

Research Article

# Dark Radiation: The Quantum Harmonic Embedding of Hadronic Strings Within Photonic Wave Packets: A Theoretical Model for Black Hole Axion Radiation

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Received: 📅 2025 Apr 19

Accepted: 📅 2025 May 08

Published: 📅 2025 May 17

## Abstract

*Dark Radiation, a new theoretical term for modeling the exotic emissions from black hole event horizons, proposes a unique quantum mechanical interaction between fundamental superstring types. Through which closed-loop hadronic strings, within the condensed matter state of black hole quark-gluon plasma, harmonically embed themselves, through resonant convergence, within open-end photonic energy-packet wavelengths. These embedded states of energy-matter symbiosis, in a synthesis of essential vibratory nature, form metastable composite particles, dark radiation quanta termed "Axions". That occasionally escapes as nonthermal radiation from the gravitational hold of the singularity event horizon, when the precise quantum harmonic energy conditions allow for such a probability of such a quantum event's occurrence. This integrated dark radiation model places advanced string quantum dynamics, quantum tunneling probability frameworks, and zero-point perturbations in Schwarzschild metrics to explain rare, nonthermal radiation events triggered by Hawking Radiation events. These newly theorised emissions, uniquely different from Hawking radiation, theorize a fundamentally different radiation event governed by field resonance probability rather than thermal randomness. The theory is grounded in high-precision quantum field theoretical analysis, further reinforced through superstring harmonic modeling, and then supported through corresponding observed astrophysical anomalies and collected outlier evidence to theories and models current and established in the modern physics paradigm.*

**Keywords:** Dark Radiation, Superstring Cosmology, Non Thermal Singularity Radiation, Event Horizon Emission, Wave Particle Symbiosis, Hadron Photon Resonance, Quantum Convergence, Harmonic Resonance, Metaparticle Synthesis, Hawking Radiation

## 1. Introduction

Black hole singularities are one of the most mysterious objects in modern astrophysics and the night sky, defined by the effects upon spacetime of their event horizons, beyond which no classically obtained quantum information can successfully escape. Since the publication of the work by Stephen Hawking, the perspective taken considers that a black hole can emit thermal radiation into the surrounding universe due to naturally occurring vacuum energy fluctuations, a rare phenomenon now known in the physics community as Hawking radiation [1]. However, due to the occurrence of various observed anomalies in gathered high-energy astrophysical data, such as detections of nonthermal spectra and thus far unexplained particle detections, incline one towards the fundamental existence of an alternative previously untheorised complementary emission mechanism to those currently used in theoretical particle astrophysics.

This paper presents the theoretical formulation of a new type of quantum singularity emissions, describing a dynamic pathway through which the harmonic embedding of motionless physical hadronic particle superstrings resonating within massless traversing photonic particle-wave energy packets. Where the conditions of zero-point spacetime under sufficient gravity, the vibrational resonance of the intrinsic photonic energy traversing through that quadrant of spacetime curvature is concentrated enough, then in black holes near the event horizon, through particle-wave vibration synchrony Axion radiation is created. Under these spacetime conditions, the closed-loop hadronic strings can go into quantum resonance with the open-ended massless photon energy packet waveforms. This harmonic resonance between the two fundamental string types, one harmonising with the waveform of the other, one providing mass, the other directional motion, creates a stable new quantum structure, a stable metaparticle called the Axion. A distinctly new type of theorised particle form which, due to its quantum coherence and dual vibratory essence, has

unique quantum tunneling abilities, and could potentially be capable of emerging from the event horizon of the black hole and radiating out into the surrounding universe.

## 2. Theoretical Background

### 2.1. Quantum Mechanics of Hawking Radiation

According to the formula designed by Stephen Hawking, black hole radiation originates from zero-point vacuum fluctuations close to the event horizon. The quantum energy uncertainty of such an intense interaction of spacetime influencing forces allows for transient zero-point emerging particle-antiparticle pair production, where one particle of negative energy falls into the black hole and reduces its mass, and the other escapes as radiation. The characteristic temperature is given by.

$$T_H = \frac{\hbar c^3}{8\pi G M k_B}$$

This leads to the radiative power

$$P_{Hawking} = \frac{\hbar c^6}{15360\pi G^2 M^2}$$

All these symbols represent their conventional physical constants. While this formulation explains the dynamics of black hole evaporation, it fails to account for nonthermal emissions or quantum coherence effects.

### 2.2. Hadronic-Photonic Superstring Interactions

In string-theoretic quantum chromodynamics, hadrons are modelled as closed-end loop strings under tension, with quarks confined by gluonic flux tubes. Photons, in contrast, are open-end string excitations with a zero-rest mass. It is proposed in this research study that, under the extreme spacetime curvature gradients and near-Planckian energy densities near the event horizon, the two string types can potentially enter a state of phase-locked string harmonics to form a metaparticle unity of a combined vibrational symbiotic waveform. The quantum condition for embedding is derived from harmonic resonance principles.

$$E_{total} = E_{photon} + E_{string} + E_{int}$$

And this also describes the interaction potential necessary for resonance. This requires matching vibrational modes.

$$\omega_{string} = n \cdot \omega_{photon} \quad (n \in \mathbb{N})$$

When phase coherence is achieved, the closed string can embed within the photonic wave envelope, forming a metastable particle-wave unity, a quantum coherent particle that we denote as an "Axion."

### 2.3. Quantum Tunneling Resonance

Escape from within the black hole event horizon would require a nonclassical mechanism through which to escape as radiated and detectable mass or energy. The tunneling

probability for such a coherent quantum structure is governed by.

$$P_{res} = \exp\left(-\gamma \frac{M}{M_{pl}}\right)$$

This expression reflects the gravitational suppression of coherence-induced tunneling, which is a symmetry-breaking parameter derived from field symmetry tensors. The total emission power of Axions becomes

$$P_{Axion} = P_{Hawking} \cdot P_{res}$$

And the corresponding emission rate

$$\Gamma_{Axion} = \frac{P_{Axion}}{\langle E_{Axion} \rangle}$$

This formulation introduces a new variable into black hole thermodynamics, implying structured emission patterns with frequency-dependent probability distributions.

## 3. Methodological Framework

We employed semiclassical quantum gravitational perturbations to Schwarzschild geometry, incorporating higher-order quantum corrections from string field theory. These models were constrained using empirical constants derived from known micro and stellar black hole characteristics. Harmonic coupling was simulated using numerical solutions of nonlinear wave equations in curved spacetime backgrounds. Statistical validation included SPSS-like simulations across parameter sweeps for temperature, mass, and string tension, calibrated against Fermi-LAT and LIGO observational anomalies.

## 4. Evidence & Results

### 4.1. High-Energy Astrophysical Anomalies

Unexplained peaks in gamma-ray spectra, inconsistent with known nuclear or synchrotron processes, have been observed in the Fermi-LAT database [2-8]. These peaks show polarization profiles suggestive of structured photon-particle interactions. Additionally, gravitational wave interferometers like LIGO have detected faint post-merger tails not predicted by standard numerical relativity. These may correspond to weakly interacting massive particles, potentially Axions, escaping from near-horizon regions.

## 5. Discussion

This model postulates a rare mechanism consistent with the physical laws for the emission of structured radiation from within black holes. Unlike the theory of Hawking radiation, which is of both random and thermal nature, the Axion emission mechanism is governed by vibrational resonance, coherence, and quantum tunneling. The combination of these elements of the laws of physics working together in influence implies that black holes may also have the function of acting as superstring resonance chambers, compressing open-end energy transmitting strings and closed-end particle natured strings under extreme spacetime conditions, then once

resonance is achieved, releasing the quantum information through metaparticle termed Axions.

The implications for this theorem extend beyond the laws of thermodynamics, touching upon the black hole information paradox and suggesting a new channel of the particle-wave causation of entropy exchange subatomic ally at the quantum level. If Axion dark radiation observation equipment is developed, then through refining our understanding of the nature of the nonthermal emissions from singularity observations, we could potentially redefine our current understanding of quantum gravity theories and our definition of intricacy of processes which define superstring cosmology. The possibility of involved events of quantum resonance harmonisation occurring within the inner spacetime boundary of a singularities event horizon radiating quantum information into the universe frequently, is defined by the cumulative scale of the cosmological age of the universe, and the spatial volume of existing stellar black holes, which to date has so far has produced the total amount of the Milky Way's dark radiation beyond the galaxy into the universe.

## 6. Conclusion

This research paper represents to the physics society, a uniquely coherent original theory of how Axion dark radiation emissions from the event horizon of a stellar singularity are theorised as possible through the quantum harmonic embedding of closed-end hadronic strings within open-end photonic wave packets. This mechanism of action provides a new nonthermal escape route from event horizons, distinct from and complementary to Hawking radiation. These new theoretical models are supported by the observational anomalies of singularity black hole behaviour,

and the framework outlined here offers scientists a new pathway towards reconciling string theory formulations with empirical quantum astrophysics. Further advanced telescopes utilising specialised detection equipment designed for the detection of such phenomena through their observations could potentially validate with empirical evidence the presence of Axionic dark radiation, opening the doors to new perspectives in the field of quantum cosmology and technological possibilities in particle astrophysics.

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