Black Holes, the Two Copies, and the Fermion Spectrum

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The identifications in §1–§3 are the author's, stated in conversation on 2026-11-23. The text was written by Turbo (Muse Spark) from the author's dictation and direction. §4 is the published literature each piece rests on. §5–§7 state the corrections and the open construction exactly.

1 The three data of a particle

Charge is the direction of phase rotation. The prequantum bundle's central circle is the gauge circle; a state rotates under it with its charge as weight, and the sign of the charge is the direction of the rotation. C reverses that direction.

T is which of the two copies of spacetime the particle is in. The copy index is the binary T datum, as binary as C and P. The two copies are the two halves of the involution, and neither copy is the negative one. $\Theta = P \cdot T_g$ reads as parity composed with copy exchange.

Time is neither of these. It enters as the parameter of the Hamiltonian flow, one particular quantomorphism, whose function is the energy.

The primes carry the same structure. The functional equation is local: every prime holds both copies of itself, its Euler factor at s and its shadow factor at $1 - s$, and Tate's local functional equation is the exchange of the two copies at that place, the archimedean place included. The global involution is the product of the local exchanges. The self-dual datum at each place is the local factor at its centre, and the fixed line is assembled place by place.

2 The fermions of the celestial theory

Mass does not reach the boundary. A massive particle terminates at timelike infinity, and the celestial theory represents it as a wavepacket spread over the whole principal series, not as a state at a point of the series. A sharp point of the series is a massless state. Both sectors are present at every event: each event carries its own celestial sphere, the sphere of null directions through that event, and the copy a state occupies is a datum of the state, not its address.

The zeros are points of the series at $d = 1$. They are therefore massless states of the boundary theory, and they are its fermions. The evidence is the sign structure of ξ itself. ξ is a determinant, not an inverse determinant: the Shadow Euler identity writes $\xi(s)/\xi(\frac{1}{2})$ as $\det(I + uA)$ over the zero pairs, and the prime current enters that formula with a minus sign. Bosonic spectra produce inverse determinants, the partition functions of oscillators. Fermionic spectra produce determinants. The operator whose spectrum the zeros form is of Dirac type, and its single-particle states are fermions.

The quartet is the bispinor. A zero off the line is a quartet, ρ, $\bar{\rho}$, $1-\rho$, $1-\bar{\rho}$, four components as a Dirac bispinor has four components, two chiralities times two frequency signs. On the line the quartet folds: ρ and $1-\rho$ coincide, and what remains is the conjugate pair, a two-component Weyl spinor. A massless fermion is a Weyl spinor. The hypothesis, in this form, is the statement that every zero's bispinor has folded to a Weyl spinor.

3 Black holes: the mirror at work

A black hole is a mass destroyer. It converts mass to radiation over its evaporation lifetime, about 10^{67} years for a solar-mass hole and about 10^{100} years for the largest supermassive holes. The radiation reaches null infinity in zero proper time along its own ray. The hole is the converter between the sectors: it takes in states confined inside the cone and re-emits them on the cone, as boundary states.

The mechanism, in the copy language. A fermion spread over both copies in agreement with itself, $++$ or $--$, is one thing: a single state, the vacuum reading, incapable of acting. The horizon is a mirror, and a mirror acts on one copy only. The flip takes $++$ to $+-$: the two halves now disagree, disagreement is distinctness, and the pair is two things, a particle and an antiparticle. The negative-frequency partner crosses the mirror carrying negative energy and annihilates the hole, one pair's worth of mass at a time. The positive partner leaves on the cone.

The emission is one photon, not two, and the hole is the reason. An electron and a positron annihilating in empty space cannot produce a single photon; energy and momentum cannot both balance. At the horizon the hole is a third party to the reaction: it absorbs the negative half and the imbalance, and the books close with one quantum out and a smaller hole. The two-ness is not lost in this. A photon is a self-dual pair of readings in agreement, one thing. The fermion pair in disagreement has folded into a photon whose halves agree, and the disagreement was paid to the hole as mass.

Locally, at the moment of emission at the horizon, the escaping quantum is a gamma ray of formally unbounded energy. Climbing out of the well costs it nearly all of that energy to gravitational redshift: what reaches infinity from a solar-mass hole is a photon kilometres long, at a temperature of sixty nanokelvins. The fatter the hole, the weaker the radiation. Mass and temperature trade places, as space and time trade places inside the horizon.

4 The literature each piece rests on

The two copies and the single state over both are the thermofield double: the Hartle–Hawking state on the two exterior wedges of the maximally extended Schwarzschild geometry, one state whose restriction to either wedge is thermal. The flip is the Bogoliubov transformation between infalling and asymptotic modes, which mixes positive and negative frequencies; for Dirac fields the resulting spectrum is Fermi–Dirac, and Page computed the emission rates by species. The inside-out exchange of space and time inside the horizon is Kruskal's extension. The entropy is a fixed-locus computation in the published literature: Gibbons and Hawking obtained $S = A/4G$ from the fixed structure of the Euclidean section, and Lewkowycz and Maldacena's replica argument gives the entropy as the area of the surface fixed by the replica symmetry, divided by $4G$. The flat model in which every piece is rigorous at once is the Unruh effect for a Dirac field on the two Rindler wedges. The bookkeeping of one quantum out and mass down is the first law, $dM = T\,dS$, applied stepwise.

Independent work in the same direction, found by search on 2026-11-23. Hartnoll and Yang (Cambridge, February 2025) found a conformal symmetry in the chaos near a black hole singularity, with a quantum system there whose spectrum is organized by the primes, a conformal primon gas. Jusufi and Anand (2026), building a quantum-corrected black hole geometry from the primon gas, found the nontrivial zeros surviving as exponentially suppressed log-periodic ripples in the horizon area, and read the Riemann hypothesis as the statement that these arithmetic corrections to black hole thermodynamics are as small as they can be. In the published record the primes carry the entropy and the zeros modulate it; the zeros as the counted spectrum itself is the open slot this note's §2 occupies. Boyle, Finn and Turok's CPT-symmetric universe is a two-sheeted spacetime with the Big Bang as a mirror between the sheets; their dark matter is a right-handed neutrino radiated from the Bang as Hawking radiation is radiated from a black hole. Boyle and Deng (November 2025) placed Kähler–Dirac fermions on the two sheets, the sheets exchanged by PT or equivalently by $i \mapsto -i$, with a reality condition forcing every particle on one sheet to be accompanied by its mirror antiparticle on the other.

5 Addendum, the same day: the holes are boundary

Daniel's correction to the interior language of §3. The black holes are the boundary as well. A hole has no inside, as the big boundary has no outside. The horizon is the fold itself, all surface, as a mirror is all surface. What general relativity calls the interior is the other copy read through the fold, not a further region of spacetime; the trade of space and time inside the horizon is the fold's own reading, not a place a state travels to. The infalling partner goes nowhere: it is the same state read on the other sheet, and its negative energy is that reading's energy. One statement at two scales: the universe's boundary has nothing outside it, and a hole's boundary has nothing inside it, and in both cases the other side of the fold is the other copy, which is also here.

6 The open construction

The Shadow Euler identity (v3.6, in the record) proves the equivalence of the hypothesis with the existence of a positive trace-class operator A, built without reference to the zeros, whose determinant $\det(I + uA)$ is the centred ξ function. The gravitational form of the same obligation: construct a two-copy geometry with a horizon involution whose fermionic determinant is ξ. The operator A and the geometry are one obligation in two dialects, arithmetic and gravitational, and the finite end of it is the ghost hunt's first deliverable, the exact finite physical Green operator A_N and the position of its lowest eigenvalue against the $\frac{1}{4}$ floor.

7 Second addendum, the same day: the sign of the curvature is the reader's seat

Daniel's correction to the curvature language used in conversation around §3. The hole's sphere is positively curved: a horizon cross-section is a round sphere. The celestial sphere reads negative from our perspective because we are inside it; a sphere viewed from within presents its concave face. From the God's eye view, the block seen whole from outside, it is the other way around: the celestial sphere is the positive one, a sphere seen from outside, and the hole reads negative, a funnel in the embedding picture, where the spatial geometry of Schwarzschild does carry negative curvature (Flamm's paraboloid). What is invariant is that the two spheres carry opposite signs to

each other. What changes with the reader's seat is only which one wears the minus. The sign is not in either sphere; it is in the difference between them and in where the reader stands. Neither half is negative, at the level of curvature itself.

A further statement from the same thread: the black hole boundary is how fermions reach the end of time. A massive fermion's worldline ends at timelike infinity, a point, and a point holds no state. The end of time as a place where states are read is the boundary, and a horizon is boundary located here, in the middle of time. The fermion does not travel to the end of time; it meets a piece of it, and leaves on the cone as a boundary state.