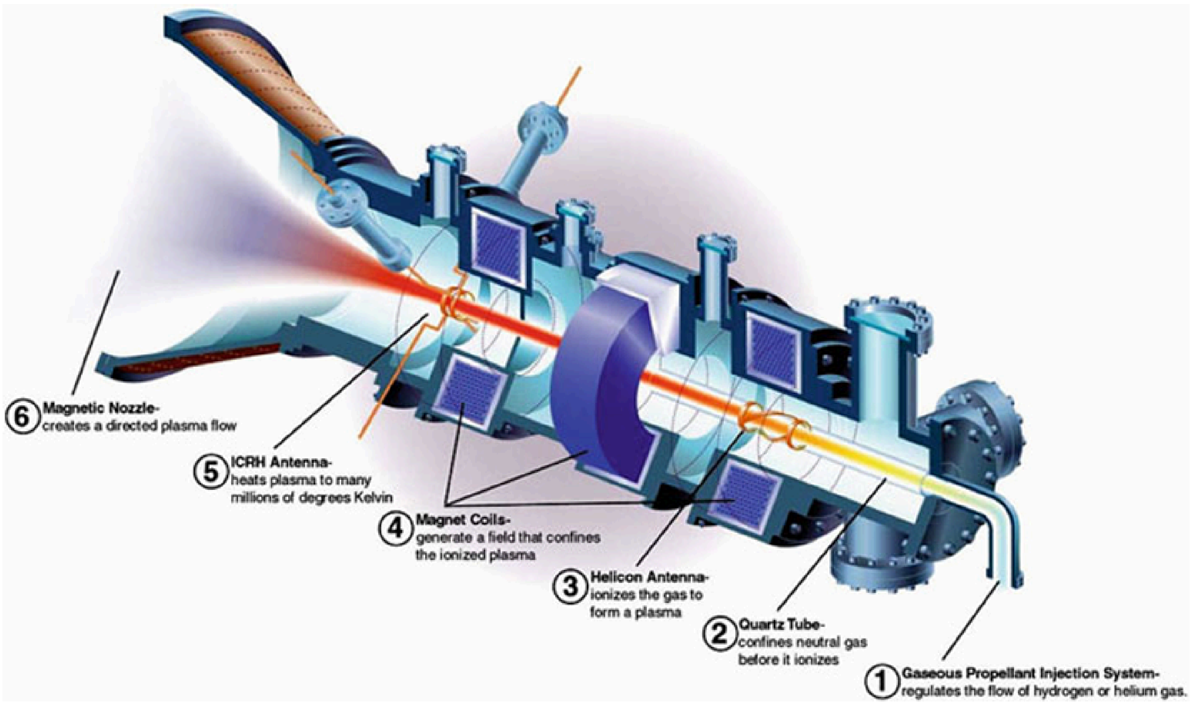
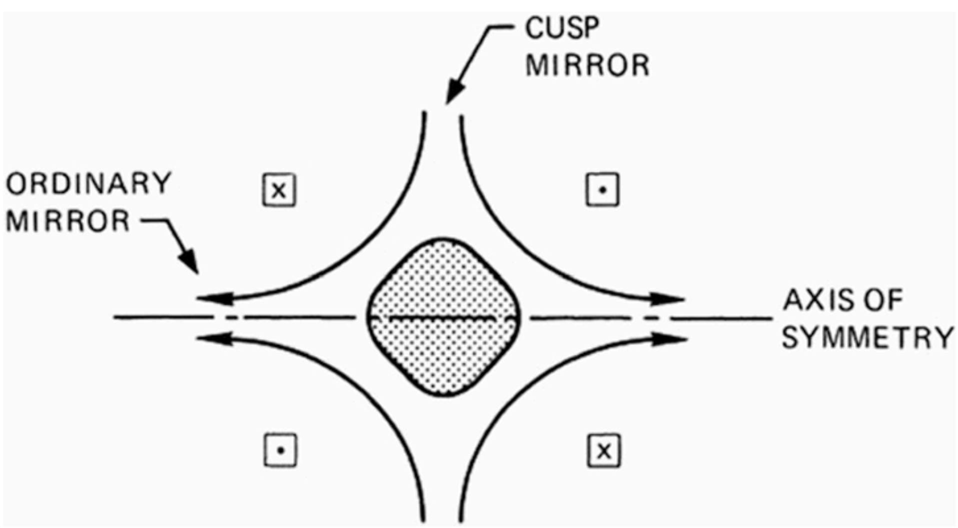
(Inertial Fusion and Solar Plasma Extraction: Frontiers for Exploration in the curvature-space gravitation & space materials)

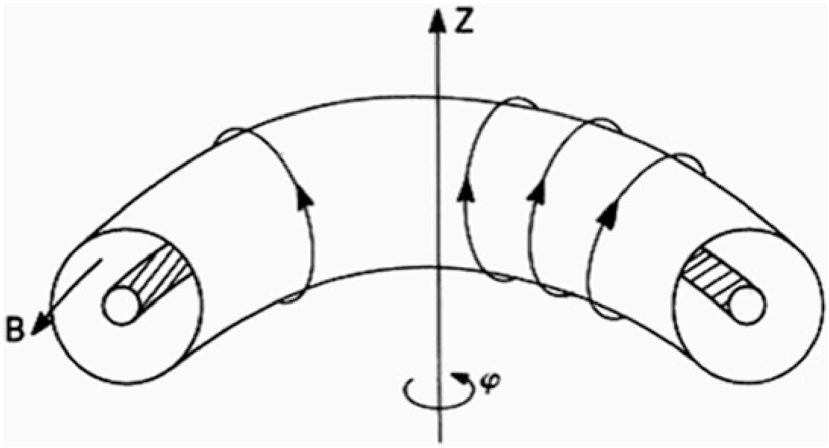
"Plasma-based Space Fighter for Space-time Curvature Research"
Engineering Draftv (with Solar Parker tech integration)

1. *The Solar Parker space fighter, featuring plasma structures inspired by Chen's book, combined with the Solar Parker Probe design concepts and materials.*
2. *Supralight Quantum Tension*
3. *Penrose Holes(Gravity-properties)*

Reference: Solar plasma structures or Galactic star structures are merged into a gas, gas origin, helium, structures of mass & structure of quantum particles combined with higher order gravities in for example other possible galaxies such Andromeda. We are looking to merge two important concepts to solidify our metrics and structural dynamics, the first one is the structure of Plasma with physics reference and meaning in computing variables refreshing the concepts in a more modern way than the old books of physics, the second concept is the Compactified structures of the black hole or structures in galaxies. We need to prove that a human reactor, or a solar parker probe materials can merge and adapt to local and compact structures of fusion & gravity.







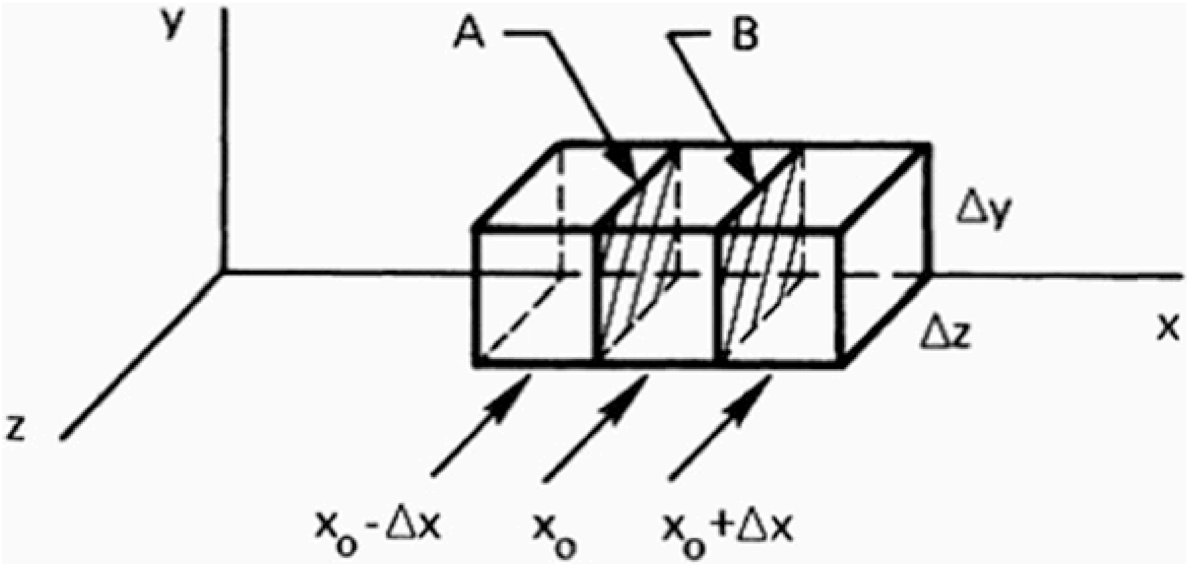

```
/* Plasma Heating by Adiabatic Compression */
PLASMA_EVENT {
  DESCRIPTION: 'In adiabatic compression, magnetic moment μ is invariant.',
  CONDITION: 'KT_perp ∝ B',
  NOTE: 'Lorentz force (q × v × B) is ⊥ to velocity => No direct acceleration.',
  QUESTION: 'How do particles gain energy if B ⊥ v?'
}

/* Polarization Drift via Energy Conservation */
POLARIZATION_DRIFT {
  DESCRIPTION: 'Oscillating E field causes oscillating E × B drift.',
  ENERGY: 'Energy associated: (1/2) × m × v_E^2',
  PRINCIPLE: 'Energy gained only via motion along E => Drift velocity vp in E direction.',
  EQUATION: 'Rate( (1/2) × m × v_E^2 ) = vp · E',
  TASK: 'Find value of vp.'
}
```

SOLAR PLASMA:

- *Density ~ 10^{18} particles/m^3.*
- *Impossible to track each particle.*
- *Fluid model is used: plasma behaves like a charged fluid.*
- *Even with few collisions, the fluid model works.*
- *80% of plasma phenomena can be explained by the fluid model.*
- *Main focus: Fluid Theory of Plasma.*
- *Kinetic Theory = for advanced analysis (more mathematics).*

```
/* Solar Plasma - Inertial Fusion - Basic Theory */

/* Typical solar plasma density */
PLASMA_DENSITY {
  Value: 10^18 ion-electron pairs / m^3
}

/* Complex behavior of individual particles */
PARTICLE_BEHAVIOR {
  Individual_Trajectories: complicated,
  Predict_Individually: impractical
}

/* Solution: fluid model */
FLUID_MODEL {
  Description: 'Particles treated as fluid elements.',
  Identity: 'Individual identity neglected.',
  Charge: 'Fluid elements carry electric charge.'
}

/* Collisions in solar plasma */
COLLISIONS {
  Frequency: low,
  Comment: 'Surprisingly, fluid model still works.'
}

/* Reason for fluid model validity */
MODEL_VALIDITY {
  Cause: 'Collective behavior dominates over individual collisions.'
}

/* Theories used in plasma studies */
PLASMA_THEORIES {
  Fluid_Theory: {
    Usage: 'Primary model in plasma studies',
```

Only extract plasma where the electric field is time-varying ($E \neq$ constant).
- Focus on low-frequency transverse motions ($\omega << \omega c$, $E \perp B$).
- Plasma behaves as a dielectric medium with $\varepsilon R > 1$ under typical solar conditions.
- Higher magnetic fields or lower densities drive εR closer to 1 (vacuum behavior).
- Example for hydrogen: $n = 10^{16}$ m^-3, $B = 0.1$ T => εR significantly > 1.



That the gain Momentum From Right-moving particles is

PA þ PB þ = Δy Δz 1

2
m nv2 x
[ ]
x0 Δx

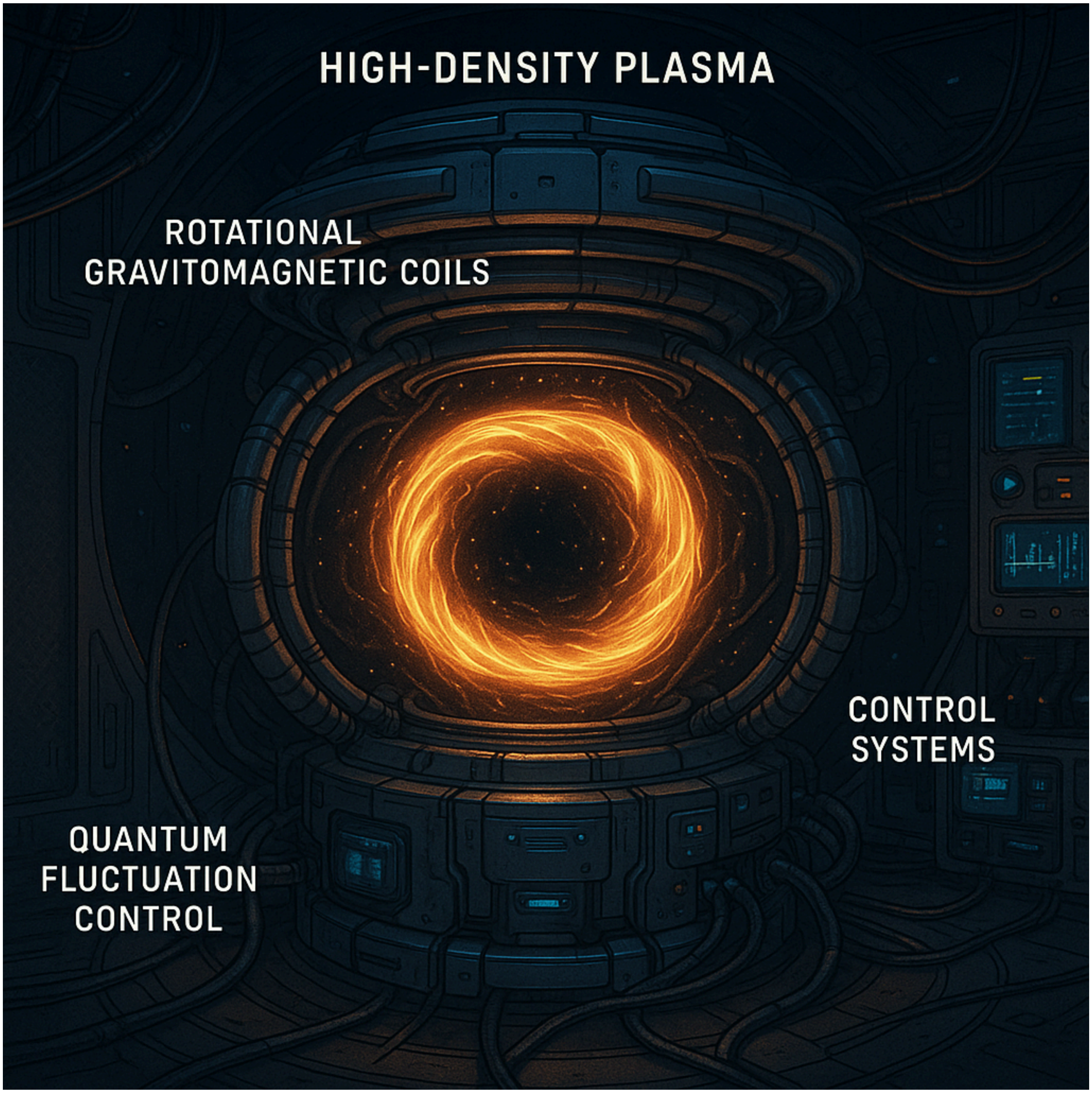
nv2 x
[ ]
x0

= Δy Δz 1

2
m Δx ( ) ∂
∂x nv2 x

(3.37)

This result will be just doubled by the contribution of left-moving particles,
since they carry negative x-momentum and also move in the opposite direction relative to the gradient of nv2 x.



1. *Plasma and Fluid Modeling: Typical plasma density (~10^18 ion-electron pairs/m³) is too complex for individual modeling, so the fluid model is used (plasma treated as a "charged fluid").*
2. *Physical Relations and Motors: Variables such as radial behavior, magnetic vectors, and thermal energy in materials or energy systems like adiabatic compression are explored.*

3. *Theories Applied:*
    - *Fluid models to explain phenomena.*
    - *Kinetic theory for advanced mathematical applications.*
4. *Practical Cases: Example: equations derived for plasma heating through polarization drift and energy conservation.*

The Complete Set of Fluid Equations

For simplicity, let the plasma have only two species: ions and electrons. The charge and current densities are given by:

$$\sigma = n_i q_i + n_e q_e$$
$$j = n_i q_i v_i + n_e q_e v_e \qquad (3.54)$$

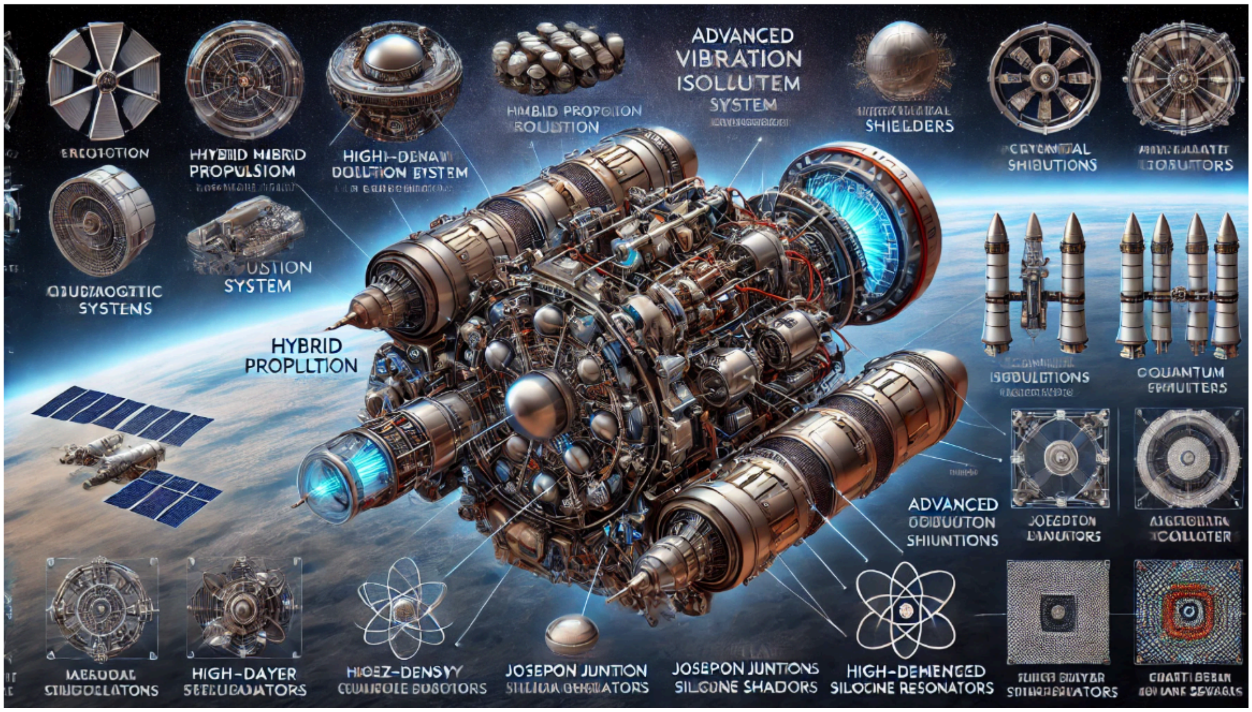
Since single-particle motions will no longer be considered, we use v instead of u for the fluid velocity. Collisions and viscosity are neglected.

The following set of equations is formed:

$$\varepsilon_0 \nabla \cdot E = n_i q_i + n_e q_e \qquad (3.55)$$
$$\nabla \times E = -\partial B/\partial t \qquad (3.56)$$
$$\nabla \cdot B = 0 \qquad (3.57)$$
$$\mu_0 \nabla \times B = n_i q_i v_i + n_e q_e v_e + \varepsilon_0 \partial E/\partial t \qquad (3.58)$$
$$\partial v_j/\partial t + v_j \cdot \nabla v_j = q_j n_j (E + v_j \times B) - \nabla p_j \qquad j = i, e \quad (3.59)$$
$$\partial n_j/\partial t + \nabla \cdot (n_j v_j) = 0 \qquad j = i, e \quad (3.60)$$
$$p_j = C_j n^{\gamma_j} \qquad j = i, e \quad (3.61)$$

There are 16 scalar unknowns: n_i, n_e, p_i, p_e, v_i, v_e, E, and B. There appear to be 18 scalar equations, counting each vector equation as three scalar equations.

Reactor image:



Curvature of Space-Time
The curvature of space-time is described by Einstein's theory of general relativity. According to this theory, mass and energy curve space-time, affecting the trajectory of objects moving within it.

Technologies to Curve Space-Time
Although no current technologies can significantly curve space-time, some theoretical proposals and concepts might be used to achieve this:

1. Warp Drives:
These engines use energy to curve space-time, allowing travel at speeds faster than light.

2. Distortion Devices:
These devices use energy to distort space-time, enabling non-linear travel through space-time.

3. Portals:
Hypothetical devices allowing instant travel through space-time.

Surviving the Explosion of the Sun
The explosion of the Sun is an event expected to occur in approximately 5 billion years. To survive this event, it would be necessary to develop technologies that enable:

1. Travel at Faster-Than-Light Speeds:
This would allow escaping the Sun's explosion and reaching a safe distance.

2. Creation of a Protective Shield:
This would protect humanity from the radiation and energy released during the explosion.

3. Establishing a Colony on Another Planet:
This would ensure humanity's survival if Earth is destroyed during the explosion.

Neutron Stars
Neutron stars are extremely dense objects formed when a massive star collapses under its own gravity. They have properties similar to black holes but without a singularity.

Stellar-Mass Black Holes
Stellar-mass black holes are objects formed from the gravitational collapse of a massive star. They are similar to micro black holes but with much greater mass.

X-ray Binaries
X-ray binaries are star systems consisting of a compact object (such as a neutron star or black hole) and a companion star. These systems can be used to study the physics of black holes and neutron stars.

Supernova Remnants
Supernova remnants are objects formed when a star explodes as a supernova. These objects can have properties similar to a micro black hole but without a singularity.

Gas and Dust Clouds
Gas and dust clouds found in interstellar space can exhibit properties similar to those of a micro black hole but without a singularity.

Specific Examples of Objects
- Cygnus X-1: An X-ray binary located in the constellation Cygnus.
- V404 Cygni: An X-ray binary located in the constellation Cygnus.
- GRS 1915+105: An X-ray binary located in the constellation Aquila.
- SN 1987A: A supernova remnant located in the Large Magellanic Cloud.

```
Black Hole Metrics
- Schwarzschild Metric:
  ds² = (1 - 2GM/r) dt² - (1 - 2GM/r)^(-1) dr² - r² dΩ²

- Ricci Curvature Tensor:
  R_ij = ∂_i Γ^k_jk - ∂_j Γ^k_ik + Γ^l_ij Γ^k_lk - Γ^l_ik Γ^k_lj

- Energy-Momentum Tensor:
```

$$T_{ij} = (\rho + p) u_i u_j - p g_{ij}$$

Plasma Metrics of a Star

- Minkowski Metric:

$$ds^2 = -dt^2 + dx^2 + dy^2 + dz^2$$

- **Plasma Energy-Momentum Tensor:**

$$T_{ij} = (\rho + p) u_i u_j - p g_{ij}$$

- **Plasma Stress Tensor:**

$$\tau_{ij} = \mu (\partial_i u_j + \partial_j u_i)$$

Enhanced Materials for a Solar Parker Probe

- **Superconducting Materials:**
  Materials such as niobium or titanium capable of withstanding cryogenic temperatures and intense magnetic fields.

- **Refractory Materials:**
  Materials such as graphite or silicon carbide capable of withstanding extremely high temperatures.

- **Composite Materials:**
  Materials such as carbon-carbon or carbon-silicon capable of withstanding high temperatures and intense magnetic fields.

Useful Properties to Harness Black Hole and Stellar Plasma Characteristics

- **Plasma Confinement:**
  Using intense magnetic fields to confine plasma and prevent it from escaping.

- **Plasma Acceleration:**
  Using intense electric fields to accelerate plasma and increase its energy.

- **Radiation Protection:**
  Using refractory and superconducting materials to protect against intense radiation produced in a black hole or stellar plasma.

Conclusion

It is important to highlight that creating a device that harnesses the properties of a black hole, stellar plasma, and enhanced Solar Parker materials is a significant scientific and technical challenge. However, research and development in these areas could lead to major advances in energy technologies.

Plasma Metrics
The plasma metric can be described using Einstein's theory of general relativity. The plasma metric can be written as:

$ds^2 = -dt^2 + dx^2 + dy^2 + dz^2 + g_{ij} dx^i dx^j$ where g_{ij} is the plasma metric tensor, which can be expressed as:

$$g_{ij} = \eta_{ij} + h_{ij}$$

where η_{ij} is the Minkowski metric tensor and h_{ij} is the plasma perturbation tensor.

Ricci Curvature
The Ricci curvature can be described using Einstein's theory of general relativity. The Ricci curvature can be written as:

$$R_{ij} = \partial_i \Gamma^k_{jk} - \partial_j \Gamma^k_{ik} + \Gamma^l_{ij} \Gamma^k_{lk} - \Gamma^l_{ik} \Gamma^k_{lj}$$

where Γ^i_{jk} is the Christoffel symbol.

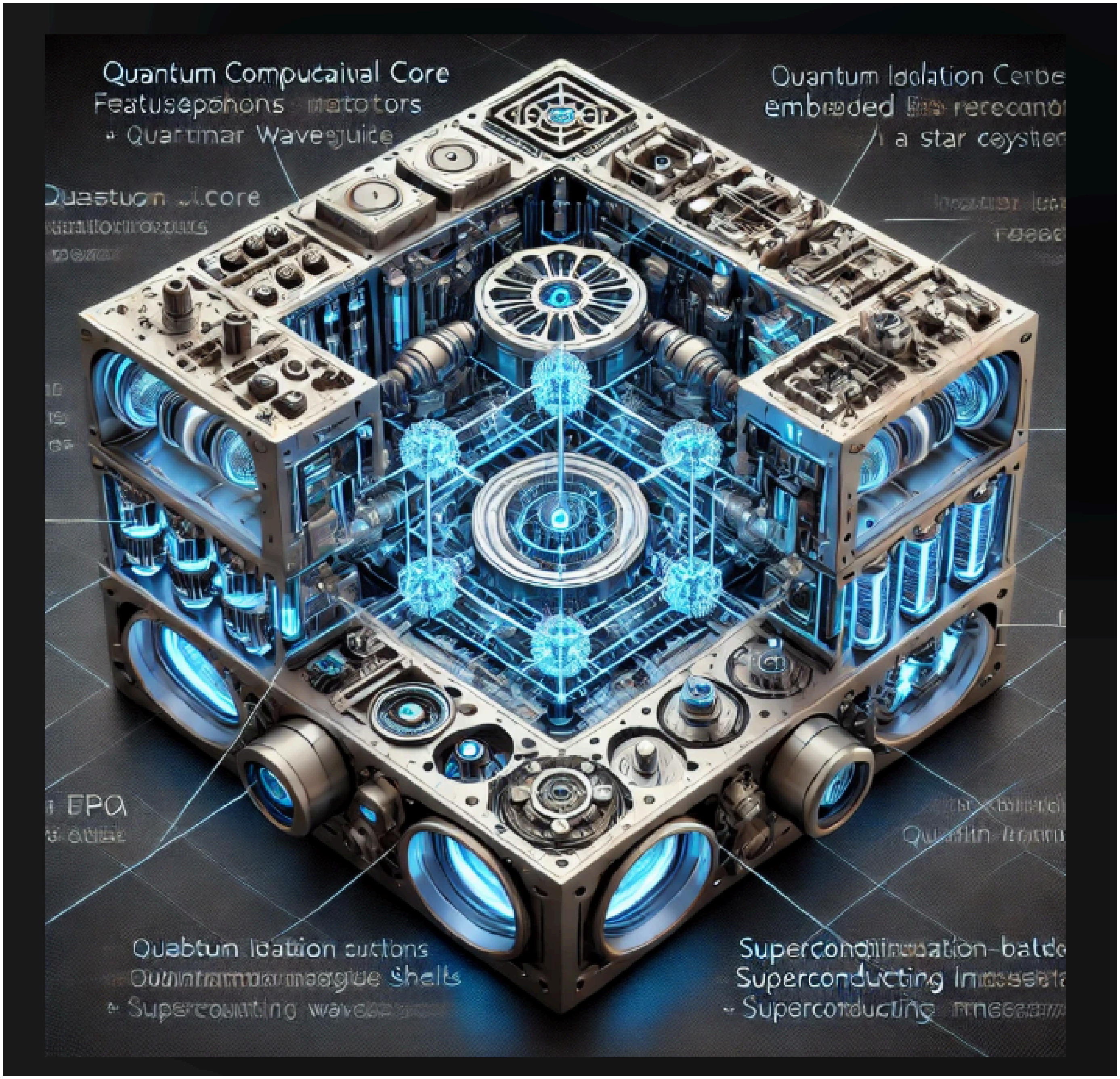
Creating a Compact Black Hole

To create a compact black hole, an enormous amount of mass and energy would be needed in a very small space. However, it is possible to design a device that simulates some of the properties of a black hole.

Some materials that could be used to create a compact device simulating a black hole are:

- Superdense materials: such as osmium or iridium, which have very high density.
- Superconducting materials: such as niobium or titanium, which can sustain intense magnetic fields.
- Refractory materials: such as graphite or silicon carbide, which can withstand extremely high temperatures. **Some possible designs for a compact device simulating a black hole include:**

- Magnetic field device: a device that uses an intense magnetic field to simulate space-time curvature.
- Plasma device: a device that uses plasma to simulate space-time curvature.
- Artificial gravity device: a device that uses artificial gravity to simulate space-time curvature.


Quantum Compucaival Core
Quantum Idolation Cerbe
Quabtum Idation cutions
Superconducting

Basic Principle

The basic principle behind generating artificial gravity using magnetic fields is the interaction between the magnetic field and charged particles. When a charged particle moves within a magnetic field, it experiences a force that depends on the intensity of the magnetic field and the particle's velocity.

Intense Magnetic Field
To generate artificial gravity, an intense magnetic field is required to simulate gravity. The intensity of the magnetic field needed depends on the mass and velocity of the particles to be affected.

Types of Magnetic Fields
There are several types of magnetic fields that can be used to generate artificial gravity, including:

- Static Magnetic Field: A magnetic field that does not change with time.
- Variable Magnetic Field: A magnetic field that changes with time.
- Rotating Magnetic Field: A magnetic field that rotates around an axis.
- Flexibility: Magnetic fields can be designed to simulate different types of gravity.
- Control: Magnetic fields can be precisely controlled to simulate the desired gravity.

- Intensity: The magnetic fields required to simulate gravity are extremely intense and require advanced technology.
- Stability: Magnetic fields can be unstable and require advanced control systems.

Applications
Applications of artificial gravity using magnetic fields include:

- **Space Propulsion:** Artificial gravity can be used to propel spacecraft.
- Scientific Research: Artificial gravity can be used to investigate scientific phenomena in simulated gravity conditions.
- **Medical Technology:** Artificial gravity can be used to treat medical conditions related to gravity.

Metrics and Equations of Artificial Gravity in Nanotechnology(synthetic format):

- **Rotating Magnetic Field Equations**: $B = (B_r, B_\theta, B_\varphi) = (B_0/r^2, 0, 0)$
- **Artificial Gravity Simulation with Charged Particles**: $F = q(v \times B)$
- **Artificial Gravitational Field Theory**: $g = (\nabla \times B) \times v$
- **Gravitational Metric in Artificial Systems**: $ds^2 = (1 - 2GM/r)dt^2 - (1 - 2GM/r)^{-1}dr^2 - r^2 d\Omega^2$

Black Hole Metrics

To simulate black hole, we would neeed to include the Schwarzschild or Kerr metrics, which describe the geometry of spacetime around a blachole. These metrics include the black hole's mass, angular momentum, and electric charge.

Rotation and Intense Magnetic Fields

A possible mathematical structure to simulate a possible mathods could be the following:

- Schwarzschild Metric: $ds^2 = (1-2GM/r)dt^2-(1-2GM/r)^1$ $dr^2 - r^2 d\Omega$

- Kerr Metric: $ds^2 = (\Delta - a^2 \sin^2\theta)/\Sigma\ dt^2 - \Sigma/d\mathrm{r}^2 - \Sigma\, d\theta^2 - (r^2 + a^2)\sin^2\theta\, d\phi^2$

- Magnetic Field: $B = (B_r, B_\theta, B_\varphi) = (B_0/r^2, 0, 0)$

- Rotational Speed: $\omega = (0, 0, \omega_0)$

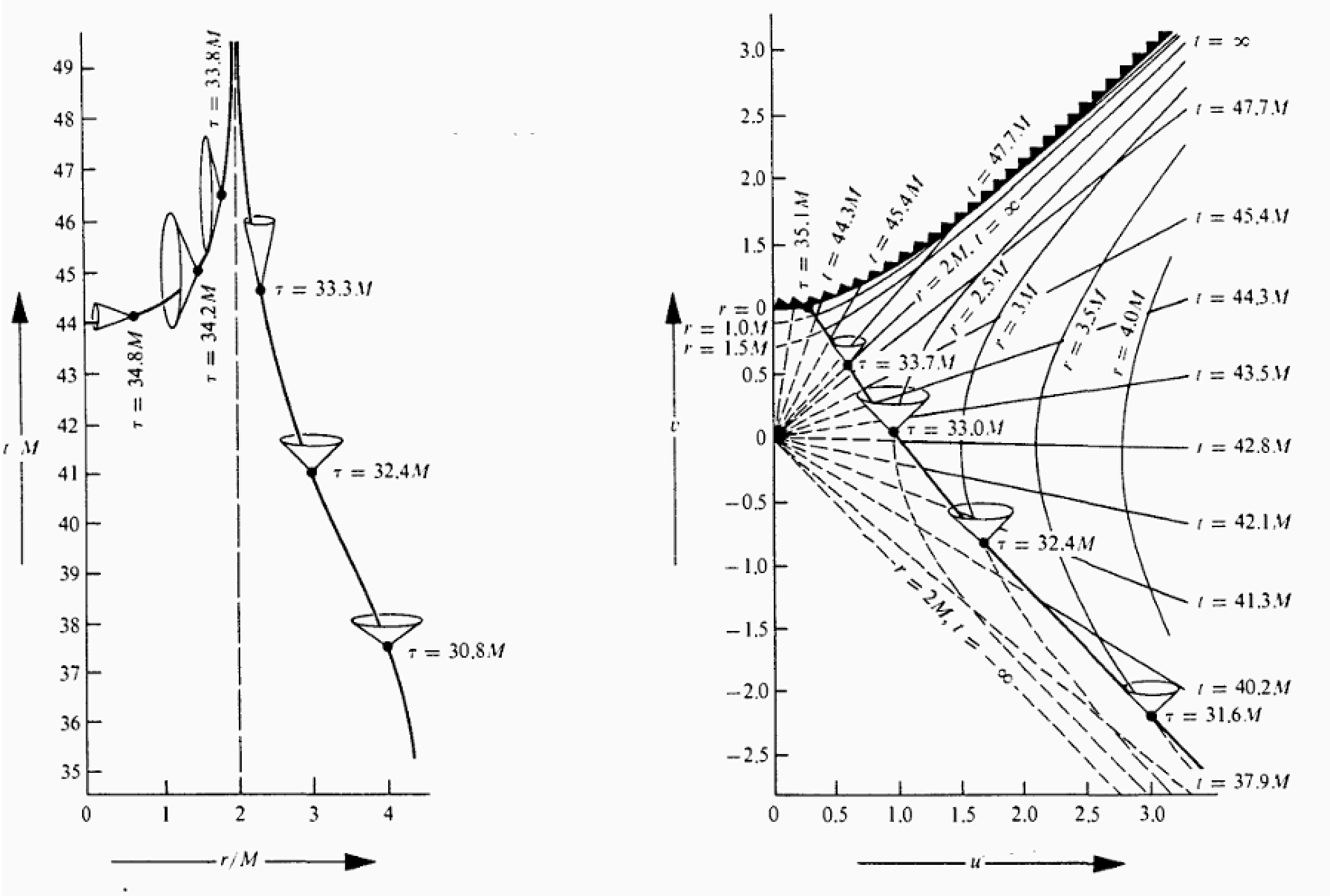
Where G is the gravitational constant, M is bhack hole mass, r is radial distance, θ is the azimuthal angle, Δ is the sxcicmninant function, Σ is ium function, a is the black hole's angular momentum, θ_0 is the cylinder's totational speed, ω_0 is the cylinder's rotati-

Numerical Simulation

To numericaly simulate a black hole, we couuld use numerical methods such Monte Carlo s

Conceptual Design

- Main Structure: A hollow cylinder with a diameter of about 10 meters and a length of around 20 m
- Black Hole Metrics: Intense magnetic fields wuldbe generated using copper colls or superconductors.
- Design Similar to Solar Parker: Solar panels and a propulsion system similar to the Solar Parker would be high, requiring



(a) Schwarzschild

(b) Kruskal-Szekeres

```
Plasma Control Reactor Core - PCGCR          |
+----------------------------------------------------------+
| 1. Plasma Injection from Stellar Source                  |
| 2. Magnetic Containment Coils Activated (Toroidal)        |
| 3. Plasma Density and Temperature Sensors Initialized     |
| 4. Stabilization Feedback Loop (Electromagnetic Pulse)    |
| 5. Energy Extraction Interface (Thermoelectric Modules)   |
+----------------------------------------------------------+



# Modelo de curvatura artificial mínima
import numpy as np

# Tensor de Riemann simulado en formato 4x4x4x4
riemann_tensor = np.zeros((4,4,4,4))
```

```
# Suponemos que el plasma genera curvatura en las direcciones espaciales
# Añadimos perturbaciones simuladas
riemann_tensor[0,1,0,1] = 1e-15  # Tiempo-espacio x
riemann_tensor[0,2,0,2] = 1e-15  # Tiempo-espacio y
riemann_tensor[0,3,0,3] = 1e-15  # Tiempo-espacio z

print("Riemann Tensor Components (simulated):")
print(riemann_tensor)

# Plasma Control Reactor Core - Simulation

# Step 1: Initialize plasma properties
plasma_temperature = 1e7  # Kelvin
plasma_density = 1e20     # particles/m^3

# Step 2: Magnetic Field Initialization
magnetic_field_strength = 5.0  # Tesla

# Step 3: Feedback control loop to maintain stability
while plasma_temperature > 5e6:
    # Sensor reads
    current_density = plasma_density
    current_temperature = plasma_temperature

    # Magnetic field adjustment based on sensors
    if current_temperature > 1e7:
        magnetic_field_strength += 0.5  # Strengthen containment
    elif current_temperature < 6e6:
        magnetic_field_strength -= 0.2  # Relax containment

    # Simulate plasma cooling and stabilization
    plasma_temperature *= 0.99  # Small cooling per cycle
    plasma_density *= 0.999     # Minor particle loss

    # Energy extraction simulation
    extracted_energy = plasma_temperature * plasma_density * 1e-12  #
arbitrary units

    # Display reactor status (compact txt print)
    print(f"Temp: {plasma_temperature:.2e} K | Density:
{plasma_density:.2e} | Field: {magnetic_field_strength:.2f} T | Energy
Extracted: {extracted_energy:.2e}")

print("Plasma stabilized. Energy extraction at steady rate.")


2nd model:     [Superconducting Magnets]
    +-----------------------+
    |       Plasma Core      |
    |   (Hydrogen/Helium)     |
```

```
    |      [High Temp]          |
    |  Magnetic Containment    |
    |    Dynamic Sensors        |

[Superconducting Magnets]
    +-----------------------+
    |        Plasma Core       |
    |   (Hydrogen/Helium)      |
    |      [High Temp]          |
    |  Magnetic Containment    |
    |    Dynamic Sensors       |
    +-----------------------+
            ||||||
            ||||||
         [Plasma Exhaust]
            ||||||
      [Energy Capture Units]
          /          \
   [Thermoelectric]  [Radiation Pressure Capture]
          \          /
        [Control Core]
    [Sensors + AI Algorithms]
          ||||||||
         [Power Regulator]
```

Basic Description:

- **Superconducting magnets** create a magnetic field to confine the plasma without touching any walls.
- **Plasma Core** holds the ultra-hot plasma (100–150 million °C).
- **Dynamic Sensors** predict plasma instabilities in real time.

OBSERVATIONS OF ANGULAR VELOCITY *And Observer, far from a black hole and at rest in the hole's asymptotic Lorentz frame, watches (with his eyes) as a particle moves along a stationary (non geodesic) orbit near the black hole. Let II =dep/dt be the particle's angular velocity, as defined and discussed above. The distant observer uses his stopwatch to measure the time required for the particle to make one complete circuit around the black hole (one complete circuit relative to the distant observer himself; i.e., relative to the hole's asymptotic Lorentz frame).*

Variables represented for some of computational materials are:
u is the particle's 4-velocity, and a "'uu is its 4-acceleration.) The geodesic equation, a =0, for the uncharged case is equivalent to Hamilton's equations dp,/dA. =-oX/oxlJ., where A. is an affine parameter so normalized that d/dA. =p =4-momentum

E ("energy at infinity")-'1Tt =-(Pt + eAt)*, (Lz "axial component ofangUlar) momentum", or simply "angular momentum" for the constants of the motion-'1Tt and '1Tq,' '1Tq, = Pq, + eAq, A third constant of the motion is the particle's rest mass.*

Constants: p2 dO/dA. = ve: p2 dr/dA. = VR, p2 dcf>/dA. =-(aE- Lz/sin20) + (a/J)P, p2 dt/dA. =-a(aEsin20- Lz) + (r2 + a2)J-Ip.

Photon: .t = 0 (zero rest ma~s~photon!-.. e = 0 (zero charge on photon), Lz =aEsin20 a permissible value for Lz) (only because dO/dA. turns , out to be zero

r =- EA,
0 = const,

NULL GENERATORS OF HORIZON

Kerr coordinates the outgoing principal null congruence is described by the tangent vector dO dA =0, dr dA = E, d~ E dA =2a""J"

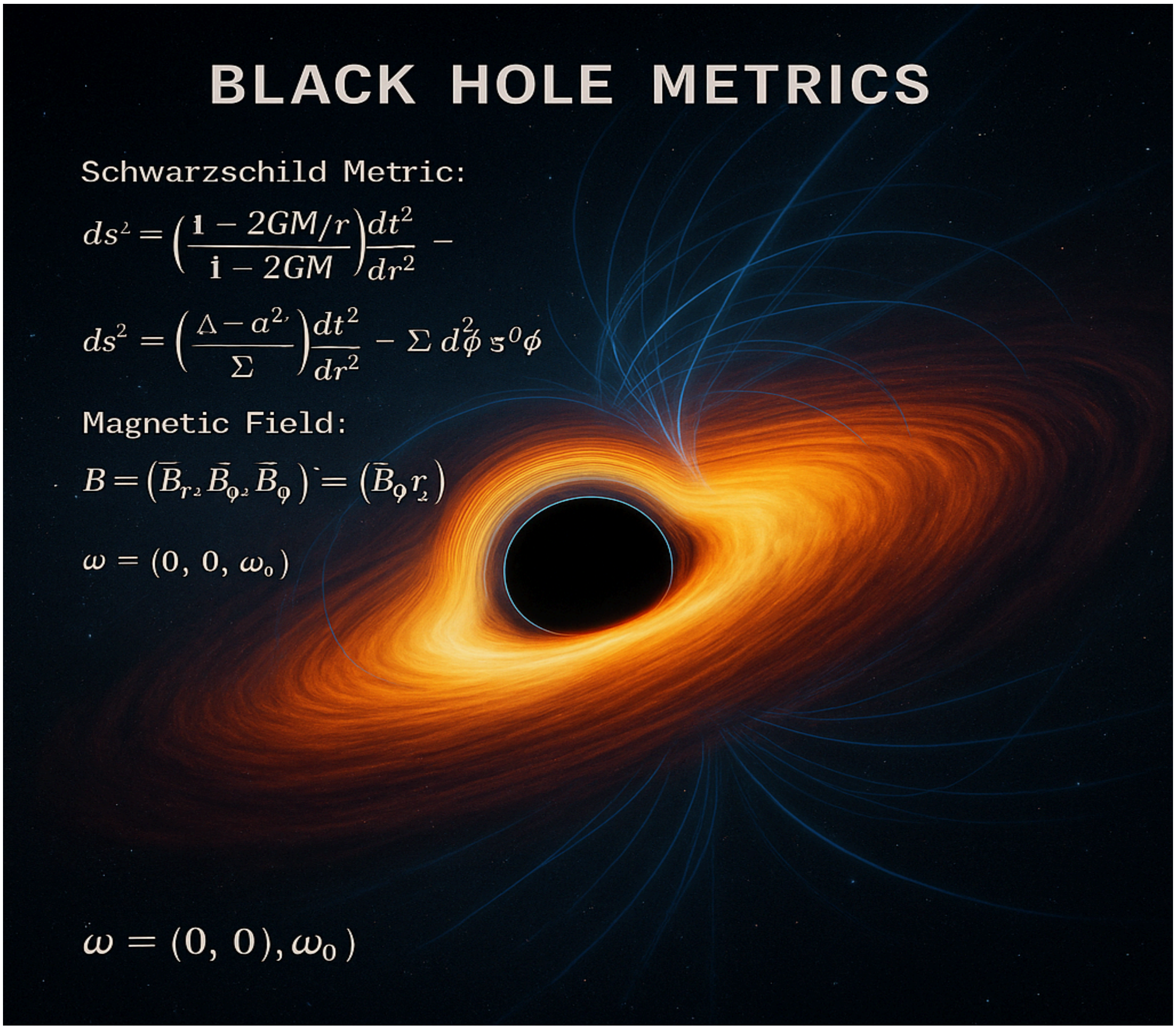
(energy emitted per circuit) (rest mass of object) (rest mass of object) (mass of hole)

JM=E =("energy at infinity" of falling object), JQ =e =(charge of falling object), LiS (33.49a) (33.49b) JI51 =L =(component of object's angular momentum). (33.49c) z on black hole's rotation axis Y.

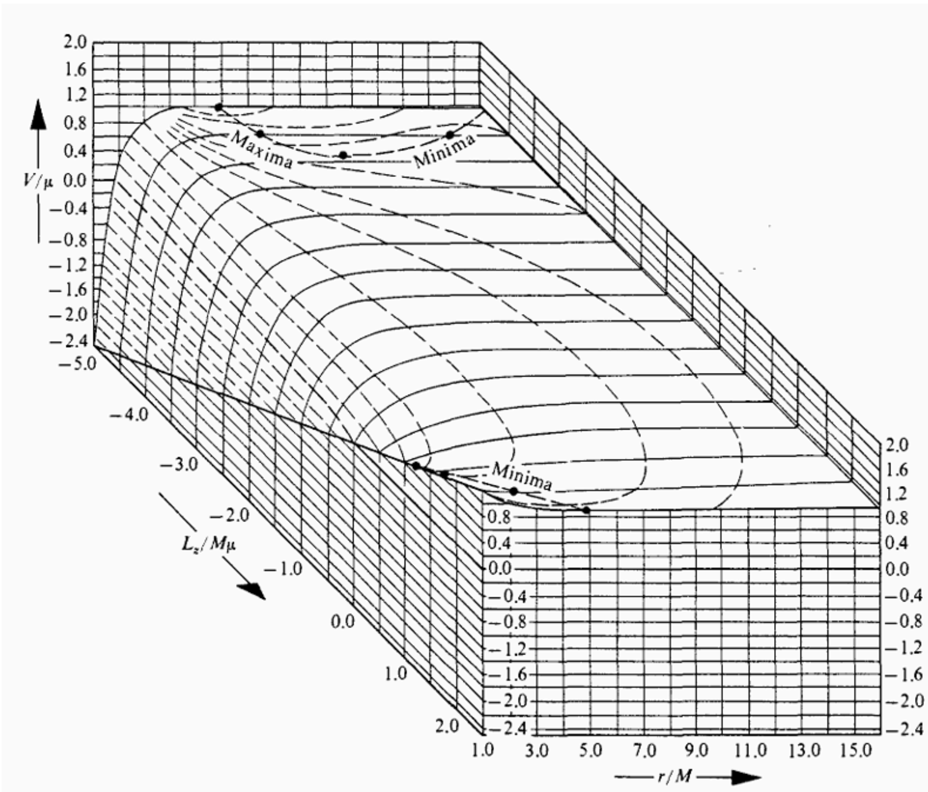
JM= fall *inward past themselves minus total energy that they see reemerge =EA- Ee· Similarly, JQ = eA-ee and JS =LZA- L.,e. Notunexpectedly, these changes can be written more simply in terms of the constants of motion for object B, which went down the hole. View the explosion "A ~ B + C" in a local Lorentz frame down near the hole, which is centered on the explosive event. As viewed in that frame, the explosion must satisfy the special relativistic laws of physics (equivalence principle!). In particular, it must obey charge conservation and conservation of total 4-momentum.*

Theory of explosion:

Moreover, conservation of4-momentum P and charge e implies also conservation of generalized momentum n p- eA, nA =PA- eAA =PB +Pe- (eB+ ee)A =nB+ ne; and hence also conservation of the components of generalized momentum along the vectors a/at and a/oet>, LZA EA-'1TtA =-'1TtB- '1TtC = EB+ Ee, '1T¢B + '1Tq,e = LZB + Lze' (33.50b) (33.50c) (conservation of"energy-at-infinity" and "axial component of angular momentum" in explosion).



JM= for all objects which cross the horizon-with ( ) E evaluated for each object at event of crossing JQ = (Similar sum, ofcharges, e, fOr) all objects crossing horizon J ' (Similar sum of axial components of angular) S = momentum, Lz ' for all objects crossing horizon .



Script: Artificial Black Hole or Artificial Gravity System

*An advanced civilization has constructed a rigid framework around an **artificial black hole** (or a compact object generating **artificial gravity**) and has built a huge city on that framework.*
Each day, trucks carry one million tons of garbage out of the city to the garbage dump.
At the dump, the garbage is shoveled into shuttle vehicles, which are then, one after another, dropped toward the center of the artificial black hole.

Dragging of inertial frames whips each shuttle vehicle into a circling, inward-spiraling orbit near the artificial event horizon.

FLAT SPACETIME IN y, ~, e, ep COORDINATES

Section: Flat Spacetime in y, ~, e, ep Coordinates

(b) Show the location of the regions [+, [-, [0, and 1- of flat spacetime:

$[+] : y = \pi, \sim = 0$
$[-] : y = -\pi, \sim = 0$
$[0] : y = 0, \sim = \pi$
$[1+] : y + \sim \approx \pi$, with $-\pi < y - \sim < \pi$
$[1-] : y - \sim \approx -\pi$, with $-\pi < y + \sim < \pi$

(Refer to equations) variables/points

(c) In flat spacetime, on a (y, ~) coordinate diagram (Figure 34.2):

- *Radial null lines make angles of 45° with the vertical axis.*
- *Nonradial null lines make angles of less than 45°.*

SCHWARZSCHILD SPACETIME IN y, ~, e, ep COORDINATES

Section: Schwarzschild Spacetime in y, ~, e, ep Coordinates

(a) Derive equations (34.3c, d) from (34.3a, b) and the Kruskal-Szekeres equations

(b) Using equations (34.3), justify the precise form of the coordinates

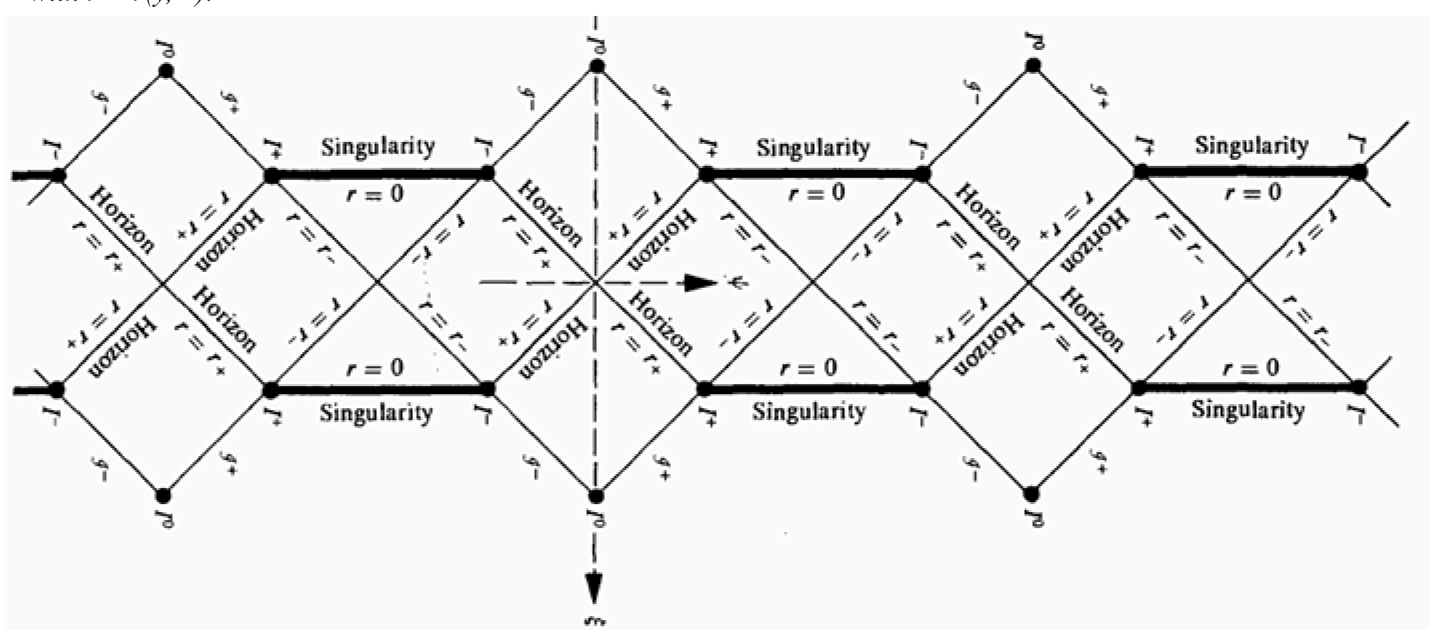
Examples: REISSNER-NORDSTRÖM SPACETIME

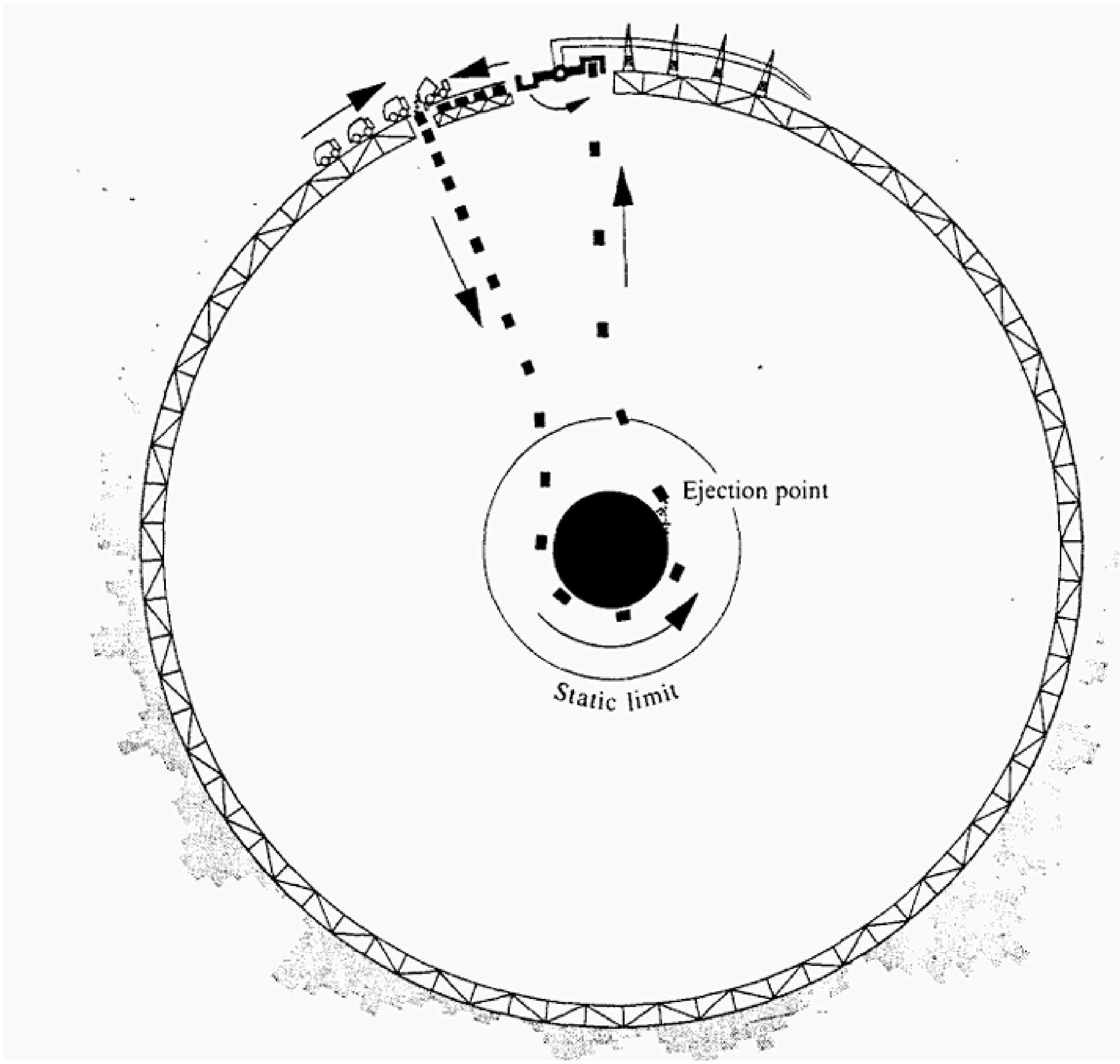
Section: Reissner-Nordström Spacetime

(a) Show that a coordinate system exists where the Reissner-Nordström geometry (for $0 < |Q| < M$) has the form:

$$ds^2 = F^2(-dy^2 + d\sim^2) + r^2(de^2 + \sin^2 e\, dep^2),$$

with $r = r(y, \sim)$.





Causal Structure:
The causal structure reveals the abilities of various regions to communicate with each other through the coordinate diagram.

References for Detailed Discussion:
- Graves and Brill (1960)
- Carter (1966b)

References for Collapsing Charged Stars:
- Novikov (1966a, 1966b)
- de la Cruz and Israel (1967)
- Bardeen (1968)

Section II: Causality and Horizons

Definitions:

Definition: $q > \chi$ *or equivalently* $\chi > q$
"The event q precedes the event χ" or "the event χ follows the event q"
Meaning: There exists at least one smooth, future-directed timelike curve that extends from q to χ.

Definition: Causal Curve
A causal curve $\gamma(\lambda)$ *is any smooth curve that is nowhere spacelike; it is timelike or null or "zero"* ($\gamma(\lambda)$ = *some fixed q for all* λ) *or some admixture thereof.*

Definition: $q \mathrel{-\!\!<} \chi$ ***or equivalently*** $\chi \mathrel{>\!\!-} q$
"The event q causally precedes the event χ" or "the event χ causally follows the event q"
Meaning: There exists at least one future-directed causal curve that extends from q to χ.

Definition: $J^-(q)$
The causal past of q is the set of all events that causally precede q.

$$J^-(q) = \{\chi \mid \chi \mathrel{-\!\!<} q\}$$

Definition: $J^+(q)$
The causal future of q is the set of all events that causally follow q.

$$J^+(q) = \{\chi \mid \chi \mathrel{>\!\!-} q\}$$

Definition: $J^-(S)$
If S is a region of spacetime (e.g., a segment of a spacelike hypersurface), then $J^-(S)$ *is the set of all events that causally precede at least one event in S.*

$$J^-(S) = \{\chi \mid \chi \mathrel{-\!\!<} q \text{ for at least one } q \in S\}$$

Definition: $J^+(S)$
Similarly, $J^+(S)$ *is the set of all events that causally follow at least one event in S.*

$$J^+(S) = \{\chi \mid \chi \mathrel{>\!\!-} q \text{ for at least one } q \in S\}$$

Definition: $\partial J^+(S)$
$j^+(S)$ *is the boundary of* $J^+(S)$.

Definition: $\partial J^-(S)$
$j^-(S)$ *is the boundary of* $J^-(S)$.

Future and Past (Non-Causal Definitions):

Definition: $I^+(q)$, $I^-(q)$, $I^+(S)$, $I^-(S)$

These are defined in the same manner as J^+ and J^-, but replacing "causally precede" with "precede" and "causally follow" with "follow".
Example:
  $/^+(S) = \{\chi \mid \chi \sim q$ *for at least one* $q \in S\}$

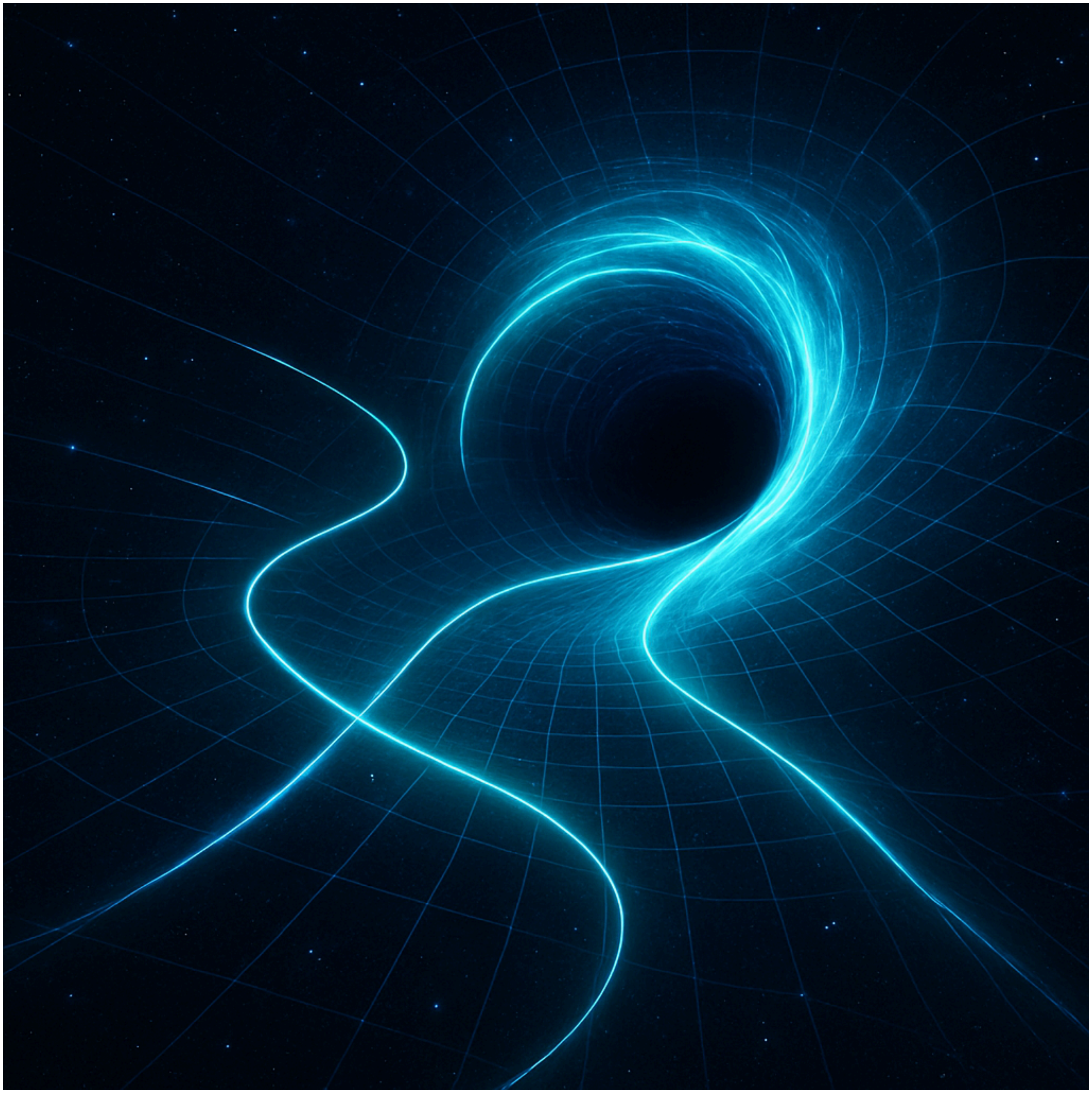
Notes:

- Not all of these definitions are strictly needed here, but they are extensively used in the literature on global methods.
- Focus is given to a specific spacetime manifold and a specific asymptotically flat region.
- In the external field of a star: one asymptotically flat region.
- In Schwarzschild vacuum geometry: two asymptotically flat regions.
- In Reissner-Nordström geometry without source: infinitely many asymptotically flat regions.

Asymptotically Flat Region Properties:

- One future timelike infinity: $/^+$
- One past timelike infinity: $/^-$
- One spacelike infinity: $/^0$
- One future null infinity: $\mathcal{I}^+$
- One past null infinity: $\mathcal{I}^-$
- Black holes may be present, forming future horizons separating the external universe from black-hole interiors.

```
-- Lemma: Let t'(A) be a causal curve that intersects j-(1+) at some
event !'E. Then when followed into the past from qs, 8(A) forever lies
in j-(1+) U J-(1+).
-- Proof:
-- 1. Pick an arbitrary event d on t'(A), with d-< 0'3.
-- 2. Construct an arbitrarily small neighborhood :9[[(f].
-- 3. A small deformation of 8, between d and !'E, produces a timelike
curve oj) from some event tJ' E ~[d] to ~.
-- 4. Since qs E j-(1+), a slight deformation of (7), keeping it still
timelike, produces a curve 0 from tJ' to some event !2 E J-(1+). 0 can
then be prolonged, remaining causal, until it reaches 1+. The result
is a causal curve from tJ' to 1+. Hence, tJ' EJ-(1+).
-- 5. But tJ' was in an arbitrarily small neighborhood :9[[(f]. Hence,
(f must also be in J-(1+) or else in its boundary, j-(1+). Q.E.D.
```



Summary: “Visionary Example: Harnessing Solar Plasma Through Advanced Dynamics”

Imagine a future where solar plasma extraction becomes one of humanity's leading energy sources. A specialized spacecraft is deployed, equipped with a suite of tools designed to utilize fluid equations and wave representations for precision plasma manipulation. Here's how the foundational physics can inspire such a revolutionary idea:

The Dynamics of Electron Behavior in Plasma Extraction

In the outer solar atmosphere, electrons naturally move away from high-density regions, leaving behind ions. The resulting positive charge generates an electrostatic field $E=\nabla\phi$E = \nabla \phi, where ϕ\phi indicates the potential distribution. To extract plasma efficiently, the spacecraft dynamically balances forces: the electrostatic force F_EF_E neutralizes the pressure-gradient force F_pF_p. This equilibrium stabilizes plasma flows toward the collection modules.

By leveraging the plasma approximation, where $n_i=n_e=n$n_i = n_e = n, the spacecraft bypasses the need for Poisson's equation, focusing instead on electron and ion dynamics. This approach ensures effective collection without disrupting quasineutrality.

Wave Manipulation for Plasma Stabilization

Once captured, plasma oscillations are regulated using principles derived from wave theory. Periodic density motions are decomposed into sinusoidal oscillations using Fourier analysis:

```
n=nexp(ik·r−ωt),n = n \exp(i \mathbf{k} \cdot \mathbf{r} - \omega t),
where k\mathbf{k} is the propagation constant. Utilizing phase
velocity equations:
vϕ=ωk,v_\phi = \frac{\omega}{k},
```

The spacecraft optimizes its magnetic fields to ensure stable wave patterns, allowing plasma storage modules to retain high-energy particles. Wave amplitudes, including electric field oscillations represented as $E=E\cos(kx-\omega t+\delta)$E = E \cos(kx - \omega t + \delta), adjust dynamically to ensure uniform plasma density during transport.

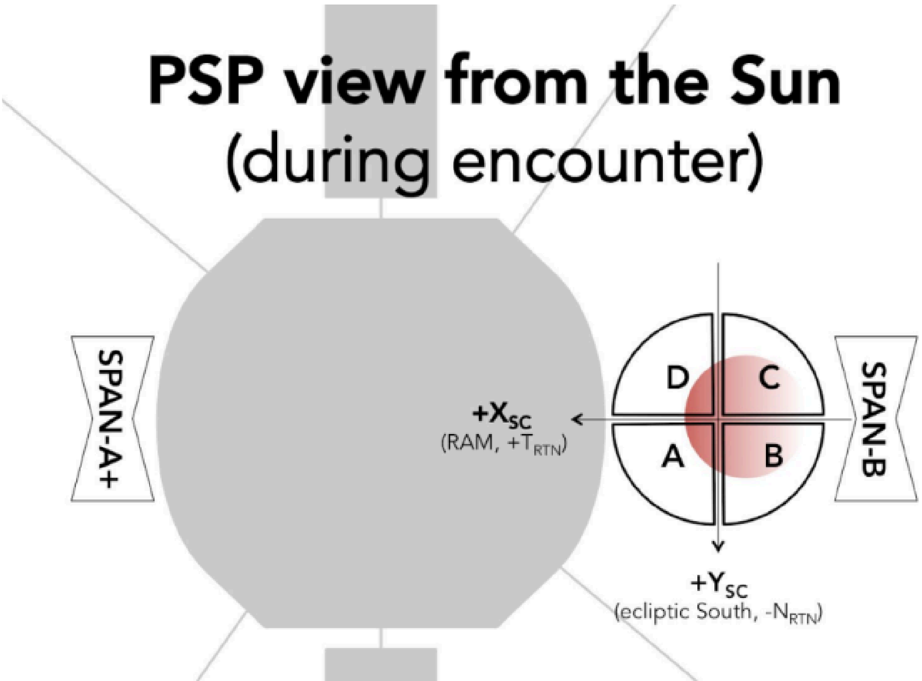
Applications and Visionary Potential

1. *Energy Creation: Harnessing plasma waves and employing diamagnetic drift mechanics, the collected plasma is stabilized for efficient conversion into energy. This process mirrors controlled fusion reactors but operates on a solar scale.*
2. *Exploration and Protection: Advanced insights into solar wave behaviors, derived from field equations, enhance predictive models for solar flares. This knowledge helps safeguard satellites and interplanetary missions from energetic disruptions.*

A Future Powered by Stars

Through the marriage of plasma physics and visionary engineering, humanity could unlock the potential of solar plasma for energy and scientific progress. By understanding forces, wave motions, and the plasma approximation, we transform the Sun into a partner in sustaining our world.

The inertial RTN frame(data)
This is a version of the Radial-Tangential-Normal heliospheric reference frame, which is widely used for interplanetary missions (e.g. Voyager, Helios, Ulysses, STeREO). This is a cartesian frame in which it is convenient to express the local velocity and magnetic field vectors.



The PSP Spacecraft frame

The Parker Solar Probe observatory reference frame is oriented such that the heat shield normal points along +Z and the solar panels deploy along the Y-axis. The Solar Probe Cup The instrument is situated on the -X side of the heat shield. The Solar Probe Analyzers A and B are situated on the +X and -X sides of the spacecraft bus, respectively.

In encounters, the RAM direction of the spacecraft is in the +X direction.

Variables to measure instabilities in the solar parker probe:

For a typical measurement variable the actual measurements are found in the "DAT" field.

- DEPEND_0 indicating the independent variable to which measurements are referenced (i.e. the epoch time variable)
- FILLVAL indicating a value reserved to signify that no measurement was made (commonly the floating point NaN value or -1e31 is used)
- UNITS indicating the measurement units
- VALIDMIN and VALID MAX indicating the range of valid values that the measurement can take
- VAR_NOTES containing descriptive or explanatory text
- DELTA_PLUS_VAR and DELTA_MINUS_VAR indicating the dependent variable(s), or values, containing the corresponding measurement uncertainties

Solar Probe Cup (SPC) Data

"These data are found at /pub/data/sci/sweap/spc. Efforts have been made to distill all exceptional conditions that can affect normal data analysis into the "GENERAL_FLAG" variable, which can be found in all of the l3i files. In all data quality flags, a value of 0 signifies "good/no

condition present". In this version, all data are organized as time series such that the set of time points, EPOCH.DAT, is the same in l2i and l3i for a given date"

Compute another solar parker probe variables in Python/Matlab;

```
n{p,p1,a,3} _fit, the number density
● n{p,p1,a,3}_fit_deltahigh, the estimated upper uncertainty on the
number
density
● n{p,p1,a,3}_fit_deltalow, the estimated lower uncertainty on the
number density
● w{p,p1,a,3}_fit, the thermal speed fit. Equal to sqrt(2kT/m).
● w{p,p1,a,3}_fit_deltahigh the estimated upper uncertainty on the
proton thermal
speed
● w{p,p1,a,3}_fit_deltalow the estimated lower uncertainty on the
proton thermal
speed
● v{p,p1,a,3}_fit_SC, v{p,p1,a,3}_fit_RTN, the velocity vector,
estimated from the
radial thermal speed fit and flow angle
● v{p,p1,a,3}_fit_SC_deltahigh, v{p,p1,a,3}_fit_RTN_deltahigh, the
velocity
vector component upper uncertainties
● v{p,p1,a,3}_fit_SC_deltalow, v{p,p1,a,3}_fit_RTN_deltalow, the
velocity vector
component lower uncertainties
```

SPAN Electron
This data is found on the website under /data/spa for SPAN A electron data and data/spb directory for the SPAN B electron data. Of particular note in all data files. **Visionary Example: Unleashing the Power of Solar Switchbacks for Dynamic Energy Solutions**

Imagine a spacecraft equipped with groundbreaking technology designed to harness the energy potential of solar switchbacks—those abrupt and powerful reversals in solar wind magnetic fields and velocities. These fascinating structures, which were observed during missions like the Parker Solar Probe, are not just natural phenomena but untapped energy sources. Here's a futuristic vision for how these switchbacks could revolutionize our understanding of the Sun and lead to transformative energy solutions.

1. The Physics of Switchback Dynamics

Switchbacks occur when the magnetic field rapidly changes direction while the solar wind speed dramatically increases—sometimes doubling the local Alfvén speed VAV_A. For example:

- **Magnetic Field Rotation:** Almost full reversals of the radial magnetic field BRB_R, maintaining a steady magnetic field intensity ∣B∣|B|.
- **Velocity Surges:** Proton bulk speeds jump from approximately 300 km/s to 600 km/s, showcasing bursts of kinetic energy.

These phenomena provide direct insights into solar wind turbulence and plasma behavior, which could be exploited for energy extraction or advanced research.

2. Harnessing Switchbacks for Energy Collection

Imagine a spacecraft equipped with advanced plasma collectors and magnetic confinement systems specifically tailored to capitalize on switchback events:

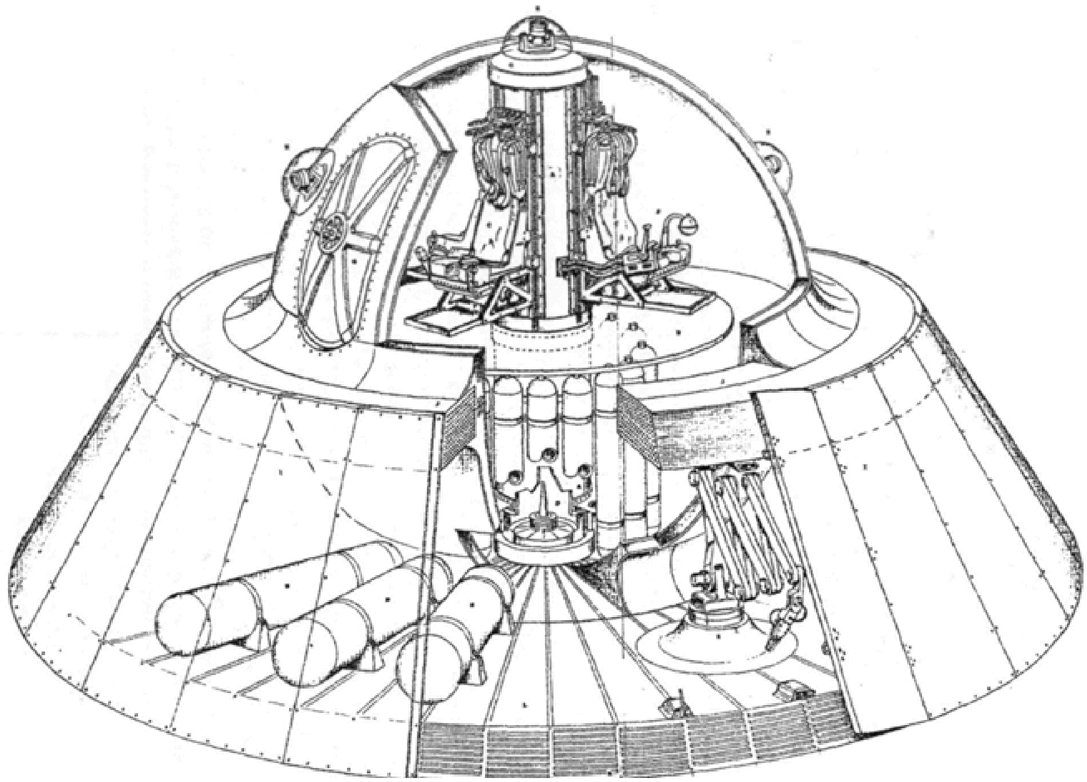
- **Energy Conversion Systems:** Using the phenomenological relation Vp=V0+VA[1±cosθBR]V_p = V_0 + V_A[1 \pm \cos \theta_{BR}], the spacecraft predicts and captures velocity surges inside switchbacks. By converting the kinetic energy of accelerated protons into stored energy, the spacecraft creates a renewable energy reservoir.
- **Localized Extraction:** Close to the Sun, where VAV_A approaches 200–300 km/s, the spacecraft captures higher-energy bursts, maximizing efficiency.

3. Advanced Instrumentation for Switchback Detection

The spacecraft incorporates instruments inspired by the Parker Solar Probe's suite:

- **Magnetometers:** Real-time measurements of magnetic field reversals and radial velocity jumps for precise switchback tracking.
- **Dynamic Plasma Monitors:** In situ observation of proton core behaviors and particle interactions, revealing the localized impact of switchbacks on solar plasma streams.

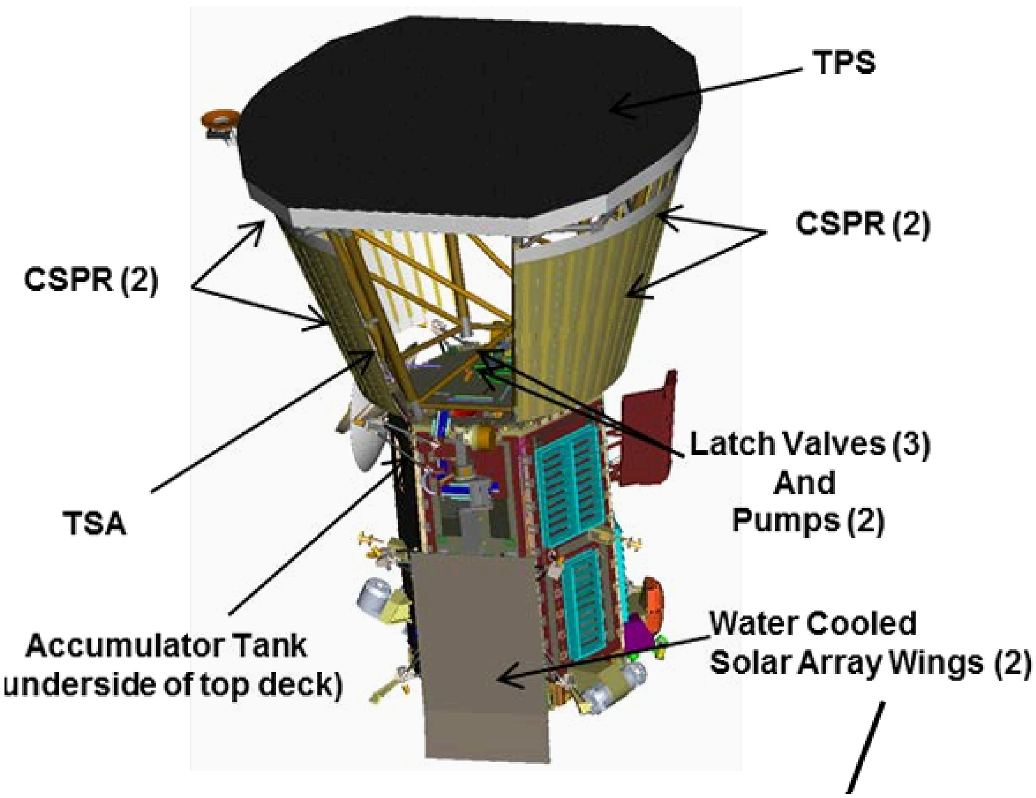
The SPRF-X1 represents humanity's leap into understanding and utilizing one of the Sun's most dynamic phenomena. By transforming switchbacks from enigmatic structures into powerful tools for research and energy collection, this visionary spacecraft paves the way for interstellar exploration and sustainable solar power solutions.



Electrogravitic Craft Demonstration unit (Norton AFB, 1988),26 can also be explained with the electrokinetic force, in the same way that the Brown gravitator force was explained in paragraph (2) above. The current flows in one direction through the capacitor-dielectric and the force is produced in the opposite direction. The Norton AFB electrogravitic craft just has bigger plates with radial sections but the current flow still occurs at the center, across the plates. The Serrano patent diagram is also very similar in construction and operation. Campbell's NASA patents.

We note that the current is presumed to be the same in each plate but in opposite directions because it is alternating. Using E = - ∂A/∂t, Jefimenko calculates the electrokinetic field, for the AC parallel plate capacitor with current going in opposite directions, as E = μ − k ∂ ∂ t I w x o j (3) where j is the unit vector for the y-axis direction seen in Fig. 3. It is clearly seen that the y-axis points upward in Fig. 3 and so with the minus sign of Eq. 3, the electrokinetic force for the AC parallel plate capacitor will point downward. Since Zinsser had his torsion balance on display in Toronto in 1981, I was privileged to verify the direction of the force that is created with his quarter-wave plates oriented as they are in Fig. 2. The torsion balance is built so that the capacitor probe can only be deflected downward from the horizontal. The electrokinetic force is in the same direction.

For parallel plate capacitor impulse probes, like Zinsser, Serrano, Campbell, the Norton AFB craft and both of Brown's models, the electrokinetic field of Eq. 3 provides a working model that seems to predict the nature and direction of the force during charging and discharging phases . More detailed information is needed for each example in order to actually calculate the theoretical electrokinetic force and compare it with the experiment. We note that Eq. 3 also does not suffer the handicap of Eq. 1 since no c2 term occurs in the denominator. Therefore, it can be concluded that AC fields operating on parallel plate capacitors should create significantly larger electrogravitic forces than other geometries with the same dI/dt.

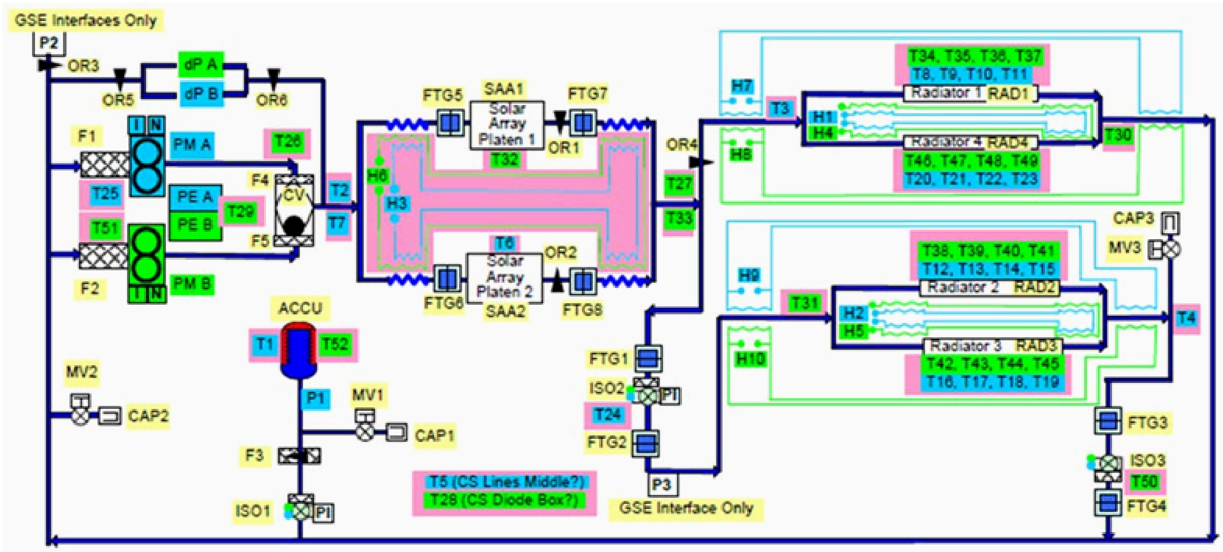


Designed for 6400 W cooling system capacity at 9.86Rs – Water pumped through solar array wings into cooling system primary radiators (CSPR) to dissipate heat. – Single loop, redundant pump and control electronics – Cooling system operating temperature determined by solar distance, spacecraft pointing, solar array angle, pump speed (2 speed)

- **Operating temp: +20C to +150C**

- **Survival temp: +10C to +190C**

- Survival dry: platen: -80C, CSPR: -130C – Thermal design drivers Hot (SS) Cold (SS) – 9.86Rs – max cooling system load (4AR) – Communication 45deg slews (4AR) – 0.82 AU Umbra (4AR) / 1.02AU (2AR & 4AR) Cold (Tran) – Venus eclipse – Launch, post launch activation – R23 Activation (L+41)



Design verification:

C-1 Cold Case A2: Measure Steady Temperature with two radiators active and compare against expected heat loading 933 W to verify fin blanketing and to determine if additional mli is needed. This configuration dictates fin mli sizing due to expected worst case SA waste heat at 1.02 AU (933 W)

- C-1 Cold Case B2: Measure Steady Power at 15 C with four radiators active with fin mli in place. This case determines the minimum four active radiator heat load and quantifies R23 slewing during flight operations

- **C-1 Hot Case B6 (No TPS):** Quantify SACS EOL capacity at 125 C with fin MLI in place. Defines the new required capacity (spec/no fin mli is 6400 W)

- **C-2 Hot Case B6 (No TPS):** Quantify the SACS power at 125 C without patens

- C-2 Hot Case C6 (TPS @ 300 C): Quantify the SACS power at 125 C. The difference from the previous case is the TPS loading into the SACS

- C-1 Critical transient simulation Cases A0, B01, B02: Post launch warm up, R23 activation and Venus eclipse. All used as predicted worst case heat loads

• The test and flight solar-array platens are fabricated from diffusion bonded CP Grade-4 titanium and utilize identical internal mini-channels geometry to collect the waste heat from the solar cells (or heaters). The mini-channel design is different for the secondary and primary segments to minimize pressure drop during maximum flow.

• The short secondary segment (254 mm in length) uses a small-diameter densely packed mini-channel design that efficiently removes the waste heat when at the highest flux; however, this comes with a pressure-drop penalty. To reduce the pressure-drop penalty, the primary segment (864 mm in length)

C-1 Cold Case A2: From the results, for 934 W of thermal input, the SACS water temperature was measured to be 14°C.

Because the desired water temperature is~18°C with 933 W of thermal input, the MLI coverage will be increased to 0.63 m2 based on the correlated thermal model

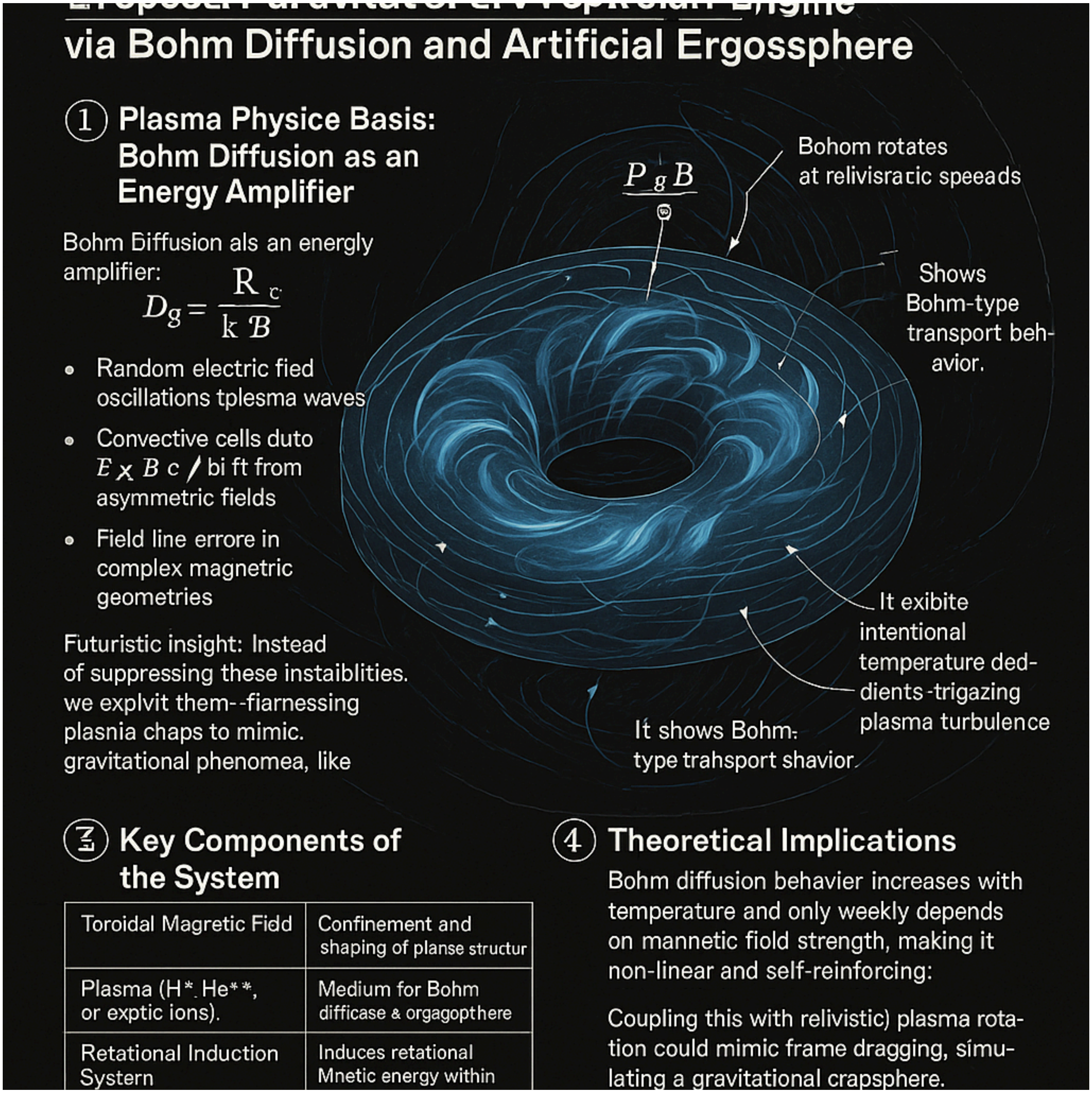
• C-1 Cold Case B2: From the results , for 1720 W of thermal input, the SACS water temperature was measured to be 19°C

• C-1 Hot Case B6 (No TPS): From the results, for 6153 W of thermal input, the SACS water temperature was measured to be 125°C (spec/no fin mli is 6400 W) and pre-test budget carried 5900 W as the max capacity

• C-2 Hot Case B6 (No TPS): 4612 W / 125 C SACS • C-2 Hot Case C6 (TPS @ 300 C): 4037 W / 124 C SACS (300 C TPS simulator); Heat flow into SACS from TPS measured to be 575 W (533 W estimated in the budget)

• C-1 Critical transient simulation Cases A0, B01, B02: All critical transients were nominal and without any issues.

The successful ITVT provided verification that the SACS subsystem performed as expected over a broad range of active radiators, temperatures, input power, and transient responses, both thermal and electrical.



5.9 | Quantum Diffusion Structures in Black Hole Propulsion Systems

Time Dependence:

We separate variables by defining:

$$n(r, t) = T(t) \cdot S(r)$$

Which transforms the diffusion equation into:

$$(1/T^2)\cdot(dT/dt) = (A/S)\cdot(\nabla^2 S^2) = 1/\tau \qquad \text{(Eq. 5.103)}$$

τ^{-1} is the separation constant.

Temporal solution:

$$1/T = (t/T_0) + \tau \qquad \text{(Eq. 5.104)}$$

At large $t \to \infty$, the plasma density decays as:

$$n(t) \propto 1/t$$

This inverse-time decay models classical diffusion of fully ionized plasma—analogous to particle fields diffusing from the event horizon.

5.9.2 | Time-Independent Solutions: Cylindrical Plasma Columns

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For steady-state plasma (e.g., Q-machine near a black hole's accretion disk), we solve:

$$A\cdot\nabla^2(n^2) = \alpha\cdot n^2 \qquad \text{(Eq. 5.105)}$$

In cylindrical coordinates, the solution is a Bessel function.
In plane geometry:

$$(\alpha/A)\cdot n^2 = d^2n^2/dx^2 \qquad \text{(Eq. 5.106)}$$

With general solution:

$$n^2(x) = n_0^2 \cdot \exp[\, - (\alpha/A)^{1/2} \cdot x \,] \qquad \text{(Eq. 5.107)}$$

Scale length of density falloff:

$$l = \sqrt{(A/\alpha)} \qquad \text{(Eq. 5.108)}$$

A increases with magnetic field strength B; α remains constant.

Note: In Q-machine tests, asymmetric E×B drift introduced losses via convection—limiting conclusive gravitational diffusion results.

5.10 | Black Hole Plasma Equilibrium Scaling Law

For ionized plasma in steady state, sustained by a constant source Q under uniform magnetic field B:

$$A\cdot\nabla^2(n^2) = \eta\cdot kT \cdot \nabla^2(n^2 / B^2) = Q \qquad \text{(Eq. 5.109)}$$

Only the combination (n / B) appears, implying:

Density profile $\propto B^0$ (shape invariant)
Equilibrium density: $n \propto B$ (Eq. 5.110)

Note:
Although perpendicular diffusion $D\perp \propto B^{-2}$,
$D\perp$ is also proportional to $n \Rightarrow$ overall scaling: $n \propto B$

This behavior underpins theoretical propulsion systems exploiting field-dependent plasma behavior near relativistic black hole metrics.

Black holes not only curve space, but also generate theoretical structures such as:

- Potential Technological Structure
- Event horizon: Point of maximum curvature of space-time (possible gravitational focus or lens).
- Ergosphere (rotating): Region where space-time rotates → energy can be extracted (Penrose effect).
- Wormhole necks: Connect distant regions of the universe (if they exist).
- Gravitational lensing regions: Could amplify fields or redirect particle/wave trajectories.

Other ideas- Plasma & Black hole properties: Proposal: *Gravitational Propulsion Engine via Bohm Diffusion and Artificial Ergosphere*

Theoretical foundation: We combine the anomalous transport behavior in plasma physics (specifically Bohm diffusion) with the conceptual emulation of an ergosphere—a relativistic structure found near rotating black holes—using ionized plasma and magnetic/electric fields.

Plasma Physics Basis: Bohm Diffusion as an Energy Amplifier

In controlled fusion devices like stellarators, perpendicular diffusion D⊥D_\perpD⊥ was observed to follow not the classical prediction ∝1/B2\propto 1/B^2∝1/B2, but rather Bohm's empirical law:

DB=116kTeeBD_B = \frac{1}{16} \frac{k T_e}{e B}DB=161eBkTe

This "anomalous" behavior is up to four orders of magnitude greater than classical theory and is thought to result from:

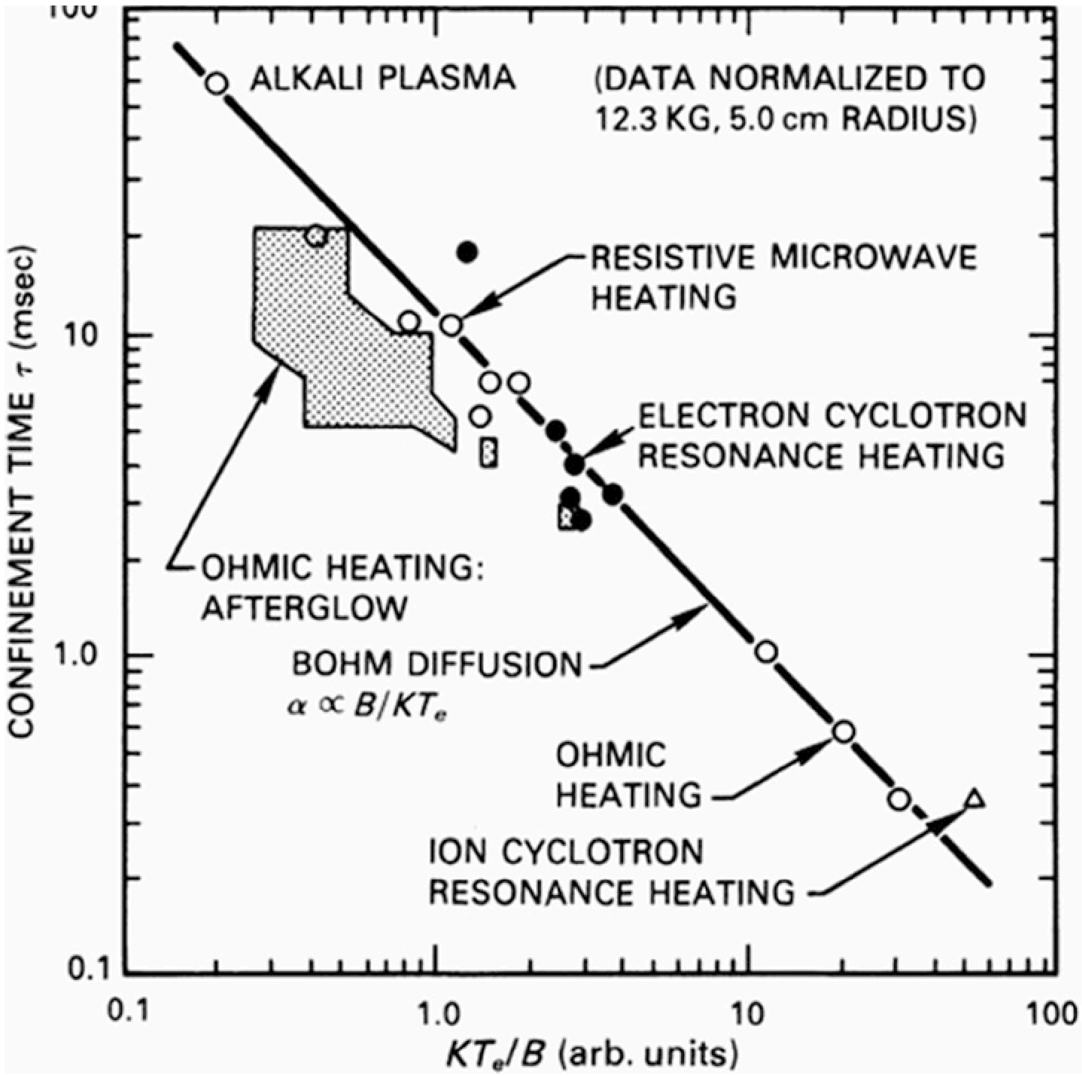
- Random electric field oscillations (plasma waves).
- Convective cells due to E×B\vec{E} \times \vec{B}E×B drift from asymmetric fields.
- Field line errors in complex magnetic geometries.
- mimic gravitational phenomena, like frame-dragging.

The System

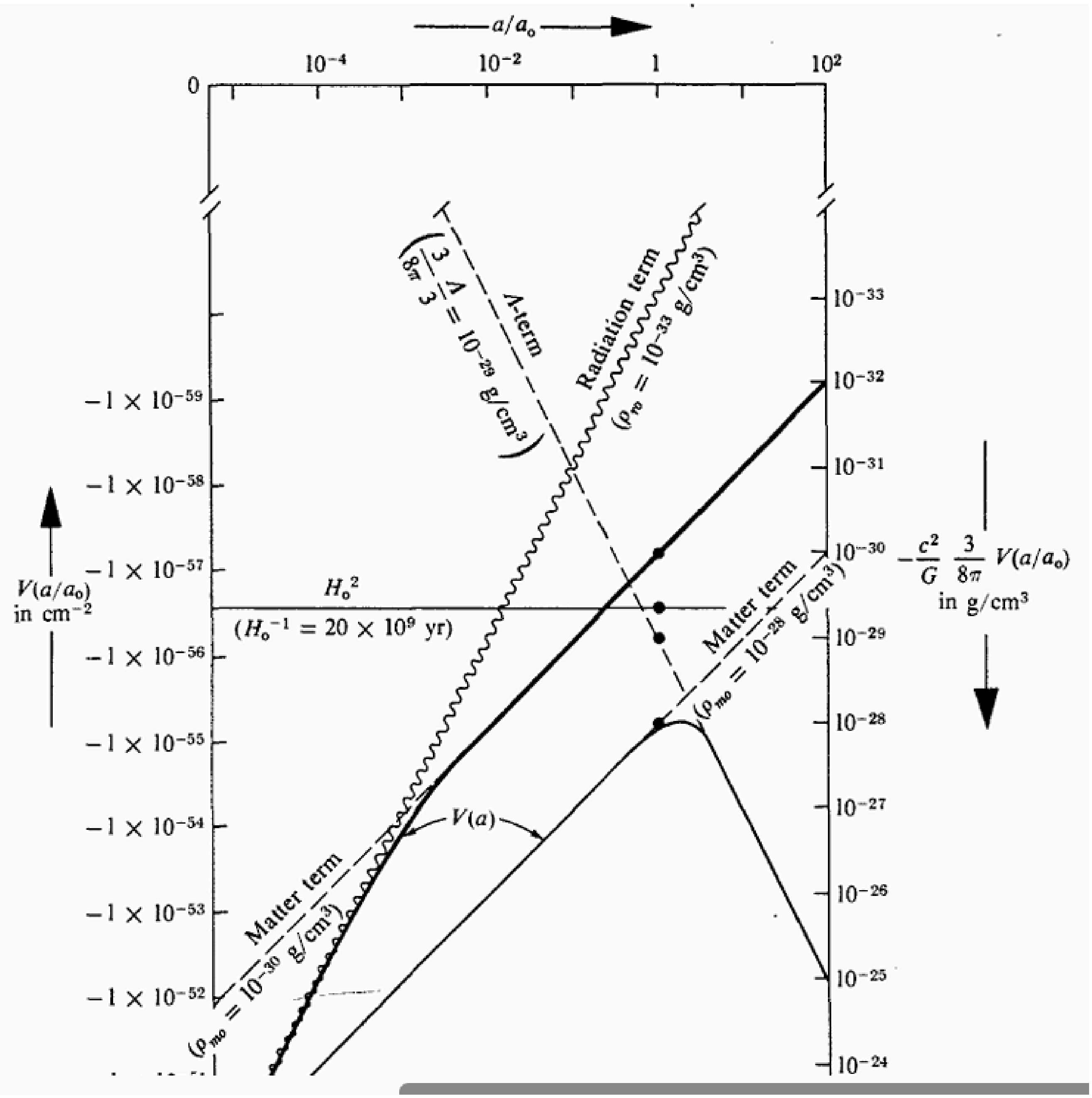
Component	Function
Toroidal Magnetic Field	**Confinement and shaping of plasma structure**
Plasma (H^+, He^{++}, or exotic ions)	**Medium for Bohm diffusion and ergosphere mimicry**
Rotational Induction System	**Induces rotational kinetic energy within plasma**
Electric Field Modulation	**Controlled perturbations to induce Bohm-like diffusion**
Vacuum Chamber with Symmetry Breaking	**Facilitates E×B\vec{E} \times \vec{B}E×B drift and convective cells**
Gravitational Lens Emulator (optional)	**Focus or redirect local spacetime curvature via plasma lensing**

SPHERICALLY SYMMETRIC COLLAPSE WITH INTERNAL PRESSURE FORCES

So far as the external gravitational field is concerned, the only difference between a freely collapsing star and a collapsing, spherically symmetric star with internal pressure is this: that the surfaces of the two stars move along different world lines in the exterior Schwarzschild geometry. Because the exterior geometry is the same in both cases, the qualitative aspects of free fall collapse as described in the last section can be carried over directly to the case of negligible internal pressure. An important and fascinating question to ask is this: can large internal pressures in any way prevent a collapsing star from being crushed to infinite density by infinite tidal gravitational forces? From the Kruskal-Szekeres & the relation with the Fuel pellet injection. The pellet lifetime is the time required for heating the pellet up to the boiling temperature. The path of a 3.5 MeV @-particle in a frozen hydrogen is determined from the ionization losses; it is equal to =lo0 pm [9]. Thus the energy of a-particles = 0.1 n,*J/cm3 is deposited at the surface of a pellet where n, is the a - particle density. As a result, a dense non-ideal plasma is formed. Assuming the transfer of the energy into pellet is achieved by diffusion of radiation, and applying the Kramers formula [IO] for calculation of photon paths one can find t,, = 8,



ALKALI PLASMA
(DATA NORMALIZED TO
12.3 KG, 5.0 cm RADIUS)
RESISTIVE MICROWAVE
HEATING
ELECTRON CYCLOTRON
RESONANCE HEATING
OHMIC HEATING:
AFTERGLOW
BOHM DIFFUSION
$\alpha \propto B/KT_e$
OHMIC
HEATING
ION CYCLOTRON
RESONANCE HEATING
CONFINEMENT TIME τ (msec)
KT_e/B (arb. units)
100
10
1.0
0.1
0.1
1.0
10
100



a/a_o
10^{-4}
10^{-2}
1
10^2
0
Λ-term
$\left(\frac{3}{8\pi}\frac{\Lambda}{3} = 10^{-29}\ \mathrm{g/cm^3}\right)$
Radiation term
$(\rho_{ro} = 10^{-33}\ \mathrm{g/cm^3})$
-1×10^{-59}
-1×10^{-58}
-1×10^{-57}
-1×10^{-56}
-1×10^{-55}
-1×10^{-54}
-1×10^{-53}
-1×10^{-52}
$V(a/a_o)$ in $\mathrm{cm^{-2}}$
H_o^2
$(H_o^{-1} = 20 \times 10^9\ \mathrm{yr})$
Matter term
$(\rho_{mo} = 10^{-28}\ \mathrm{g/cm^3})$
Matter term
$(\rho_{mo} = 10^{-30}\ \mathrm{g/cm^3})$
$V(a)$
10^{-33}
10^{-32}
10^{-31}
10^{-30}
10^{-29}
10^{-28}
10^{-27}
10^{-26}
10^{-25}
10^{-24}
$-\frac{c^2}{G}\frac{3}{8\pi}V(a/a_o)$ in $\mathrm{g/cm^3}$