# 星际推进技术

章鱼喵

星际移民中心

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是什么?
干什么?

# 主要内容

1. 推进技术要干什么
2. 推进技术需要什么
3. 推进技术大地图
4. 一些技术理解
5. 奇思妙想

# 飞船的推进技术

改变飞行器速度

推力
/
冲量

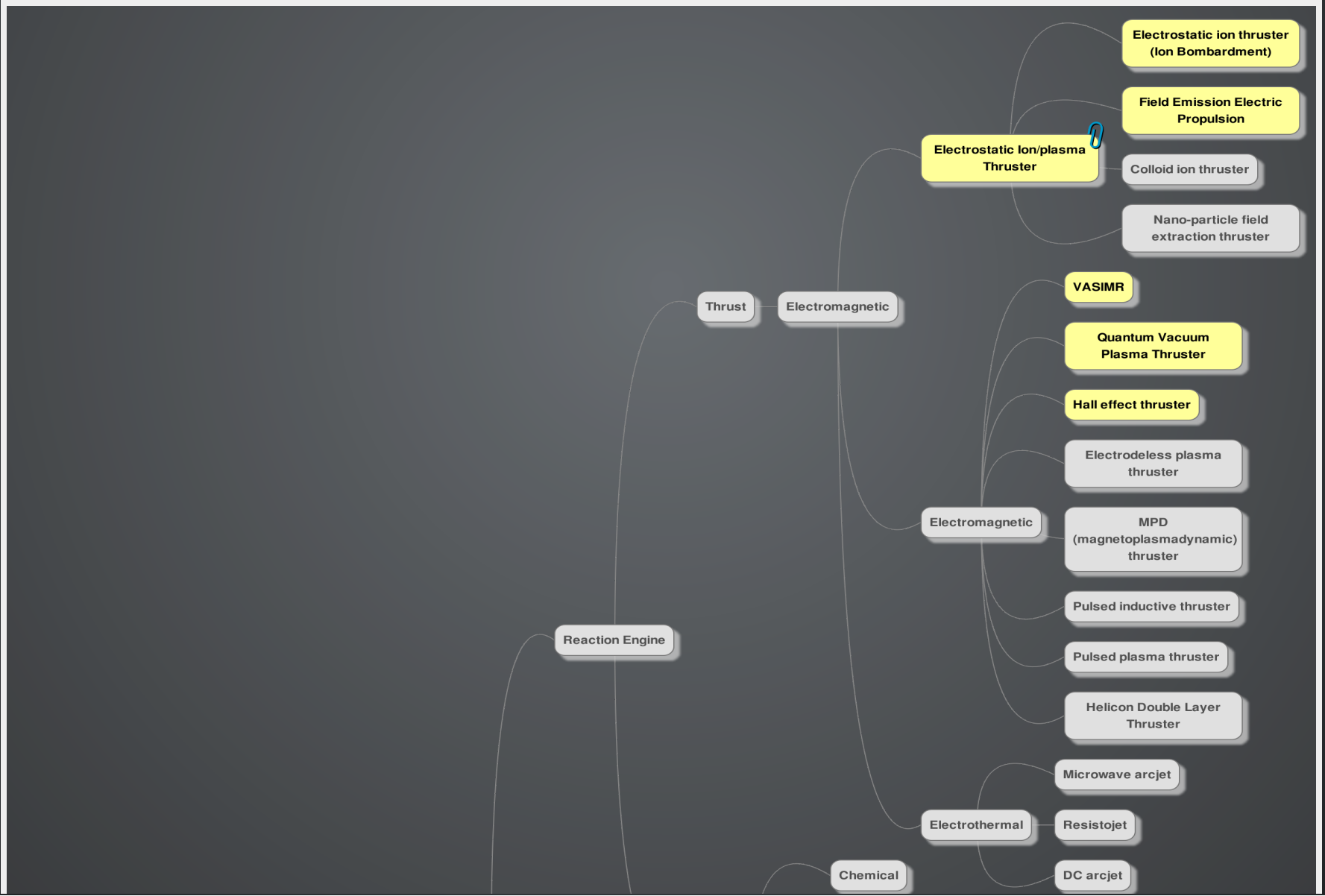
# 需要什么

工质
能源

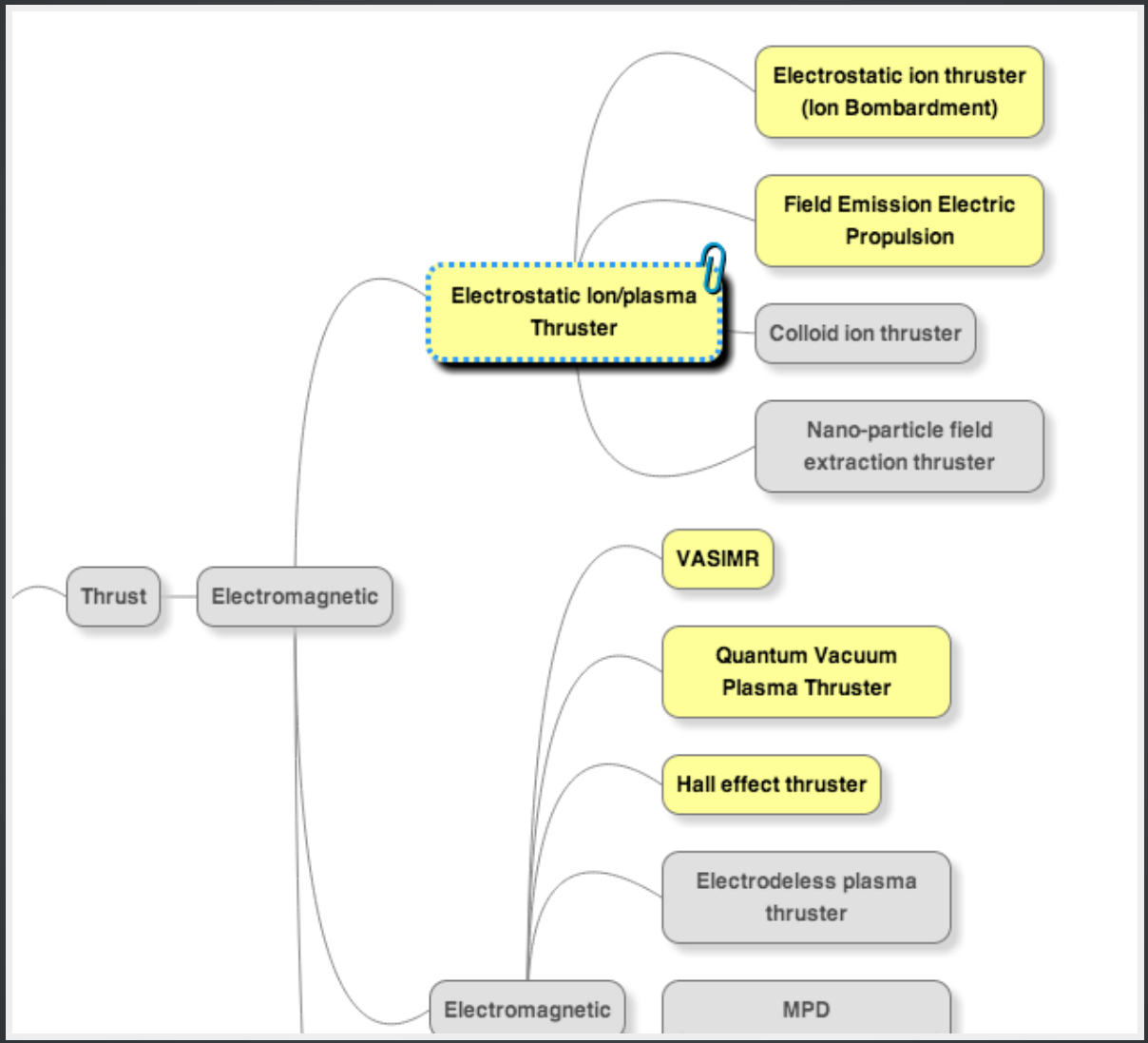
或许
……
只要能源

# 大地图

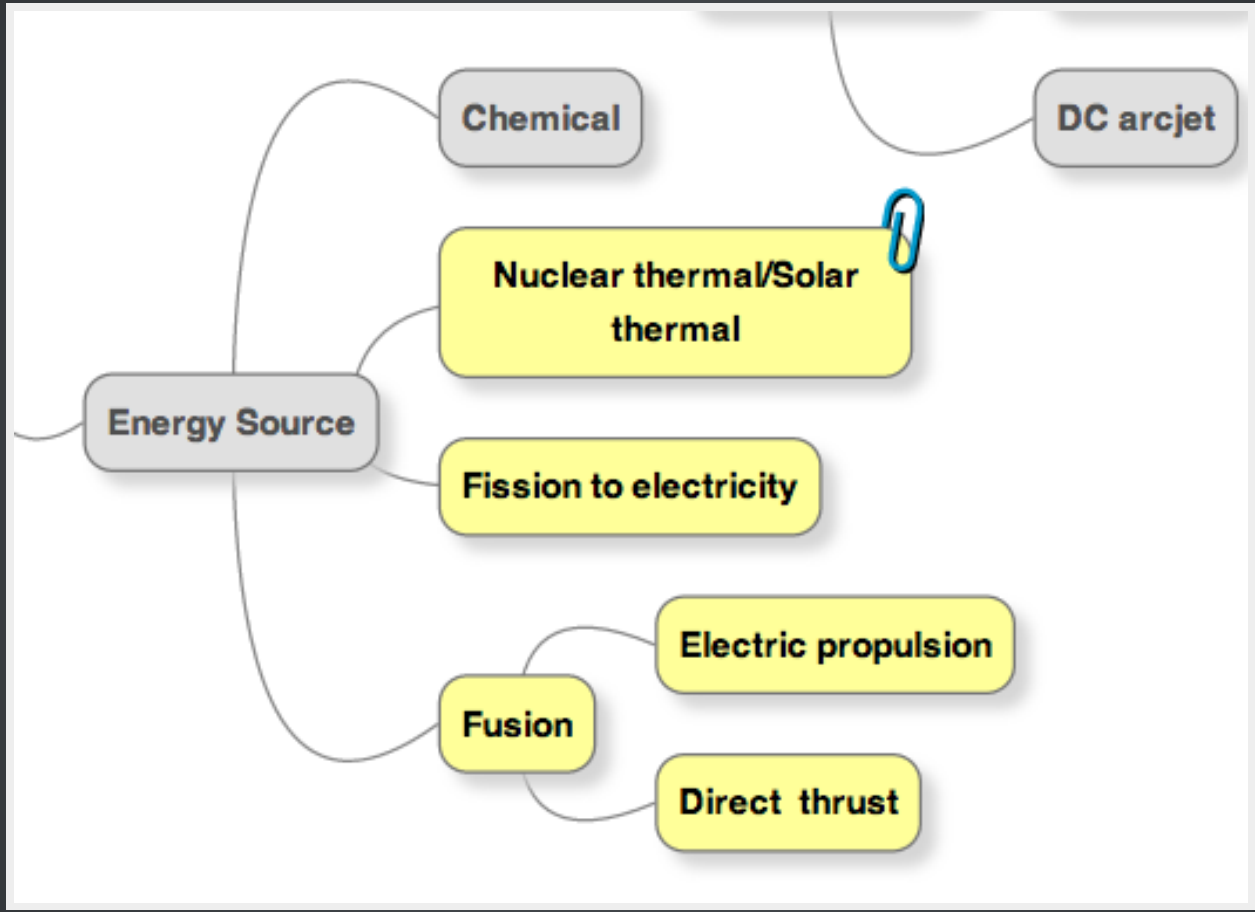
（显然看不清，所以戳此）



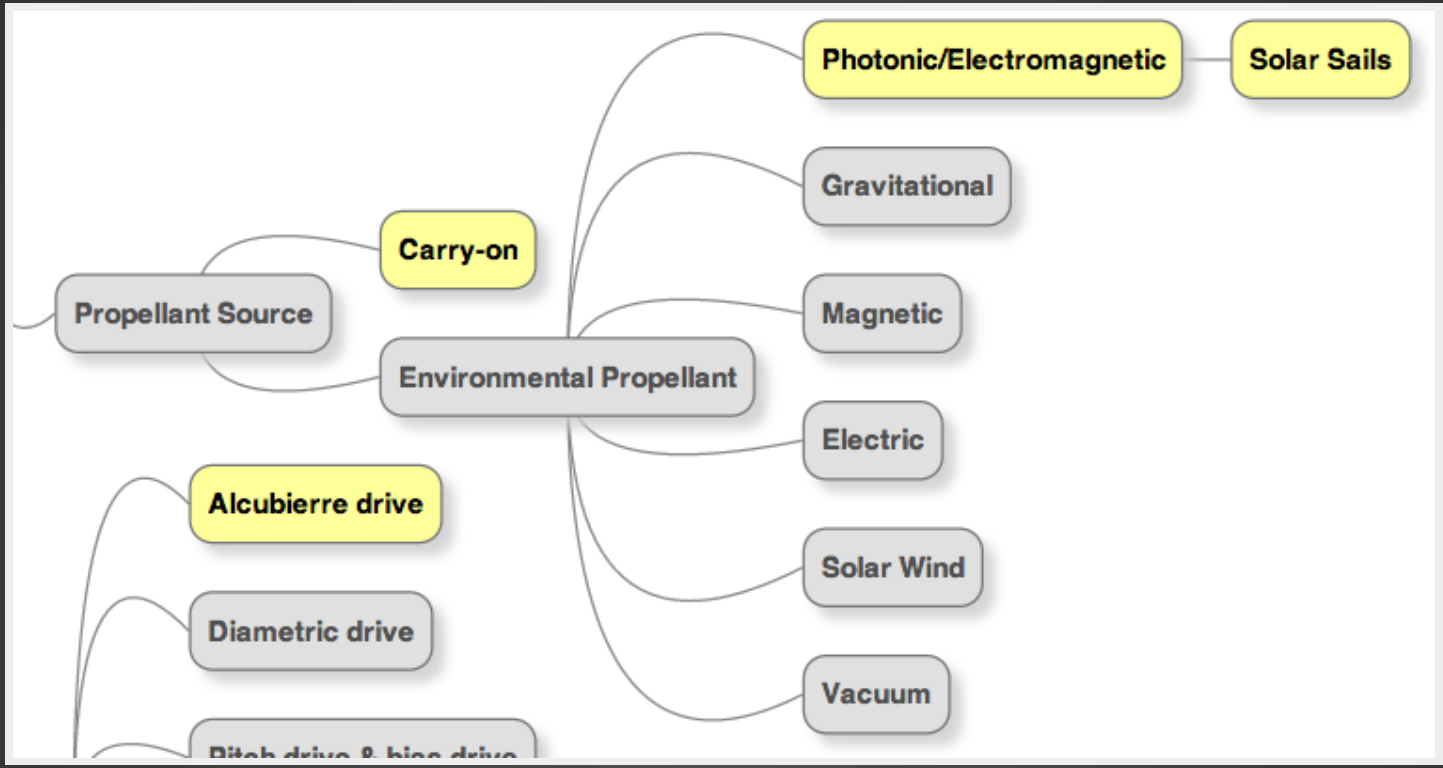
# 电磁推进技术


Thrust
Electromagnetic
Electrostatic Ion/plasma Thruster
Electrostatic ion thruster (Ion Bombardment)
Field Emission Electric Propulsion
Colloid ion thruster
Nano-particle field extraction thruster
Electromagnetic
VASIMR
Quantum Vacuum Plasma Thruster
Hall effect thruster
Electrodeless plasma thruster
MPD

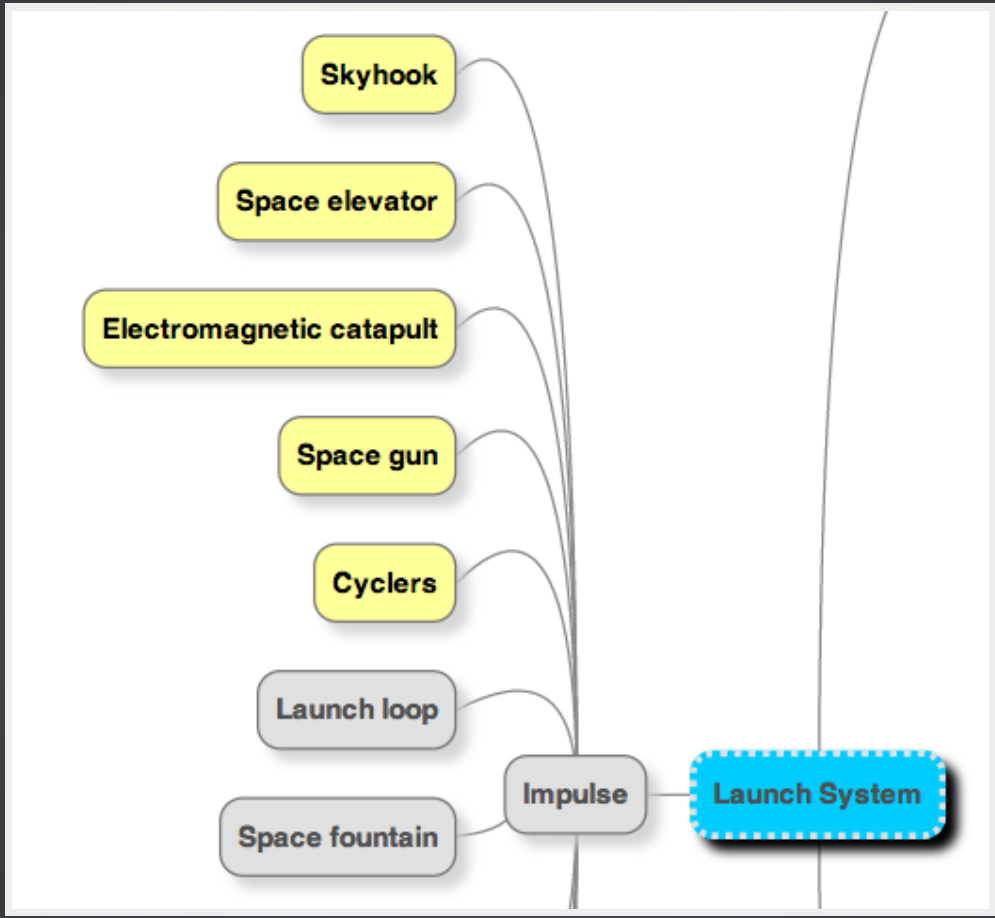
# 能源


Energy Source
Chemical
Nuclear thermal/Solar thermal
Fission to electricity
Fusion
Electric propulsion
Direct thrust
DC arcjet

# 工质来源


Propellant Source
Carry-on
Environmental Propellant
Photonic/Electromagnetic
Solar Sails
Gravitational
Magnetic
Electric
Solar Wind
Vacuum
Alcubierre drive
Diametric drive

# 奇思妙想


Skyhook
Space elevator
Electromagnetic catapult
Space gun
Cyclers
Launch loop
Space fountain
Impulse
Launch System

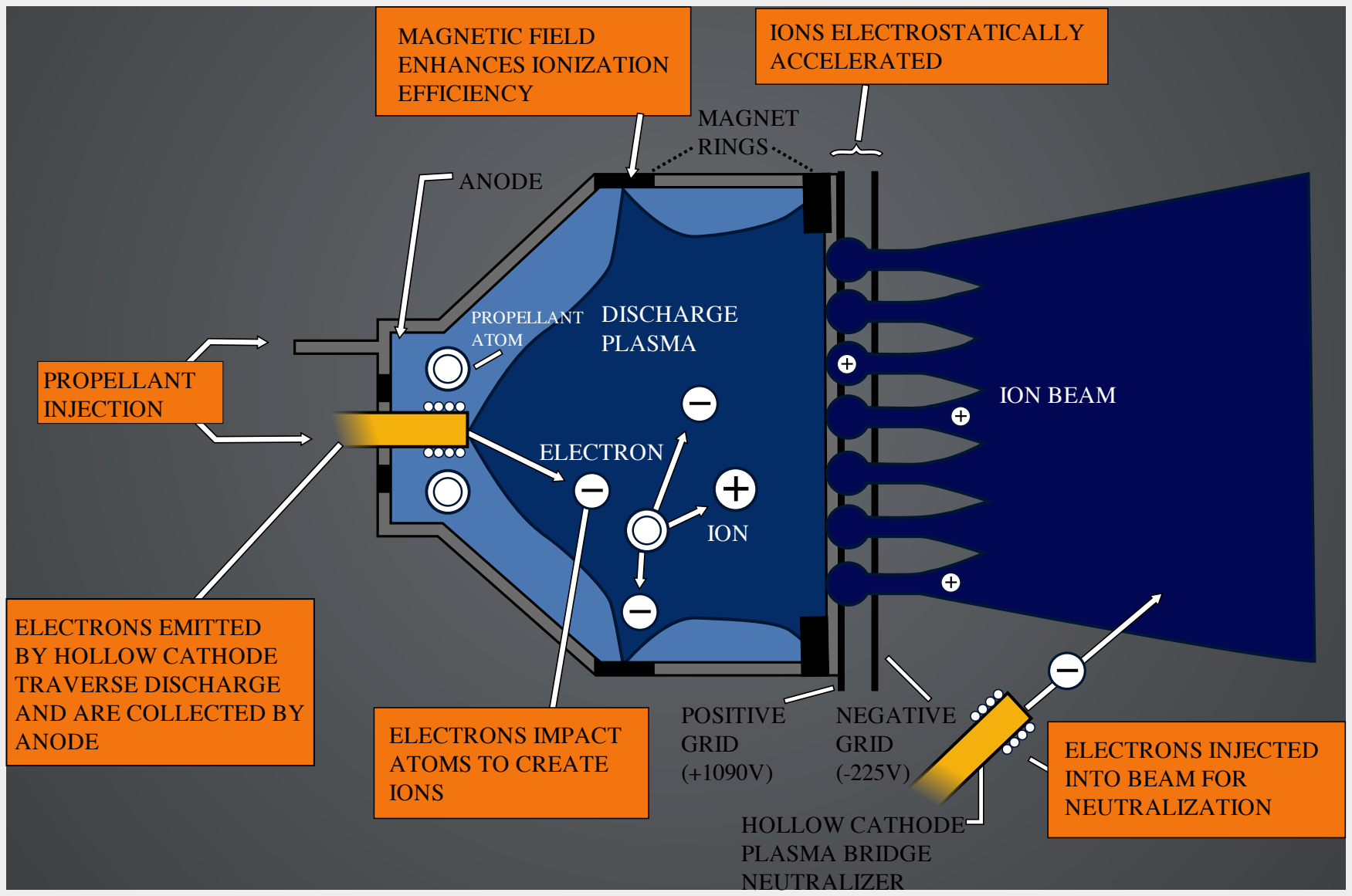
# 电磁推进

等离子体

电场加速

磁场束缚

# GRIDED ES ION THRUSTER



# GRIDED ES ION THRUSTER

工质：[氙]，[氪]

液体储存
容易气化
低污染低侵蚀
（早期使用汞和铯，
这些东西都会在推进器上聚集，
侵蚀电极，
而且不安全）

# GRIDED ES ION THRUSTER

DS1

1. 电压 1280V
2. 离子出口速度：146,000km/h= 40.6 km/s
3. 最大功率2300W，仅仅产生 90 mN 的推力

作为对照

化学燃料燃烧推进中，会产生 450 ~ 2250N 的推力

那么我们为嘛还要发明这个?

# GRIDED ES ION THRUSTER

1. 10 倍高的燃料利用率（[化学燃料出口速度只有5000 m/s左右，只能作用500s]）
2. 冲量决定动量改变。（细水长流）
3. 推进器本身质量小

例如，

DS1 的燃料有 81kg，

以最大功率一半运行，

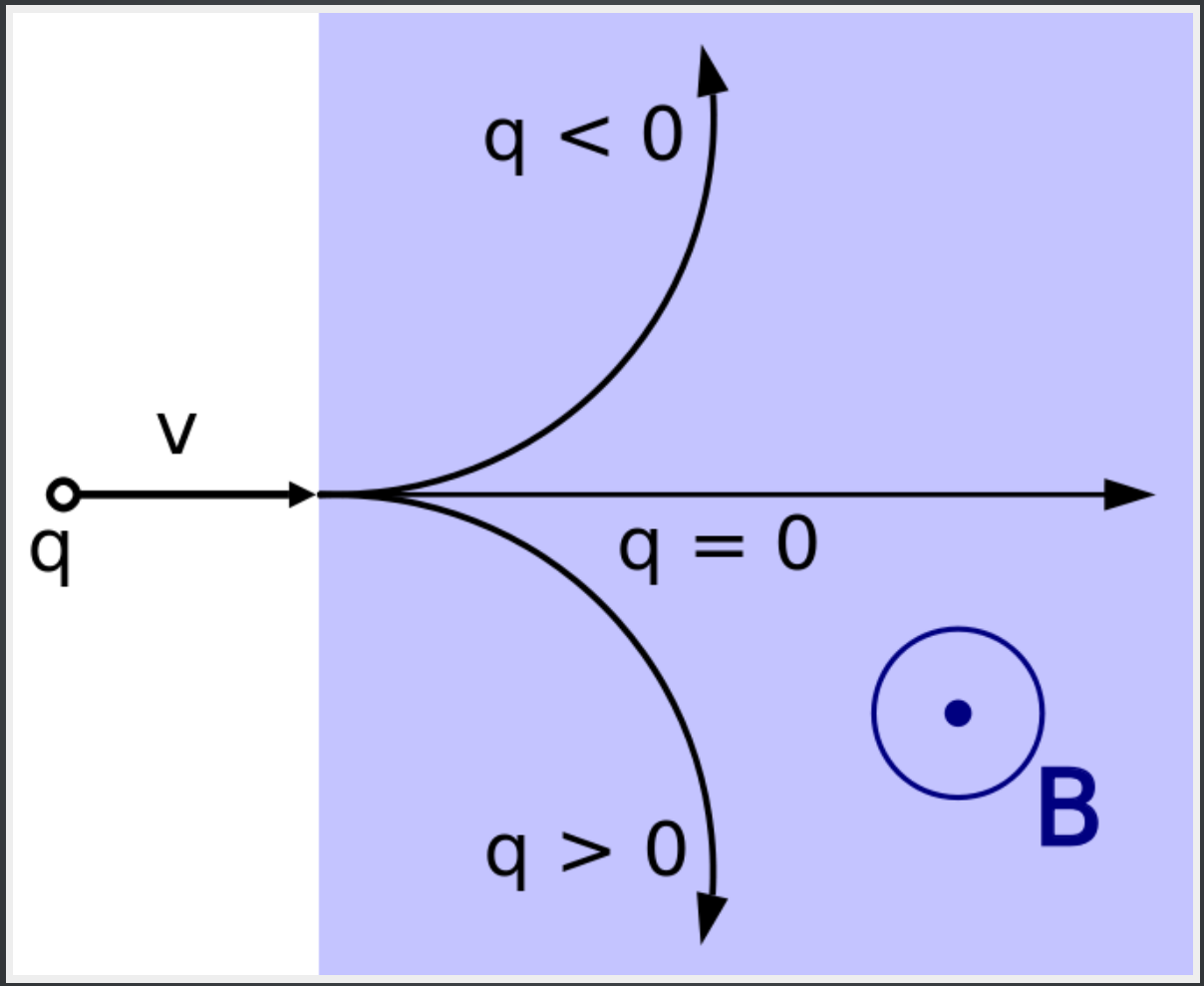
可以持续20个月。

时间是化学推进的 10^5 倍。

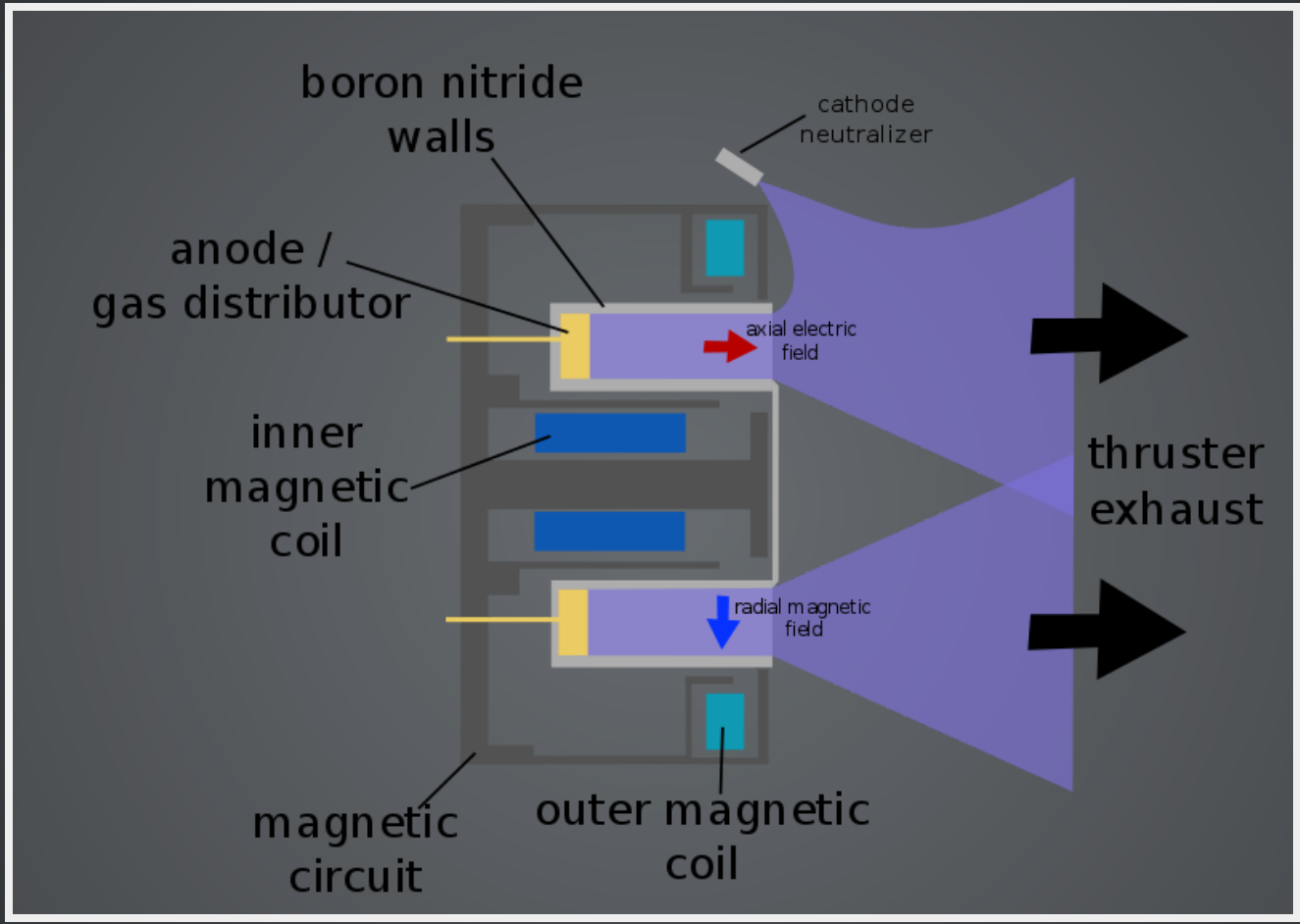
而化学燃烧的推力只是IT的10^4倍。

# 霍尔效应推进器

洛伦兹力



# 霍尔效应推进器




更充分的电离

# 霍尔效应推进器

[ SMART-1 ]

- Discharge power: 0.46–1.19 kW
- Specific impulse: 1,100–1,600 s
- Thrust: 30–70 mN
- Thruster operating time: 5,000 h
- Xenon throughput: 82 kg
- Total impulse: 1.1 MN·s
- Total ΔV: 3.9 km/s

Specific impulse:

$$I_{sp} = \frac{v_e}{g_0}$$

对于这真空中运行的时候的极限速度，

# 对照

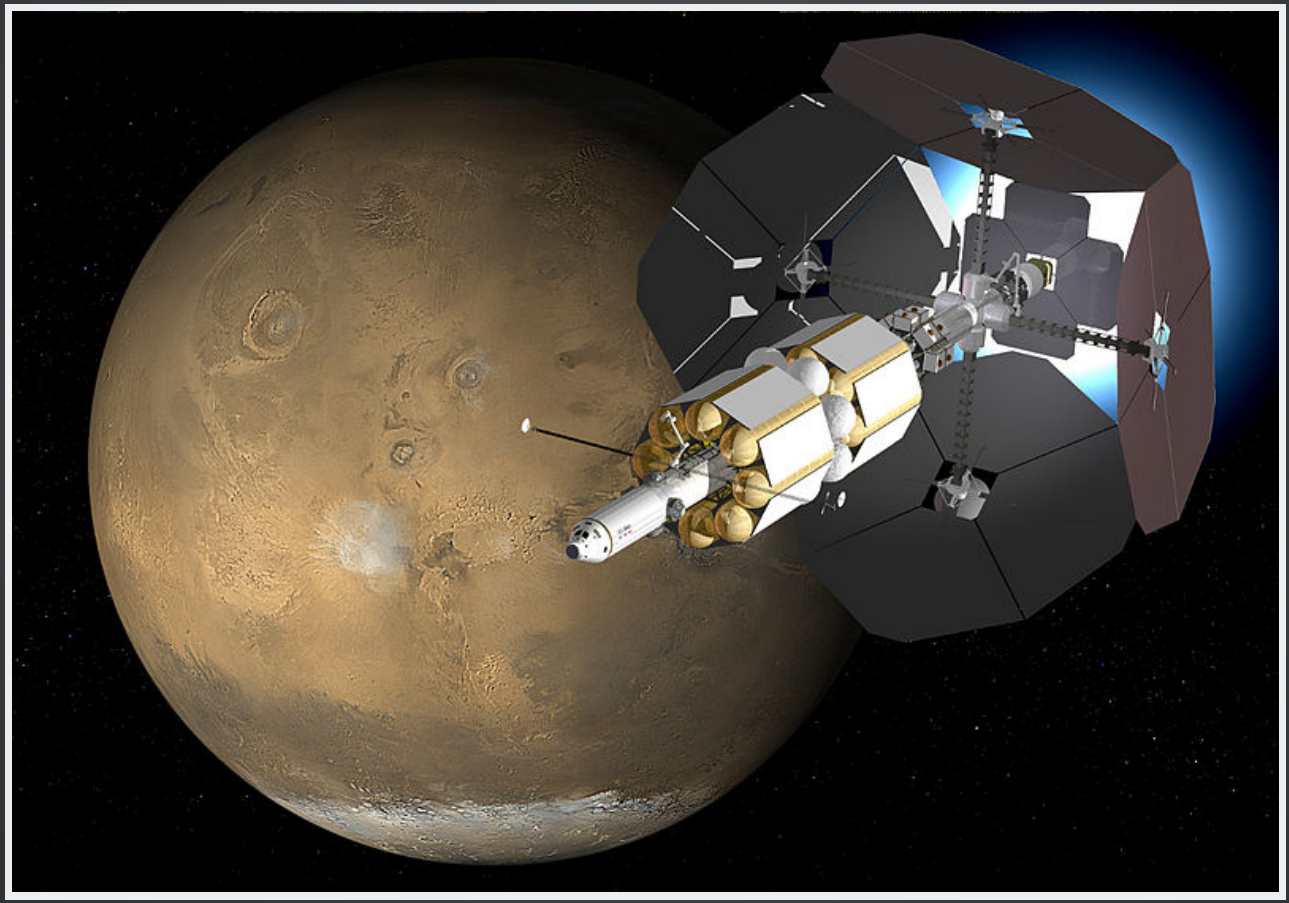
| 推进器 | 有效的极限速度 | SI |
| --- | --- | --- |
| Solid rocket | 2,500 | 250 |
| Bipropellant liquid rocket | 4,400 | 450 |
| Hall Effect | - | 1600 |
| Ion thruster | 29,000 | 3,000 |
| Dual-stage 4-grid electrostatic ion thruster | 210,000 | 21,400 |
| VASIMR | 30,000-120,000 | 3,000-12,000 |

SI = Specific Impuse

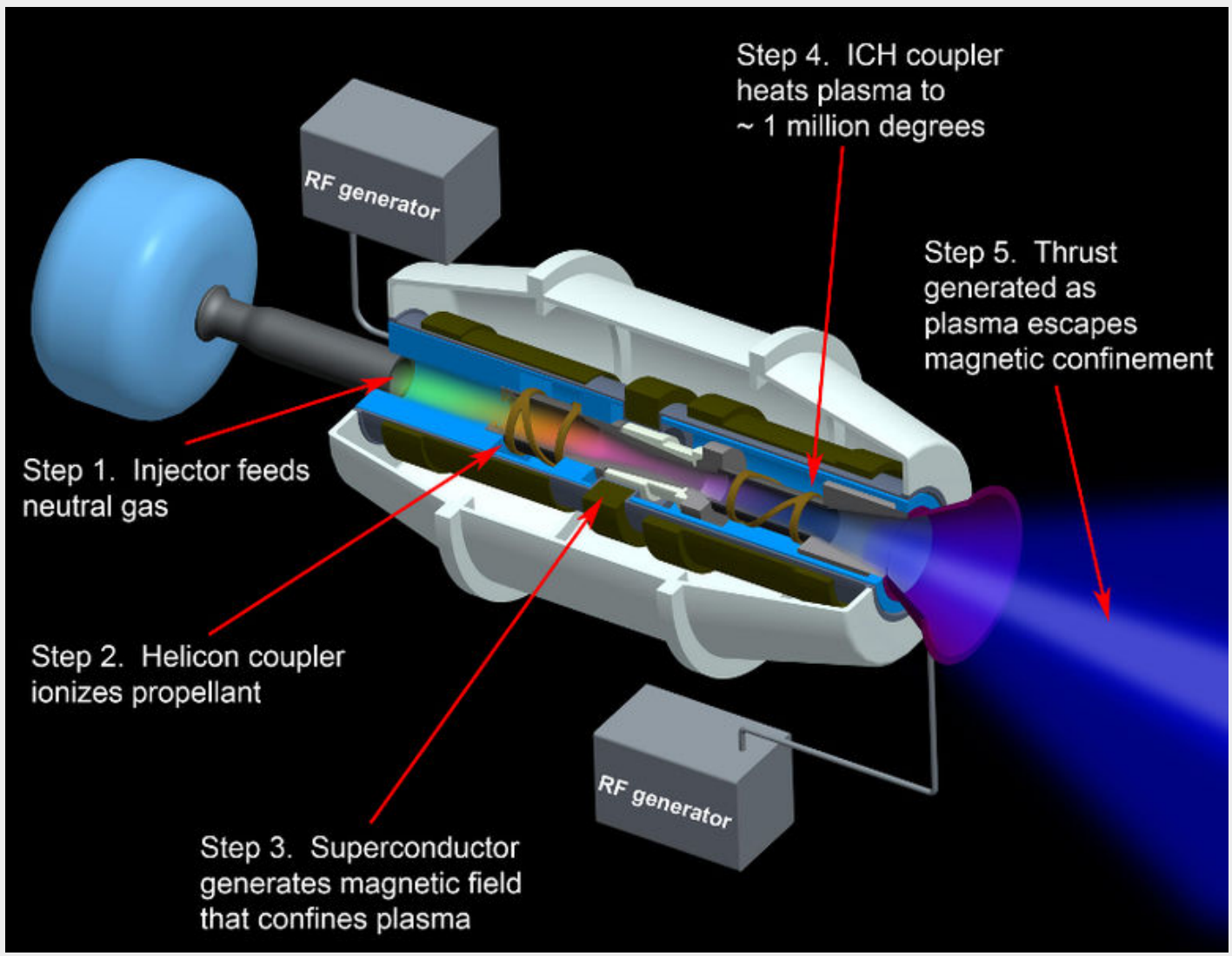
这个 VASIMR 是啥

# VASIMR

[VASIMR]
[Variable Specific Impulse Magnetoplasma Rocket]



# VASIMR


Step 4. ICH coupler heats plasma to ~ 1 million degrees
RF generator
Step 5. Thrust generated as plasma escapes magnetic confinement
Step 1. Injector feeds neutral gas
Step 2. Helicon coupler ionizes propellant
RF generator
Step 3. Superconductor generates magnetic field that confines plasma

# VASIMR

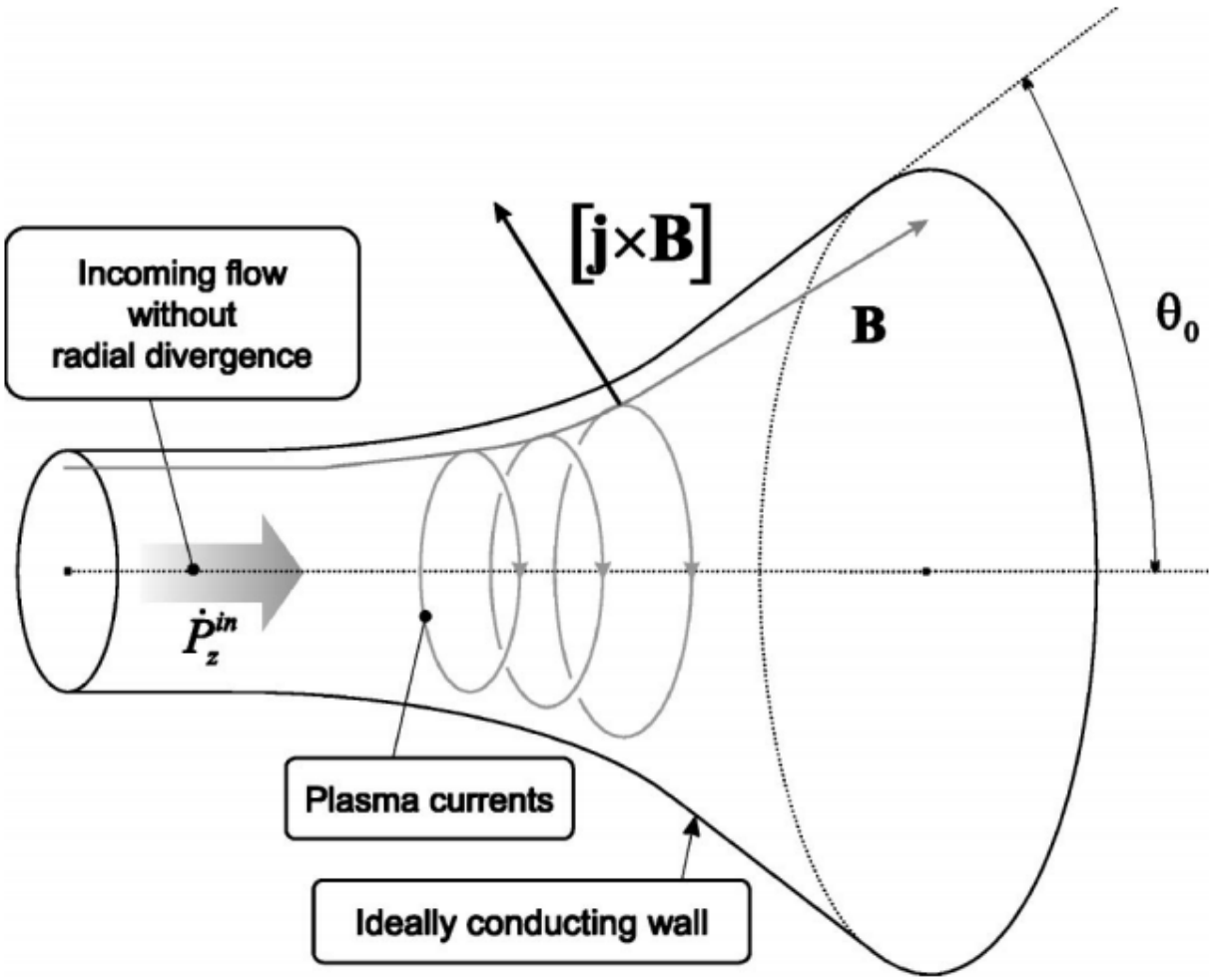



FIG. 3. Nozzle with curved magnetic field lines. At the nozzle entrance, the walls are straight and the field lines are parallel to the axis. The nozzle expands slowly and eventually becomes a conical nozzle with angle $\theta_0$.

# VASIMR

将来可能用大功率的 VASIMR 来组建货运轨道

[Projected Lunar Cargo Capabilities of High-Power VASIMRTM Propulsion]

# Q-THRUSTER

[Quantum vacuum plasma thruster]

# FUEL

现在大多使用Xe

- 惰性气体不腐蚀
- 原子数还算大
- 相对容易电离

# 质量投射器

炮姐投射器
[StarTram]

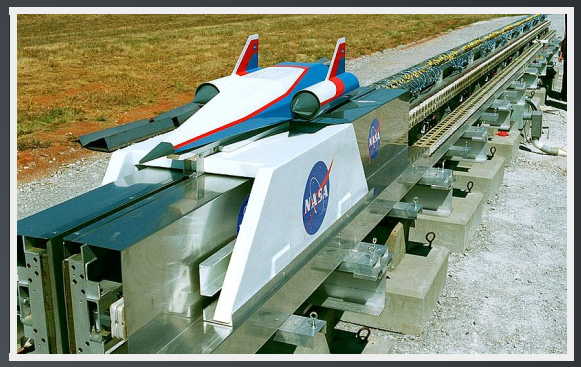
# STARTRAM

[ StarTram ]

第一代是地面设计

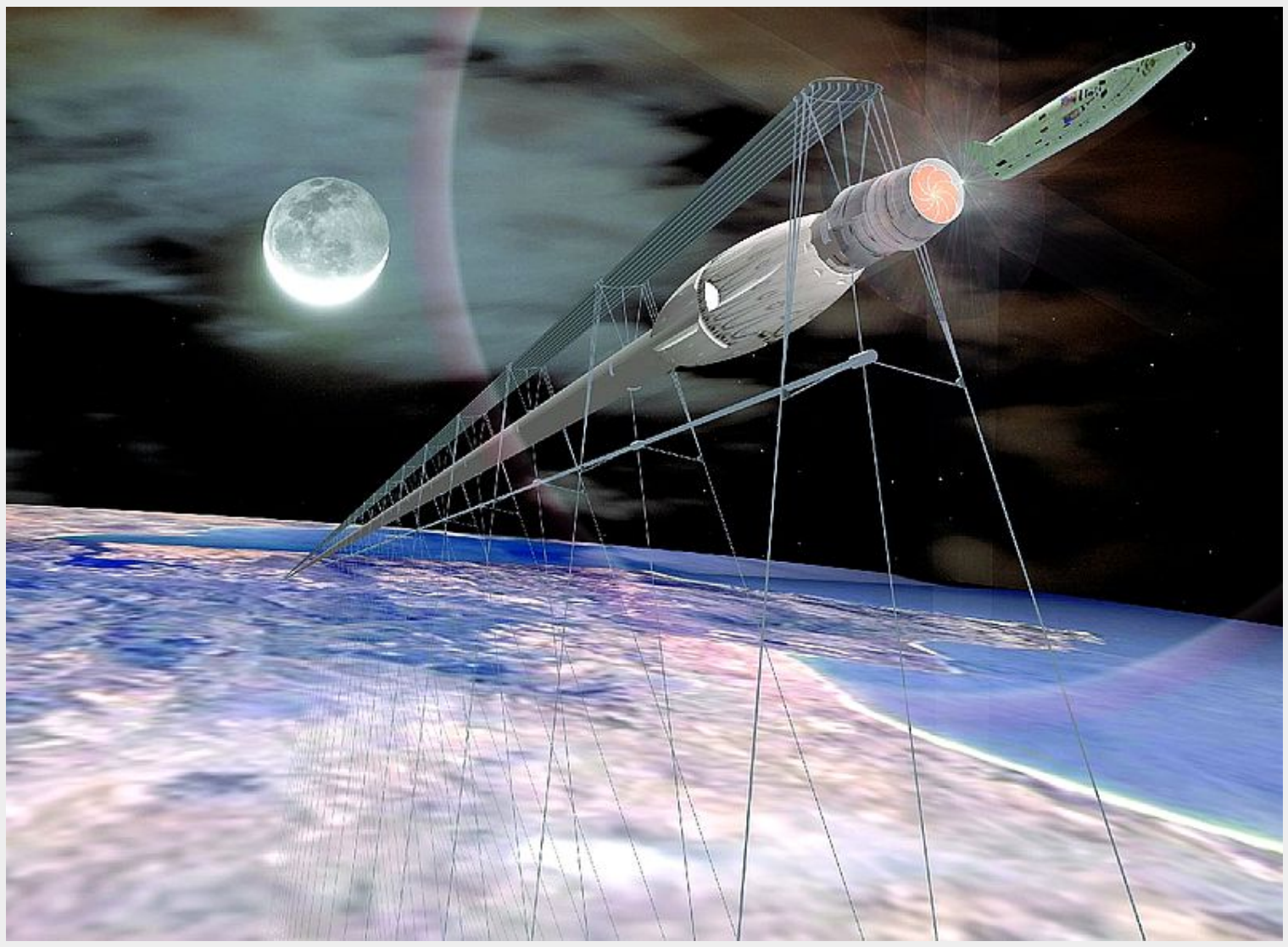
1. 6km 高的山顶
2. 8.78 km/s 的发射速度
3. 发射角度： 10°

（地面的第一宇宙速度7.9km/s）



# STARTRAM

第二代是轨道上



# SKYHOOK

# 讨论

还有哪些可能技术?
哪种比较有希望?
星际移民需要哪些?

星际移民中心: http://interimm.github.io/
星际移民中心微博: http://www.weibo.com/iiaofficial

# 计划

你希望讨论什么话题:

近未来的：如何移民（所需的技术，资金，人才）
远未来的：例如曲率推进，人类移民后的发展