Cymatic Plasma Confinement and Multi-Frequency Fuel Siphon (Conventional RF Coils)

Executive summary

This system is a plasma fueling and ash-exhaust architecture for the Cognitive Supernova Generator (CSG) fusion–fission hybrid reactor. It uses 122 independently driven RF coil assemblies mounted on a truncated icosahedron (“soccer ball”) shell around the plasma to move different ion species along different field lines based on their ion-cyclotron resonance frequency at a background field of about 5 tesla. Instead of mechanical pellet injectors or a single massive toroidal magnet, the design relies on magnetized ion orbits and 3D standing-wave patterns so that fuel ions naturally accumulate and burn in geometric field nodes while helium ash is continuously directed toward exhaust points.

Coil concept

Each assembly is a compact superconducting toroidal or solenoidal RF coil, using high-temperature superconductor (e.g. REBCO/YBCO) operated near 77 K to carry kiloampere-level currents with minimal resistive loss. Typical operation assumes a static background field $B0 \approx 5B0 \approx 5$ T at the plasma edge, produced by a separate main field system, and RF drive in the ion-cyclotron range of frequencies (ICRF), tens of megahertz. The single-charge ion cyclotron frequency is $fc=qB0/(2\pi m)fc=qB0/(2\pi m)$; for

B0=5B0=5 T this gives approximate bands:

Deuterium (D, m≈2mpm≈2mp): fc≈38fc≈38 MHz

Tritium (T, m≈3mpm≈3mp): fc≈25fc≈25 MHz

Helium-4 (He2+2+ treated as a single-charge equivalent band): effective fc≈19fc≈19 MHz

Lithium-6/7 (Li++ breeder feed): fc≈11fc≈11 MHz

Driving a coil at one of these bands launches RF fields that strongly interact with the matching ion species:

those ions absorb energy, are phase-locked to the wave, and follow tight helical orbits whose guiding centers drift along the local magnetic geometry, while off-resonant ions see much weaker coupling and largely follow the background field. This is the same basic physics used in ion-cyclotron resonance heating in tokamaks and stellarators. In this document the term “vortex” is used only as an intuitive label for the helical streamlines and spiraling ion trajectories in the combined field; the actual hardware is a conventional bank of RF coils, not specialized winding topologies.

122-coil distribution on soccer-ball geometry

The truncated icosahedron shell provides 12 pentagonal faces, 20 hexagonal faces, 60 edges where a hexagon meets a pentagon, and 30 edges where two hexagons meet. This mesh is used as a scaffold for coil placement so that fuel and ash channels align with a highly symmetric 3D pattern.

The CSG fuel-siphon system maps conventional RF coils onto these features as:
Location type Count Ion / function Frequency at ~5 T Role
Hexagon–pentagon edges 60 Deuterium (D) ~38 MHz Primary fuel intake along edge channels

Hexagon–hexagon edges 30 Tritium (T) ~25 MHz Secondary fuel intake; sets natural ~2:1 D:T ratio
Pentagon centers 12 Lithium (Li blanket) ~11 MHz Breeder material injection into the blanket region
Hexagon centers 20 Helium-4 (ash) ~19 MHz Fusion-product exhaust and ash removal

In total 102 coils operate as intake/fueling channels (D, T, Li) and 20 as exhaust channels (He), giving 122 independent RF control points distributed evenly over the spherical shell.

Operating principle
Startup: When the reactor is brought up, the main background field is established and all 122 RF coils are energized at their assigned

frequencies. The superposition of these oscillating fields on the spherical shell creates a spectrum of ion-cyclotron waves which interfere to form a three-dimensional pattern of nodes (minimal oscillation) and antinodes (maximal oscillation) throughout the plasma volume, analogous to cymatic standing-wave patterns on a vibrating plate.

Fuel intake: Magnetized deuterium and tritium ions, injected from external gas feed or recycling systems, encounter the edge coils tuned to 38 MHz (D) and 25 MHz (T). At resonance they absorb RF power and are driven along helical trajectories that spiral inward from the shell toward resonant nodes where the local cyclotron frequency matches the drive. These nodes form overlapping shells of high D and T density in the core region, providing well-mixed fusion fuel without pellets or directional gas jets.

Ash exhaust: Fusion-born alpha particles and thermalized helium-4 ions are magnetized by the same background field. Because their charge-to-mass ratio differs from D and T, they couple more strongly to the ~19 MHz network associated with hexagon-center coils. In steady state, this network is phased to create outward-biased trajectories that guide helium ions away from the core and toward hexagon centers, where magnetic field lines are connected to pumping ducts, divertor structures, or neutralization and recombination systems. This provides continuous helium exhaust to prevent dilution of the fusion plasma.

Lithium feed: Lithium-bearing ions in the breeder blanket region are addressed by the ~11 MHz pentagon-center coils. These coils can bias Li transport toward or away from specific blanket zones, enabling controlled tritium breeding and redistribution of lithium inventory while participating in the same integrated standing-wave pattern as the main fuel coils.

Taken together, these effects produce a quasi-steady “breathing” cycle:

roughly 102 intake coils draw D, T, and Li inward along frequency-selected channels, the standing-wave pattern forms geometric confinement pockets where fusion power is generated, and 20 exhaust coils continuously remove helium ash along outward-biased paths, all using standard magnetized plasma physics and RF technology rather than moving mechanical injection hardware.

Relationship to the CSG core design

The cymatic fuel-siphon system is intentionally matched to the CSG neutronics geometry. The same truncated-icosahedron framework that optimizes tritium breeding and neutron economy in the U-238/Li blanket (validated with OpenMC simulations) is reused here as the mounting structure and symmetry group for the RF coils. This unifies three elements—fusion source, breeding blanket, and plasma fueling/exhaust—into one geometric design so that:

Tritium breeding remains self-sufficient (TBR ≈ 1.25 in the reference model).

Fuel is supplied to the plasma continuously rather than in discrete pellets.

Helium ash is continuously removed to preserve core reactivity.

Plasma stability is helped by passive geometric resonances rather than relying solely on high-gain active feedback.

All of this is implemented with conventional electromagnetic hardware and well-studied ion-cyclotron resonance physics, making the concept compatible with established magnetic-confinement fusion practice while extending it to a highly distributed, 122-coil, 3D configuration.