already handling *immense* amounts of contramatter. A typical vehicle design might resemble the “puddle-jumpers” of *SG-1* and *Atlantis*: a vessel just able to fit through a standard stargate, with a personnel capacity of a dozen or so, and a maximum acceleration of tens of *g*’s (limited mainly by the tolerances of its crew and passengers).

Larger interstellar “seed ships” were used by the Ancients to build the stargate network and initiate terraforming projects across the Galaxy. By maintaining multi-*g* accelerations for years at a time, a contramatter-propelled vessel can make interstellar hops at speeds approaching *c*.

Artificial Gravity

According to Einstein’s theory of relativity, gravity and acceleration are fundamentally equivalent making artificial gravity closely related to propulsion technology.

- **Centrifugal gravity ①:** *Contemporary* spacecraft can simulate gravity by rotating the vessel or part of it, or by connecting multiple vessels with tethers.
- **Accelerational gravity ③:** *Advanced spacefaring* fusion torch rockets or *breakthrough* neutrino thrusters allow prolonged near-*g* or multi-*g* acceleration, providing reasonable apparent gravity.
- **Gravity generator ⑤:** True artificial gravity fields require bulk production and manipulation of contramatter, and are thus *miraculous* technology.

Power Sources

Power generation is also closely tied to spacecraft propulsion. Typical power generators available at each technology level are listed below:

- **Chemical Fuel ①:** This is the only source of power available to civilizations up to late-20th-century technology. In oxygen-rich atmospheres, steam turbines, reciprocating combustion engines, and multi-fuel gas turbines are the typical sources of motive power or electricity generation up to the early 21st century. Closed-cycle chemical fuel cells are typical of short-duration spacecraft.
- **Fission Generator ①:** This is the go-to solution for *contemporary* power generation on long-duration remote operations, especially in military vessels that don’t have the same public relations constraints as civilian agencies. Small modular reactors can be as small as few hundred kilograms (possibly only a few kilograms with *near-future* technology). For portable systems, radioisotope thermoelectric generators (RTGs) can also be quite compact (kilograms), and can supply small amounts of power continuously for decades.
- **Fusion Reactor ②:** Fusion power will be the default energy source for any *mature spacefaring* civilization. A typical design might weigh around 100 t, similar to the magnetic containment fusion drive on p. 27. (*Near-future* fusion reactors are plausible but would be massive installations the size of a city block.)
- **Compact Fusion Reactor ③:** Optimistically, fusion reactors can be shrunk to a more manageable size. A typical *advanced spacefaring* design, based on the same technology as a fusion torch rocket, might be only 100 kg.
- **Antimatter Reactor ③:** Antimatter reactors are *easy* to build, even with *contemporary* technology. What is challenging is the equipment to create and store antimatter efficiently. An optimistic storage system for an *advanced spacefaring* society might be able to store and handle antimatter in bulk, perhaps as frozen magnetically-levitated antihydrogen. In that case, small (perhaps even microscopic) antimatter reactors are imaginable, limited only by their power dissipation requirements.

Of course the antimatter fuel still has to be *synthesized*, requiring at least as much energy as it provides. Antimatter would never be a primary energy source, but would be a fuel for systems requiring a compact high-energy-density fuel supply. One gram of antimatter can provide 50 gigawatt-hours of energy, or 43 kilotons TNT-equivalent yield if detonated.

- **Contramatter Generator ⑤:** The ability to inflate a stargate wormhole implies the ability to create (or channel) immense quantities of contramatter, which produces as a “side effect” an endless supply of free energy. A contramatter generator creates equal amounts of positive energy and negative contra-energy out of nothing. The contra-energy is dissipated in harmless forms (channeled through a wormhole, or radiated as contramatter analogues of neutrinos), and the positive energy is used to power equipment. Since this is a *miraculous* technology, power constraints are unspecified: they will be limited by the ability of the equipment to safely dissipate the energy it receives.

Medical Technology

Medicine and healing devices also play an important role in the *Stargate* setting, starting with Ra's sarcophagos in the original feature film. Many of these technologies can be carried over to the hard SF setting with a few modifications.

Sarcophagos

This is a medical pod that can heal almost any illness or injury, and even resuscitate the recently-deceased. It operates through a combination of conventional robotic surgery and “wet” nanotechnology (biotechnology) devices operating inside the patient. These can cure illnesses and repair most trauma with a few hours of treatment. Repairing major injuries (including restoring lost or irreparably crippled limbs with biofabricated replacements), or whole-body rejuvenation, would take longer, possibly days or weeks.

Most dramatically, the sarcophagos can resuscitate the dead, and maintain life support functions while it performs repairs. However, the victim cannot have been clinically dead (i.e. without breathing or circulation) for more than tens of minutes, or else irreversible cellular degradation will occur.

As depicted in the *Stargate* film and series, the sarcophagos would be a *mature spacefaring* technology. Similar devices might exist across a range of technology levels:

- *Robosurgery pod* ①: An automated self-contained surgery without the nanotechnology capabilities described above. It can perform resuscitation, maintain life support, and repair trauma as above, but cannot cure illnesses, restore crippled appendages, or perform whole-body rejuvenation.
- *Microsurgery pod* ②: The standard sarcophagos unit as described above.
- *Nanosurgery pod* ③: An advanced sarcophagos with more sophisticated “dry” nanotechnology mechanisms. It can perform whole-body rejuvenation and repair an order of magnitude faster than a regular sarcophagos, and can revive a patient up to hours after death, so long as cellular structures in the brain have not decayed. Beyond that point, it *could* rebuild an entire organism from an intact genetic sample, but without any memories or personality (a “blank-slate” clone).

Ascension & Reincarnation

While ascended beings are typically portrayed as having *miraculous* levels of technology, this is usually a consequence of their ascension rather than a prerequisite. The theoretical path towards mind uploading is fairly well mapped out, though not without some technological hurdles on the way, making it a *mature spacefaring* technology.

- *Destructive ascension* ②: A mind uploading procedure that involves physically disassembling and scanning the brain. This is irreversible, and risky, as there is no way to recover from any errors or inaccuracy in the scan. This would tend to promote its use as an end-of-life or postmortem procedure, which further reduces the odds of preserving the patient's full mental faculties. It also involves significant surgical facilities, so is not to be undertaken lightly. Thus, many societies with the *capability* for ascension might hesitate to employ it as a matter of course.
- *Nondestructive ascension* ③: Optimistic but plausible developments in nanoscience might allow for brain scans with sufficient precision for mental uploading, *without* destroying the original brain. This would allow for mental backups, with the individual committing to an immaterial existence only after they are assured that an accurate copy has been made. It would most likely involve a combination of high-end medical scanning equipment and deployment of specialized nanobots inside the subject. (For example, following the premise that the Ori used religious rituals to select followers for ascension, then sanctified wine or communion wafers might actually contain doses of diagnostic nanomachines, and confessional booths might have extensive scanning equipment: the combination providing for weekly updates of the brainscans of their parishioners.)
- *Reincarnation* ③: A nanosurgery pod (advanced sarcophagos, p. 30) could also fabricate a clone or other body with a brain mapping based on a stored personality, allowing an ascended being to reincarnate into a physical form. For individuals who were originally scanned from flesh, it is simplest to restore them into a copy of their original body, but with some care other alternatives are possible.

Hibernation & Stasis

Suspended animation technologies are a boon to early spacefaring civilizations, especially those planning long-term enterprises, such as terraforming or slower-than-light interstellar voyages. Prior to their ascension, the Alterans pioneered many techniques in this area.

- *Cryostasis* ①: Simple freezing is not an effective method of suspended animation, as ice crystals cause irreparable cellular damage. *Contemporary* cryogenic techniques are somewhat better, *vitrifying* tissues by injecting fluids that do not crystallize as they cool. Still, the resulting preserved corpse cannot simply be “thawed” and brought to life; at best, it could be destructively scanned to create a mental upload. Nanosurgery pods (p. 30) might be capable of reviving the individual, essentially by recreating their body using the original as a template.
- *Hibernation* ②: A standard sarcophagos is capable of safely maintaining life support at a reduced metabolic rate. A hibernating patient ages and consumes nutrients and oxygen at roughly 1/10 the usual rate. Specialized *hibernation pods* provide the life support functions of a sarcophagos without the repair and healing capabilities.
- *Stasis* ③: True stasis involves using nanomachinery to build molecular scaffolding within the patient’s cells while shutting down their metabolism entirely. Nanomachines remain within the structure to restart the metabolism and disassemble the structures when it is time to revive the subject. A nanosurgery pod (p. 30) is capable of this operation, but again, specialized *stasis pods* would be the norm.

Symbiote Healing & Tretonin ③

As described in the section on *Goa’uld*, p. 4, Goa’uld symbiotes are bioengineered organisms that provide enhanced healing, immunity, and endocrine augmentation to their host, in addition to their cognitive effects. The endocrine response is volitional and requires an implanted symbiote, but the healing and immunological upgrades are provided by “smart” nanoware and cellular microsurgeons that can operate largely autonomously.

Thus, a symbiote’s healing and immunity abilities are available to Jaffa, who carry symbiotes that are not yet mature enough for neurological blending. With some ingenuity, the cellular machinery that provides these functions can be extracted from a symbiote and injected into individuals without implanting the symbiote itself. This extract is a medicine known as *tretonin* in the *SG-1* series. These cellular machines are grown within symbiotes and are not self-replicating, making them relatively safe to dispense, but living symbiotes must be kept to maintain an ongoing supply. Furthermore, as is the case with symbiote implantation, regular use of tretonin risks degrading the user’s own immune system, creating a permanent dependency.

The bioengineering required to *create* a symbiote or tretonin involves nanotechnology typical of an *advanced spacefaring* civilization. (The fact that the dominant Goa’uld culture in the Galaxy is only a *mature spacefaring* society reinforces the notion that modern Goa’uld are *not* the intended cultural heirs of the society that created them.) However, simply extracting and isolating tretonin from a symbiote is within the capabilities of even 20th-century medicine.

Other Healing Devices

The *hand device* ① (sonic and microwave devices, p. 22) can be used as a medical scanning and diagnostic tool, using one or both of its ultrasonic scanning and terahertz molecular spectroscopy functions. Its acoustic tweezers could also supplement or replace other noninvasive or minimally-invasive surgical techniques.

The full benefits of the hand device would be achieved in combination with cellular “wet” nanoware ②, combining external scanning and direction with internal drug delivery and cellular repair. This would provide curative abilities similar to symbiote healing (above), but requiring the expertise of a high-tech physician rather than operating autonomously.

Autofactories

Realistically, it is extremely difficult for a low-tech society to reproduce a product of high-tech industry from a working model. The historical trend is that, as technology increases, specialized supply chains proliferate to

“build the tools to build the tools”. A large educated population base is also needed to provide the requisite breadth of expertise. This produces an advanced and efficient industrial network, but with a certain fragility: a disaster that causes significant depopulation or disruption of society may lead to technological collapse.

Recent developments in *rapid prototyping* seem to buck this historical trend. A spacefaring society might need to develop a manufacturing capability that can be transplanted to a world lacking established infrastructure or population. If a low-tech society were to gain access to one of these autonomous industrial facilities, then they might be able to jump-start a technological revolution: they would obtain many of the products and inventions of the high-tech society, though without the efficiencies of scale provided by the full industrial infrastructure.

The following artifacts are representative of this trend:

- *Macrofactory* ①: An automated room-sized robotic factory, making use of additive and subtractive manufacturing techniques to fabricate any individual device for which it has plans. It is not completely independent of supply chains: specialized materials, chemicals, and microelectronics would need to be provided to it, while the macrofactory would handle structural and mechanical assembly.
- *Microfactory* ②: A truly off-the-grid manufactory, this cabinet (or larger) system makes use of micro-machines, atomic-force 3d printers, and multipurpose refineries to build *any* gadget of its own tech level from raw materials. However, it is *extremely slow* if it must perform its own refining, smelting, and nanolithography; it works much more efficiently if these parts can be provided to it.
- *Nanofactory* ③: An ideal nanobot-based assembler can build any device atom-by-atom, provided it has atomic-level design schematics and a supply of raw elements. Hierarchical assembly means that even sophisticated devices can be “grown” quite quickly, at a rate that depends only on total mass rather than complexity. The size of the system is determined by convenience and the size of artifact to be assembled: a hand-held fabricator could build small gadgets, while a building-sized nanofactory could assemble whole vehicles as a unit.

Parity Reverser ⑤

The idea of being “out of phase”, invisible and intangible to others, is a common trope in science fiction – and is almost never handled correctly. The hard-SF *Stargate* reboot presents an opportunity to do it right!

Theory

“So, how come I don’t fall through the floor?”

– Yolanda Reese, *Wormhole X-treme!*

A plausible approach based on real physics involves the concept of “mirror matter” particles: hypothetical counterparts to ordinary particles with reversed parity. Mirror matter has been proposed as a possible form of dark matter. It interacts with ordinary matter only through the weak interaction and gravity, whereas the strong and electromagnetic interactions have mirror analogues that do not cross-interact with their ordinary counterparts. Depending on the particular theory, mirror matter particles may be lighter or heavier than normal matter, or they may be essentially identical. We will assume the latter case.

A parity reverser is a particular kind of *non-orientable* wormhole, in which the connection between its two endpoints has a twist that results in a spatial reflection. Thus, matter entering one end emerges from the other as a mirror matter, and vice-versa. While production and manipulation of mirror-matter is only a *breakthrough* technology (see *Transphase Enhancement Region*, p. 34), the transformation of whole objects into mirror matter requires traversable wormholes, and thus falls under the category of *miraculous* technology.

If, as we assume, interactions among mirror matter particles are the same as the interactions of ordinary matter, then living beings converted to mirror matter would not notice any change in themselves, or any equipment they brought with them. However, they would be intangible and invisible to the ordinary-matter universe, and *vice versa* – though they would still be affected by gravity. From their perspective, the walls, floor, and air would vanish, leaving them to plummet through empty space. A mirror traveler would need both a pressurized suit and a vacuum-capable flight system to avoid a fateful outcome.

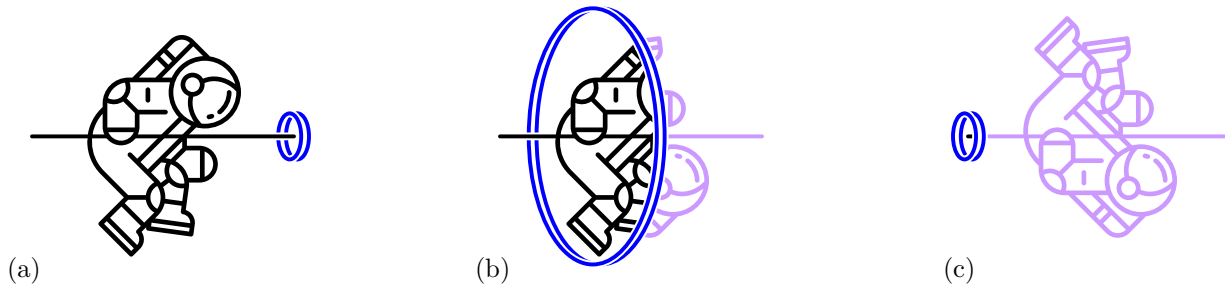


Figure 6: Use of a transient pulsed portal to perform parity reversal.

A parity-reversing wormhole would likely be built and deployed differently than a stargate: if the goal is to travel locally in insubstantial form, then you would want a portable device, rather than having to return to the original gateway to rematerialize. One solution is a *transient pulsed portal*: an elongated device (or pair of devices) that initiates wormhole inflation in front of one end, sweeps the inflated gateway across the traveler, and then collapses it behind the opposite end. This is illustrated in Figure 6 (animation available at <https://www.youtube.com/watch?v=98J0aetkWWs>). Unlike a stargate, the wormhole would envelop the device itself, allowing the traveler to bring it along. Furthermore, only the atmosphere within the affected volume would translate over into the mirror phase: you would not need to worry about air gushing through an open gateway into the effective vacuum on the far side.

Plot points

- Since the postulated mirror matter interacts with itself just like normal matter, mirror matter stars, planets, and even civilizations, are all certainly possible. Studies of dark matter show that the distributions of *all* forms of matter are correlated on galactic scales, but not down to the level of individual stars and planets: travelers shifting to mirror phase would find themselves in interstellar space within a mirror-matter galaxy.
- Nonetheless, there might be occasional close approaches between mirror-matter and regular-matter systems. If a mirror-matter star or planet were to pass through the Solar system, it would be undetectable until its gravitational field started to play havoc with the planets. Such an event might be devastating to an inhabited system (on either side), but might also be the trigger for research and exploration efforts. Missions could be sent to seek out mirror-life and mirror-civilizations, or vice-versa.
- Mirror-matter travelers can *also* travel via stargates. While the stargate devices are made of ordinary matter, the wormholes are gravitational constructs, which equally affect all forms of matter. Thus, people in mirror-matter phase might not be able to operate the controls, but they can still pass through the gateway.
- In addition to environmental suits and flight systems, mirror-matter travelers would also want to have a high-precision gravimetric sensor (p. 26), as this would be the only way to detect the ordinary universe and determine one's location. Similarly, people in regular phase would need such equipment to detect the mirror traveler. Gravity-based devices would also allow the two phases to communicate.
- An ultra-tech artifact might integrate some or all of the above systems with the parity-reverser device into one convenient tool, vehicle, or suit. For example, the “ultimate infiltrator suit”: a smart form-fitting pressure suit that can shift to and from mirror phase at will, with integrated reactionless flight systems, gravity gradiometers that project a density map on a holographic visor, and a gravitational-wave communicator.
- In *SG-1* storylines, phase-shifting technology was developed by at least three distinct groups: the Giant Aliens who posed as Mesoamerican deities; the Tollan who were apparently descended from Mesoamericans; and an individual Ancient who had reincarnated into a physical form. Some non-canon sources have identified the Giant Aliens with the Furlings – who naturally seem to get credit for any exotic technology that is not explicitly associated with another major race – but this has no canonical support within the *SG-1* series.

Transphase Enhancement Region ④

A Transphase Enhancement Region (TER) is bubble of space generated within a device, where the weak interactions between normal and mirror matter are amplified to useful levels. While *transforming* macroscopic objects into mirror phase (above) involves wormholes, and is *miraculous* technology, the *manipulation* of mirror matter is only a *breakthrough* technology (similar to the weak-interaction-enhancing fields used in *neutrino thrusters*, p. 28). E.g. the Reetou (p. 12) have TER capability but cannot wholly manifest as normal-phase creatures.

A few useful TER tools are itemized below.

- **TER sensor:** This device emits and absorbs mirror-photons, allowing the user to see into mirror-phase space. In principle, one can build transphase analogues of most normal-phase passive and active sensors (with the exception of gravity sensors, which already detect all forms of matter).

Note that a TER sensor made of mirror-matter (either carried into mirror phase by a parity reverser, or built by mirror-matter creatures) will absorb and emit *ordinary* light and other radiation. Thus the portion of the sensor extending into the TER bubble will be visible, and at least somewhat tangible. A stealthy traveler will want to make the interface region as small as possible, and perhaps only activate it sporadically.

- **TER grabber:** A basic tool for holding and manipulating mirror matter. Mirror matter can pass freely through the device, until it enters the TER bubble, where it is held in place by transphase fields. A basic grabber just locks on to a mass of mirror matter; refined models may provide varying degrees of fine manipulation.

Equally important, a *mirror-phase* TER grabber will hold on to *ordinary* matter, allowing a mirror-phase traveler to manipulate objects and (most importantly) stand on floors without falling. The action is more akin to “climbing” than “walking”, since the grabber must be disengaged and re-engaged to move its point of contact with the surrounding matter. Notably, it is not restricted to grabbing *surfaces*, either; it can lock on to a volume *within* a larger mass, allowing the user (for instance) to climb up or down through solid ground.

Perhaps somewhat disturbingly, a TER grabber can be used as a *mêlée* weapon, striking the *inside* of the target. Specialized “TER blades” or “TER spears” may be developed for this purpose.

- **TER laser/blaster:** A directed-energy weapon that emits mirror-photons or mirror-particle beams. It would work similarly to laser or particle beam weapons (p. 21), but would affect mirror matter rather than ordinary matter. As above, a mirror-phase version of these devices would allow mirror-phase users to inflict damage on ordinary matter.

Sangrail ④

“What invention could’ve been so important that it would have led him to give up his Ascension?”

“A weapon. A weapon capable of destroying Ascended beings.”

*– Samantha Carter and Daniel Jackson, **Arthur’s Mantle***

The Sangrail is a device used to destroy all ascended beings within some region, possibly on a galactic scale. In the *SG-1* series it is described as channeling energy into the mode occupied by ascended beings, interfering with and nullifying their own energy patterns.

In the hard-SF interpretation, ascended beings are software entities living in distributed information networks. While it is possible to imagine an emitter that could interfere with their preferred communication channel, that would not affect local processors and data backups. A more plausible method of attack would be a form of malware that can propagate through the network, disabling local and distributed systems alike. Since the network would likely be quite heterogeneous, the malware would have to be adaptable, perhaps even sentient, and would have to have been designed by an ascended being with in-depth knowledge of the network. This would therefore be less like Levinson’s virus from *Independence Day*, and more like the Blight from *A Fire Upon the Deep*. Within the tech progression chart, it would be a *breakthrough* technology: requiring knowledge at the level of the Ancients, but not their industrial infrastructure.

In appearance, the Sangrail device might actually look like a cup or dish (hence the name), since its most prominent feature would be a focusing element for beaming its signal towards the nearest node of the Ascended network. Its speed and range of propagation would be determined by the network technology and architecture: assuming that this includes links through stargates, it would spread faster than light over interstellar distances. It might or might not be able to leap across major network partitions, so isolated or noncommunicative ascended communities could possibly escape the cataclysm. It is also possible, indeed likely, that a Sangrail might be designed to target specific systems or communities (with the obvious dramatic twist if flawed malware exceeds its intended constraints).

Timegates ⑤

A timegate is a wormhole-based time travel device. It is similar to a stargate, except that it forms a *closed timelike curve* (CTC), allowing travelers to interact with their own past. After the quantum Jinni (p. 38), it represents one of the greatest technologies achieved by past civilizations.

Theory

Wormholes naturally develop small time shifts between their endpoints, due to the fact that “time” is reference-frame-dependent and the endpoints are not always at rest with respect to one another. That is, “proper” or “gate network time” (synchronized via gate travel) will drift slightly compared with synchronization signals exchanged through normal space. In most stargate networks, normal-space signals take *years* to relay, whereas differences between proper time and relay time typically accumulate at rates less than a few hours per *millennium*, making the effect largely ignorable.

A CTC occurs when the time drift becomes greater than the spatial separation, which can be arranged simply by transporting two stargates to close proximity. In a normal stargate network, it is assumed that attempting to do so will sever the wormhole due to quantum noise amplification, as described in the section on *Stargates* (p. 16). This not only permanently disables the gates, but also releases energy equivalent to a 1 kt nuclear blast (at least). There is some theoretical justification for this effect, but the analysis is by no means ironclad, nor does it rule out circumventing the destruction of the wormhole by some means (which may be impossible, or may be as simple as reinforcing the wormhole with sufficient contramatter).

We will assume that constructing a timegate is possible but *difficult*: a substantial challenge even for the gate-builders. This assumption is more for narrative convenience than any theoretical certitude. It allows for time travel in specific storylines, without making it broadly available to any user of the stargate network.

Operation

A timegate can be activated and traversed in exactly the same way as an ordinary stargate; the two endpoints simply lie at different points in time. Crossing in one direction moves the traveler backwards in time, the other moves forward. The temporal displacement can be combined with a spatial displacement: the only requirement to be a timegate is that the spatial displacement (in lightseconds) is less than the time displacement (in seconds). Then, by moving from the “future” endpoint to the “past” endpoint and sending a signal (or traveling sufficiently quickly), the signal (or traveler) can arrive back at the starting gate *before* the initial departure.

Once a timegate is formed, the endpoints can be moved around as needed; though if the spatial displacement ever exceeds the time displacement, quantum feedback will once again occur, possibly destroying the timegate. The time displacement can also be increased or decreased via relativistic time dilation, by rapidly moving the past or future endpoint (respectively). In the simplest configuration, the two endpoints are brought together to form a *single* gateway, that takes you some fixed interval into either the past or future depending on which direction you pass through it.

Clearly the earliest point in time that can be accessed by a timegate is the moment when it was first formed: it can be thought of as a device for *receiving travelers from the future* rather than *sending them to the past*. To access the distant past, you must find a timegate that already existed in the desired era. Since we presume that timegates were built by the Ancients, this may not be such a restriction, though it does raise another concern: If you travel backward far enough, you will eventually encounter the original builders or other early users of the system, who may have placed countermeasures to block intruders from the future.

Predestination

The use of timegates is also limited by the *self-consistency principle*: any interaction of travelers with their own past must be such that the past remains unchanged. By definition, a timegate connects two points on the *same* timeline, not alternate timelines or histories.

Like the other consistency requirements of hard SF, this principle presents a challenge for story writers, but with the reward of more believable and compelling stories. Just as introducing fantastic technology as a *deus ex machina* can trivialize the characters' efforts, so too being able to rewrite history cheapens their sacrifices, and diminishes the audience's (and writers') investment in the story continuity. While most cinematic time travel tales do change the past, some of the best work within the constraints of self-consistency, including *Interstellar*, *12 Monkeys*, *Bill & Ted's Excellent Adventure*, and the original *Terminator* (but not the sequels!).

Certain questions naturally come up when dealing with self-consistent time travel.

- *What if you try to change the past?* Quite simply, you will fail. Either the attempt will fail in an obvious way, or the attempt will appear to succeed, only for you to realize that you unknowingly brought about the events that had always been part of your past.
- *Why don't you just create an alternate timeline?* It turns out that alternate timelines don't actually resolve the logical paradoxes created by inconsistent histories – at least not for timegates. There is no physical mechanism for bridging alternate histories: when one combines CTCs with the “many worlds” model of quantum mechanics, the result is a “multiverse” of diverging timelines, *each of which is bound by the self-consistency principle!*
- *What's the good of time travel if you can't change the past?* The capability of time travel can increase the odds of a favourable outcome, *even if no time travel actually occurs!* If the protagonists have access to a time machine, and witness a preventable disaster (e.g. a sneak attack), then self-consistency would require that either they willingly allowed it to happen, or they failed to avert it – both of which might be less likely than an alternative favourable outcome (e.g. the attack went astray). Thus a favourable but seemingly unlikely outcome may end up being the *most* probable of the *allowed* histories.

Furthermore, when time travel *does* occur, it can create beneficial “self-fulfilling prophecies”. E.g. the team might receive a warning from themselves in the future about a sneak attack, and act to prevent it. They would then need to follow through with sending the warning, *even though the threat had ended*. Their commitment to completing the prophecy is crucial: if they were to change their mind, then the Universe would have “known” that in the first place, and they wouldn't have received the warning.

These points are elaborated further under *Conditional Probabilities* (p. 37).

- *What if you don't know the past?* There is no sense of predestination if you arrange your use of the time machine around gaps in your knowledge. For instance, if there's an artifact you need from the past, and you don't know what became of it, you can jump to its last-known time and location and try to steal it. For all you know, it disappeared from the historical record *because* you stole it. And *if your attempt succeeds*, then that's exactly what had happened!
- *But what about free will?* The *perception* of “free will” has little to do with whether an outcome is foreseeable, and more to do with one's sense of *control* over it. Random unpredictable outcomes actually *undermine* this sense of control, while outcomes that flow predictably from one's goals and intentions reinforce it. Often you do know in advance what choices you plan to make, without feeling that they have been imposed on you. You are free to contemplate that you *could* change your mind, if you wanted to: the principle of self-consistency simply ensures that *you will not want to*.

To put it another way, predestination does not imply lack of *agency*. A self-consistent history must also include a self-consistent version of your mental state governing your actions. If you can reliably see the consequences of your choices, then outcomes that are self-consistent *and* aligned with your motives will be more likely than ones that require you to think or behave uncharacteristically. The challenge of writing a time travel story is to develop such scenerios, in which characters *willingly* and *believably* make natural in-character choices, even in cases where they may already know the outcome.

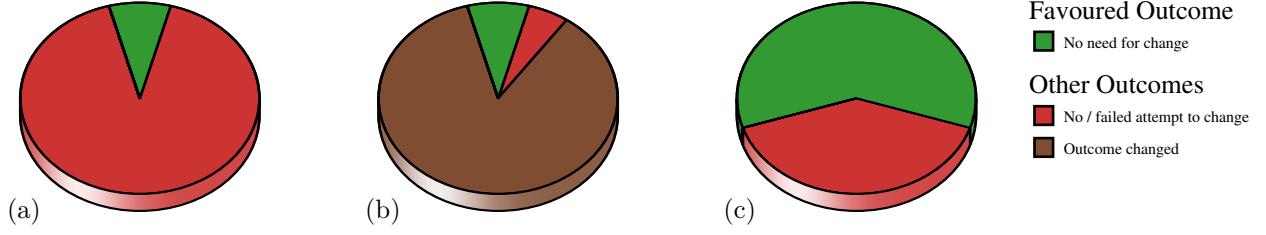


Figure 7: The *possibility* of time travel can affect probabilities even when no time travel ultimately occurs. (a) No time travel is possible. (b) Inconsistent time travel. (c) Self-consistent time travel is possible but does not actually occur.

Conditional Probabilities

Sherlock Holmes famously pointed out that “when you have excluded the impossible, whatever remains, however improbable, must be the truth.” Time travel forces us to view histories through the lens of *conditional probability*, where (impossible) *inconsistent* timelines are excluded, and probability is reapportioned among (improbable) *consistent* timelines.

To see the effect of time travel on timelines, we first consider the probability of outcomes in the *absence* of time travel, shown in pie charts (a) of Figures 7 and 8. Next, we introduce time travel but do *not* enforce self-consistency: that is, we consider choices that the characters would naturally make to avoid unfavourable outcomes, and the plausible consequences of those choices under ordinary (local) cause-and-effect. This is shown in pie charts (b) of Figures 7 and 8. Finally, we *condition* the probabilities on the (global) constraint of self-consistency: we exclude inconsistent histories, and rescale the remaining probabilities so that they add up to 100%, as shown in pie charts (c) of Figures 7 and 8.

Broadly, we categorize the various outcomes as follows:

1. **Favourable outcome, no self-interaction:** Protagonists have no desire to change the natural course of history. This might be intrinsically unlikely if their circumstances are dire.
2. **Favourable outcome, consistent self-interaction:** If a satisfactory outcome would not “naturally” occur, protagonists can use future knowledge to *create* one as a self-fulfilling prophecy.
- *3. **Favourable outcome, inconsistent self-interaction:** Time travellers neglect to “follow through” after a successful self-interaction, which erases any gain from that intervention.
4. **Unfavourable outcome, no self-interaction:** No time travel occurs despite an adverse outcome, due to failure of the time travel mechanism, or reluctance on the part of the protagonists. This would be intrinsically unlikely if the mechanism is robust and the characters are determined.
5. **Unfavourable outcome, consistent self-interaction:** The time travellers inadvertently bring about the outcome they hoped to avoid. Knowledge and planning can reduce this probability.
- *6. **Unfavourable outcome, inconsistent self-interaction:** Time travellers change history to alter an undesirable outcome. This could be the most probable result *if not constrained by self-consistency*.

* These outcomes are removed from the space of allowed histories when determining the possible final results.

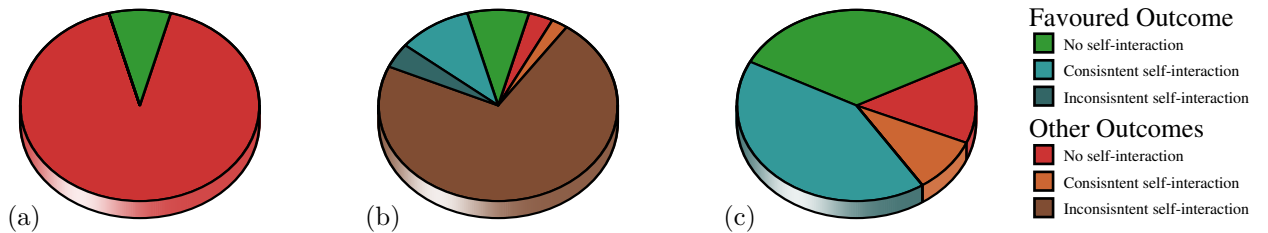


Figure 8: Probabilities of various outcomes when self-fulfilling interventions can occur. (a) No time travel. (b) Inconsistent time travel. (c) Self-consistent time travel.

As noted on p. 36, the existence of timegates can affect the probability of outcomes even when they end up not being used (Figure 7). If the character are determined to change an adverse outcome, and ostensibly have the means to do so under local causality, this shifts probability to **case 6**. To avoid this inconsistency, one must posit obstacles (**case 4**) that would dissuade or prevent them from executing their plan: if such circumstances are implausible, it increases the relative likelihood of timelines where such a plan was never required in the first place (**case 1**). Furthermore, when time travel *does* occur (Figure 8), characters can use judicious knowledge of the future to create self-fulfilling prophecies (**case 2**) while avoiding “failed” prophecies (**case 3**) and self-inflicted disasters (**case 5**).

The only “paradox” in self-consistent time travel lies in reconciling the characters’ motivations when they become aware of an unfavourable outcome. Much of the potential benefit of time travel comes from converting probability from **case 4** to **case 6**, which requires the characters be willing to attempt to change the past, *even though the attempt cannot possibly succeed*, solely to promote an alternate history where such an attempt was not needed. In a sense, they are irrationally “blackmailing” the Universe with the credible threat of creating a paradox if they don’t get their way, and are “rewarded” with a higher probability of a favourable outcome. But if the team knows that any actual mission to change history is doomed to fail, they might be less inclined to follow through with the “threat”, which reallocates probability from **case 6** back to **case 4**.

One way around this conundrum is to restrict the team’s knowledge of any predestined outcome, placing key decisions in the hands of an uninvolved person or machine intelligence that will single-mindedly maximize the conditional probability of a desired outcome, disregarding “common sense” reasoning based on local causality. This is similar to the way a “doomsday device” can exact concessions precisely because it is an irrational actor: in this case the threatened “mutually assured destruction” is the creation of a paradox, which the laws of physics *must* avoid. The *quantum Jinni* (below) is an example of such a machine.

Quantum Jinni ⑤

“Ours is the only reality of consequence.”

– *Teal’c, Point of View*

In *SG-1*, the *quantum mirror* was a window through which one could view alternate timelines, selected through an analog control device. Touching the surface of the window then physically transported the person to that timeline.

This item may well be the ultimate technology within the *Stargate* universe, potentially exceeding even stargates and time machines in both utility and technological sophistication. It appears to be of Furling design, based on the physical resemblance of its control device to that of the Furling transporter in *Paradise Lost* (see Fig. 9), and the mirror itself to the pseudo-canonical Furling control stations in *200*. As such, it might be the only example of another race surpassing Ancient technology.

While the artifact depicted in *SG-1* is physically implausible, a conceptually-similar device is *remotely* possible, based on ideas from quantum computation. In the hard-SF setting, this analogous device is known as the *quantum Jinni*. Its essence is the same: an artifact that allows the user to realize and experience a selected timeline among a myriad of possible alternate histories.

Theory

In *very* loose terms, quantum computation can be conceptualized in the “many worlds” interpretation of quantum mechanics. The computer is set up in an initial *superposition* of input states, which can be thought of as “alternate timelines”. If these states are allowed to interact (in quantum mechanical terms, *entangle*) with the environment, they *decohere*, and cannot interfere with one another: each timeline proceeds blissfully unaware of all the other timelines that coexist with it. However, if the states are isolated from the environment, then they can be made to interfere, either increasing (constructive interference) or decreasing (destructive interference) the probability of particular timelines. In a quantum computer, the interference pattern is set up so that only states with the correct output get constructively interfered. When the system finally interacts with the environment, it has a 100% probability of being in a state (timeline) where it randomly entered the set of input values that give the desired result.

The quantum Jinni combines quantum computation with a closed timelike curve to apply this selection retroactively. First, one subsystem is set up in a superposition of states, and allowed to interact with the environment, producing multiple decoherent timelines. Some time later, the device in each timeline poses the question, “Does this timeline satisfy criterion *X*?”, and encodes that answer into the state of another subsystem. That second subsystem is connected via a wormhole to the first subsystem *before* it interacted with the environment. This connection is isolated from the environment so that the two subsystems can interact coherently, in a carefully-arranged manner that destructively interferes states that did *not* satisfy criterion *X*. The final result is that the device *and environment* have 100% probability of being in a timeline that satisfies *X*.

In slightly more succinct terms, the quantum Jinni acts as a wish-fulfillment device. You turn it on and specify a desired outcome. The universe branches into a multitude of *possible* histories: those that satisfy the outcome get *retroactively* reinforced, while those that fail the test are weeded out. Ideally, as long as the outcome was possible at all, you will find yourself on a timeline in which it occurs.

Some additional caveats and considerations:

- The branching of accessible timelines starts with the positing of the desired outcome and triggering of the device. The device cannot affect events outside of its causal domain from the moment it is triggered. If the Earth is about to be irradiated by a supernova that went off centuries ago, you cannot wish for it not to have happened.
- In practice, interference is never perfect, and there is always *some* probability of finding oneself in an undesired state. The device *amplifies* the probability of the desired outcome, but cannot guarantee it 100%, especially if its intrinsic probability was very small.
- If the desired outcome proves to be *impossible*, then the device has no effect: you will find yourself in one of the *possible* timelines, according to their classical probabilities. However, “success” or “failure” might also be determined in a nonbinary manner, so even if the particular outcome is impossible, you may increase the probability of a *similar* outcome. This is entirely dependent on the decision criterion that the device uses when establishing the interference pattern.
- The desired outcome must be specified before triggering the device; otherwise, users on each divergent timeline might be wishing for different outcomes, and there would be no unique way to set up the interference pattern. Once you make your wish, you will have to see it through.
- Timelines that are destructively interfered *do not exist* in any real sense: although they play a role in creating the interference pattern, they ultimately have zero probability of occurring. It is a narrative choice whether to portray any of these counterfactual histories in a dramatization; but certainly the *characters* in the “real” surviving timeline will have no perception or memory of them.
- In general a “time-loop Jinni” does not need to involve quantum computation. It only requires (a) a mechanism that can influence an outcome based on some inputs, and (b) a temporal link that retroactively changes those inputs if the the desired outcome is not met. Since the latter would result in a paradox, the self-consistency principle forces the system to be in a state that yields the desired outcome (or that triggers a fault in the mechanism, if that proves more likely), as illustrated in Figure 7 on p. 37. The *quantum* Jinni is one realization of such a mechanism, in which the subtle nature of quantum entanglement obscures any observable causal link between the device and the outcome: after specifying the desired result, events leading to it will appear to happen serendipitously.

Story writers should be warned that this device is nearly a literal *deus ex machina*: it should be introduced with care, and its use curtailed if necessary. Significantly, if characters use it to amplify progressively smaller and smaller probabilities, eventually they may reach a point where the more likely outcome is the irreparable breakdown of the Jinni, no matter how robust its design.



Figure 9: (a) Quantum mirror control device. (b) Furling portal key. (c) Iconic Jinni lamp.

Design

Much of the dramatic impact of *SG-1*'s quantum mirror lay in its compelling user interface: a window and portal into a parallel universe. Unfortunately the analogous device presented above does not lend itself to this sort of design. Essentially, the laws of quantum mechanics preclude anyone from observing a timeline other than their own: the act of observation decoheres their own timeline and prevents further interaction with other timelines. The quantum Jinni device, by contrast, works by scrupulously isolating the subsystem performing the interference (i.e. the actual interaction among timelines) from the rest of the environment. In each branch of the timeline, an integrated AI (the “Jinni” *per se*) objectively determines how close that branch comes to the stipulated outcome, and only that minimal piece of information is allowed to affect the interference among states.

The device itself could look like anything. In *SG-1*, the quantum mirror control device and the Furling portal key were both handheld artifacts with a flattened oblong shape, which is visually reminiscent of a Middle Eastern oil lamp (see Figure 9): this could well serve as the basis for legends of Jinn residing in such lamps and granting wishes to whoever handles them.

Concluding Decalogue

No pitch bible would be complete without some commandments. We list here ten common space opera tropes to treat with care in a hard-SF setting. Most of these have been discussed in detail previously.

- *Thou shalt not surpass the speed of light.* Except via wormholes.
- *Thou shalt not amend the past.* Self-consistent time travel only, please.
- *Thou shalt not beam thyself up.* Except as a digital copy.
- *Thou shalt not find aliens in humanoid form.* Besides actual descendants of Earthlings.
- *Thou shalt not breed humans and aliens.* Just... no.
- *Thou shalt not speak with aliens in English.* But nondiegetic “treated as dubbed” dialogue is possible.
- *Thou shalt not go whoosh in space.* Any such effects are part of the soundtrack, not the fictional reality.
- *Thou shalt not practice psionics.* Other than what can realistically be achieved with technology.
- *Thou shalt not countenance woo.* Such as “life energy”, psychic healing, quantum consciousness, etc. The goal is to provide natural explanations for esoteric ideas, not the reverse.
- *Thou shalt not suffer a witch to defy physics.* Any sufficiently advanced technology is indistinguishable from magic, but the converse is not true: “magical” technology must still obey physical law.

Stargate By Any Other Name

“I wouldn’t mind one last jaunt through the old orifice... What? We call it that sometimes, don’t we? Orifice?”

– Jack O’Neill, *200*

The backstory presented on pp. 3–13 assumes a *Stargate reboot*: hewing as closely as possible to the themes of the original *Stargate* franchise, while remaining within the bounds of hard SF. It assumes that creative works within this universe would be licensed by the IP holder (Metro-Goldwyn-Mayer Pictures).

However, the broader ideas explored in this treatment could be developed independently of MGM’s *Stargate* property. The fictional concept of an interstellar portal dates back at least to the “orifice” of A. E. van Vogt’s *Secret Unattainable* (1942) – a presentation of the device that was actually closer to the current hard-SF version than many since. The name “Star Gate” for such an artifact originated with Arthur C. Clarke’s *2001: A Space Odyssey* (1968). The idea of advanced aliens inspiring or impersonating ancient gods is an entire science fiction sub-genre (and field of pseudoscience), occurring since late-1800’s “scientific romances”. Even an alien parasite that takes over a host’s mind is a fairly common SF trope, originating in Robert Heinlein’s *Puppet Masters* (1951), to say nothing of ancient tales of demonic possession.

Of course certain combinations of these elements can run into copyright issues even if the elements are individually generic. In particular, combining puppeteer parasites with alien gods is quite specific to the *Stargate SG-1* franchise. However, the concept of *technological apotheosis* is not specific to *SG-1*: attaining immortality or godhood through mind uploading is scientifically more plausible than using a biologically engineered symbiote. Similarly, other *Stargate* premises have undergone substantial adjustments in the interest of hard-SF consistency, resulting in significant changes from *SG-1* canon.

The theme of such a *Stargate*-adjacent reboot would come down to three main plot elements:

- A group of Ancient Aliens, traveling via relativistic ships and stargates, contacted Earth in prehistoric times. Human initiates departed with the aliens to begin various terraforming projects.
- Descendents of these human pioneers have occasionally returned to Earth to recruit followers and spread Earth’s societies to newly-terraformed worlds. Advanced extraterrestrial humans, or their transhuman successors, have been identified (deliberately or inadvertently) as gods, angels, spirits, or wizards.
- In modern times, terrestrial humans located one of the Ancient stargates (probably *not* in Egypt, and possibly not even on Earth). They have begun using it to explore the Galaxy and discover their scattered cousins, both primitive and advanced.

This explicitly excludes the Goa’uld backstory (pp. 4–7) from the setting. For other story elements, *SG*-specific terminology would need to be changed (e.g. Alterans, Furlings, Asgard, Replicators, Ori, and Reetou), but the same *ideas* could be explored under other names.

Similarly, the technologies presented on pp. 15–40 would largely be transferable to a non-MGM-licensed production. The changes required to bring hard-SF consistency to *Stargate* technologies mean that the re-imagined devices are influenced more by *scientific necessity* than by copyrightable conceptions.

Only Tretonin (p. 31) would be excluded entirely, as Goa’uld would no longer be part of the setting. Sonic and microwave devices (p. 22) could still exist but would need an ergonomic redesign, so as not to resemble the *kara-kesh* “hand devices” of the *Stargate* movie and series. Sarcophagoi (p. 30), TER devices (p. 34), and the Sangrail (p. 34) would have to be renamed but could otherwise be used as written.

The stargates themselves might require an aesthetic makeover, removing chevrons, glyphs, and the rotating ring (which serves no obvious physical function). More radical redesigns, such as dodecahedral or other polyhedral shapes, are intriguing but not necessary: the simplicity of a disk-shaped portal can be justified on scientific grounds, and has a long history within SF literature. Requiring all stargates to be *spacegates* (p. 20) would be a natural way to create both a stylistic and thematic break from the *SG-1* franchise.

The term “stargate” could still be used for the eponymous devices: that usage dates back at least to 1968, and is a generic word combination. However, it might not be used in the *title* of a non-MGM production.

“I wanted to call the show ‘Going to Other Planets’, but Research says that shows with ‘X’ in the name get higher ratings.”

– Martin Lloyd, *Wormhole X-Treme*

