Tunnels
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From *Modern Propulsion,* Chapter 1: Introduction

The fundamental problem about space is staying there.

At first glance, it seems easy enough—just head upward. But do that in a rocket or a fast plane, and you'll quickly discover that you run out of fuel or air. Then what goes up comes back down—often forging a plasma sheath and a burned-up, martyred pilot in the process.

The trick is an orbit: a fancy way to cheat. If you raise your speed to something like 8 kilometers per *second* going *sideways*, then Earth's pull balances your tendency to fly away to infinity. The result is a neat elliptical path.

The inconvenience, of course, is getting going that fast.

All this gave the rocket techs the same headaches it gave everyone else—although for a different reason: the sheer speed itself is both difficult and expensive to create. As a consequence, orbital rocketry was relatively rare. This was the sorry state of affairs until the mid-21st century—when an army of engineers, led by some smartass mathematician, invented the tunnel drive.

The mechanism was mainly technobabble jargon—level sets of gravimetric potentials and suchlike. The *effect* was that you could point your spaceship in any direction, and then punch a button to teleport to a place where the magnitude of gravity was exactly the same. So if you started on Earth's surface, you could aim at Jupiter and teleport to a safe, yet still breathtakingly-close, 44 500 km (ignoring the lesser pull of the sun, which, of course, must be accounted for). In both places, you'd feel the same gravitational attraction of 1g.

At this point, of course, the vessel would begin to accelerate at 1 gravity toward a noxious, crushing death in Jupiter's atmosphere. Insertion into a cloud-skimming elliptical orbit required a (fairly obnoxious) 29 km/sec burn. Instead, tourist sightseeing was limited to the amount of time that could be economically spent “hovering”.

However, it was quickly discovered that not only was gravitational potential energy conserved, but so too was kinetic energy. As such, for Jupiter as well as other interesting, larger planets, during a surprisingly large time of the year, a “launch” from Earth could be timed to fling the spacecraft into a perfect elliptical orbit. With a tiny Oberth boost at periapsis, the orbit's apoapsis could be raised, at which point, the spacecraft could teleport back to Earth at a higher altitude, and so could parachute the rest of the way back to Terra Firma.

The impact of the tunnel drive on interplanetary expansion cannot be understated. Where before, lethargic governments slowly heaved tiny satellites into low orbits, now megacorporations spearheaded an expansionist charge to colonize the planets. You needn't concern yourself with getting your gigaton-mass colony into orbit and then on a Hohmann transfer at an obscene propulsion budget. You have only to worry about landing it.

The fact that the teleportation is, as precisely as present measurements permit, instantaneous, obviates, for example, tiresome 10-hour round trips to the Pluto colonies. The physicists explained away the obvious temporal and relativistic difficulties by developing a new topology of the universe where every point of some potential was identified with every other (simultaneously and conveniently integrating those pesky invisible dimensions from the various quantum theories). No one could really explain how the points all got connected, but Mother Nature seemed to make it happen regardless. So teleportation is more like wormhole traversal than anything else, and it doesn't violate relativity because everything is already connected in the first place. No one was especially happy with that, but a better explanation wasn't forthcoming—and the effect had by this time become essential, regardless of whether it was properly understood.

The tunneling procedure is not, unfortunately, without its risks—a fact well-established by the case study of the recent total loss of the *U.S.S. Reliant*.

The *Reliant* was constructed on Mars for the purpose of returning heavy cargo to cis-Lunar space (to which Mars's leisurely gravity was naturally suited). Her maiden voyage began with a routine shipment of nanofoams produced in the low-g environment conveniently available in Martian factories to Space Station Clarke, the space elevator counterweight which was, at that time, under construction in cis-Lunar space.

It failed to arrive.

Initial reports stating that the Reliant's arrival was delayed began filtering in thirty minutes after scheduled arrival time—since after twenty minutes or so, mixup in usage of Earth Standard Time or Mars Imperial Time could be ruled out.

A tunnel pod from Moon Station 4 was quickly dispatched to Mars to ascertain the cause for delay. It discovered that the *Reliant* had been marked as having left on the "DoT" (a pun: for "Departed on Time"). Indeed, their first realization that the ship was missing came from the arrival of the investigation pod itself.

It was a tightbeam that relayed the news back to Earth System, lest the problem be discovered to be a breakdown in the tunneling mechanism. However, after several robotic probes subsequently made the Mars-Earth jump uneventfully, transportation quickly returned to normal.

Retrospective analysis of the incident attributes the disappearance of the *Reliant* to a faulty gimbal, as ground-based telemetry indicates that at the instant of departure, the *Reliant*'s orientation was incorrect by slightly less than 14 arcminutes. The result, of course, was that the tunnel, which ought to have ended in cis-lunar space, continued substantially farther.

It is now thought that the *Reliant*'s initial teleportation ended somewhere within the 36-Ophiuchi triple-star system, although under the circumstances it is impossible to pinpoint precisely where. Calculations indicate a significant probability that the *Reliant* emerged too close to one of the stars to avoid plunging into it before being able to recharge her tunnel engine. It is also possible that the *Reliant*, recognizing her error, made an attempt to return to Earth and, unaware of the faulty component, made a second error, sending the Reliant shooting through the solar system the other direction, to land somewhere deep within the Taurus constellation.

The prospect of rescue, of course, was quite out of the question. By the time the nature of the error was recognized, the Reliant was calculated to have either been incinerated, or else forced to make another jump. While in principle each tunnel ship contains fuel enough for countless jumps, navigational difficulties compound, at *best*, exponentially. If the *Reliant* attempted more than two jumps trying to return home without being able to fix the gimbal, she would almost certainly be well beyond reach. It is established, by Olbers's paradox, that the average patch of sky is mostly devoid of objects; if the *Reliant* even once accidentally tunneled into such a region, odds are excellent that it was thrown an inconceivable distance beyond the limits of our astronomy.

As the *Reliant* was never heard from again, it is expected that, in whatever way, she has perished along with all hands. Radio telescopes will be pointed toward the Ophiuchi system in a decade or so, in hopes of catching the crew's last wills.

Note: for calculating the velocity, I derived the following equation from the Vis-viva equation and gravitational potential. It may be incorrect, although it does seem to produce plausible results. It's implemented in Python:

```
from math import *


G = 6.67408e-11

#Calculates minimum delta-V required to do an insertion into a surface-skimming
#      elliptical orbit around a given planet, given a starting distance defined
#      by the given gravitational acceleration.
#E.g. if the planet is Earth and your starting acceleration is 9.80665, then
#      you're 0 meters off the ground, and to create a non-planet-intersecting
#      (circular) orbit, you need to burn 7.905km/sec sideways.
#E.g. if the planet is Jupiter and your starting acceleration is 9.80665, then
#      you're 44,500 km up, and to create an (eccentric) orbit, that skims the
#      cloud tops at periapsis, you need to burn 29.041km/sec sideways
def orbit_speed(desired_g_at_apsis, planet_radius,planet_mass):
      root_GM = sqrt(G * planet_mass)
      numer = 2.0 * planet_radius * desired_g_at_apsis * root_GM
      denom = root_GM + planet_radius * sqrt(desired_g_at_apsis)
      return sqrt( numer / denom )

#orbit_speed(9.80665, 6.371e6,5.972e24) #Earth to surface orbit
#7905.621972373951

#orbit_speed(9.80665, 6.9173e7,1.89813e27) #Earth to Jupiter
#29041.457832429296

#orbit_speed(9.80665, 5.7316e7,5.68319e26) #Earth to Saturn
#24186.961262896933

#orbit_speed(9.80665, 2.5559e7,8.68103e25) #Earth to Uranus
#15631.765167844736

#orbit_speed(9.80665, 2.4764e7,1.0241e26) #Earth to Neptune
#15830.917521494746
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