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## Information and Geometric Interpretation of Radioactive Decay

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### A Brief Description

This paper proposes a philosophical and conceptual interpretation of radioactive decay based on informational geometry and quantum spatial structures. Inspired by the ideas of loop quantum gravity, the hypothesis suggests that particles do not simply escape atomic nuclei through probabilistic quantum tunneling, but instead follow geodesic paths shaped by localized geometric deformations in the spin network of space-time.

The decay process is treated as an informational transaction: a temporary geometric distortion triggered by a local imbalance (of mass, energy, or symmetry), followed by a restoration of balance through a response from dark energy, guided by quantum informational input. Alpha, beta, and gamma decays are reinterpreted as geometrically organized transformations, each restoring equilibrium through the regulated curvature of space.

This perspective shifts the paradigm: rather than describing decay in terms of forces and energy transfer between particles, it is viewed as a geometric mechanism of self-regulation by space-time itself, reacting to informational tension. In this framework, energy does not propagate as a transferable substance, but emerges as a manifestation of localized geometric evolution. The model invites a reconsideration of dark energy, neutrinos, and photons as agents of informational reconfiguration within quantum geometry.

### Introduction

Modern physics interprets radioactive decay as a probabilistic process governed by the laws of quantum mechanics. An  $\alpha$ -particle, for example, is assumed to already exist inside the nucleus and attempts to escape with a certain frequency. Yet, from the perspective of classical physics, the  $\alpha$ -particle should not be able to do so, since it lacks the necessary kinetic energy. Nevertheless, it still has a finite probability of tunneling through the potential barrier and leaving the parent nucleus. In this process, part of the system's mass is converted into kinetic energy according to Einstein's equation.

However, within this interpretation several questions remain unclear:

- Where does the particle's initial momentum and kinetic energy come from?
- How exactly is the act of escape realized if no «external force» is applied?
- What is the role of the background — Space-Time — in organizing the decay?

The atom's drive to transition from an unstable to a more stable state is entirely understandable. Yet, it is difficult to agree with the hierarchy of energy transformations in radioactive decay as proposed by modern science. What seems most troubling is the idea that an  $\alpha$ -particle somehow «gains» the opportunity to leave the nucleus, mobilizes part of the parent nucleus's mass, converts it into energy, and then propels itself beyond the potential barrier. This strongly resembles an attempt to pull oneself out of a swamp by one's own hair.

I would like to propose an alternative vision of this process — one that, in my view, could reflect the true nature of particle emission in radioactive decay. Undoubtedly, this is a hypothetical, philosophical-physical interpretation, inspired by the ideas of Loop Quantum Gravity, and is by no means suggested as a replacement for the Standard Model.

## Novelty and Distinction from Existing Approaches

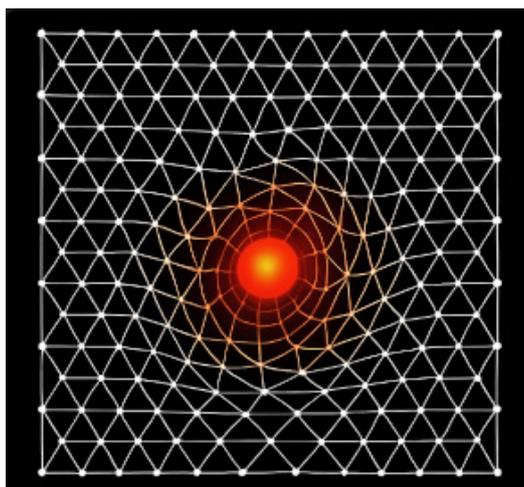
The presented model of the information-geometric interpretation of radioactive decay integrates ideas from several areas of modern physics — Loop Quantum Gravity, quantum information theory, nuclear physics, and hypotheses about the nature of dark energy — into a single conceptual framework. Unlike traditional descriptions, in which decay is treated as a probabilistic process of particle and energy exchange between nucleons, this article interprets the process as a geometric act of restoring the local integrity of the space-time structure.

The key distinctions of the proposed approach are:

- The role of dark energy For the first time, it is proposed to consider it not as a passive background or a global cosmological constant, but as an active executor of instructions coming from the informational field.
- The informational function of bosons  $W^-$ ,  $W^+$ ,  $Z$  bosons, and photons are interpreted not as force carriers, but as quanta of control information that determine the reconfiguration of the spin network.
- Neutrinos as elements of geometric balance Neutrinos and antineutrinos are not regarded as mere by-products but as stabilizers of momentum, spin, and topology. They also carry away information incompatible with the new configuration of the nucleus.
- The gamma quantum as an informational marker Gamma radiation is interpreted as a signal marking the completion of geometric reconfiguration, rather than simply as the release of excess energy.
- A unified model for all three types of decay Alpha, beta, and gamma processes are described within a single information-geometric mechanism.
- Taken together, these points form an original interpretation in which physical processes are explained not in terms of particle interactions, but as the dynamics of the space-time structure itself, governed by information.

## Spin Foam as Dynamic Geometry

I see the Spin Foam of space-time as a living, ever-changing geometry, which essentially defines the «life» of nucleons, elementary particles, and interactions (Figure.1). From my point of view, the fundamental driver of changes in the geometry of space-time — in the nodes and faces — is the action of Dark Energy, which executes the «instructions» encoded by the edges of the spin network.



**Figure 1: Spin Network and localized Distortion of Edges**

What could cause a change in the geometry of the spin network? Let us assume there is an unstable «heavy» nucleus, in which an excess of nucleons induces a local imbalance and a violation of symmetry.

## Stabilization is Required

The edges of the spin network — in the context of quantum gravity, the edges of a graph carrying quanta of spin — receive a command to create the necessary «instruction» from the informational field through interactions with photons, which act as carriers of quantum information. Suppose that within the unstable nucleus an alpha particle has formed, and it has obtained a probabilistic chance to leave the parent nucleus — but to do so, it needs energy.

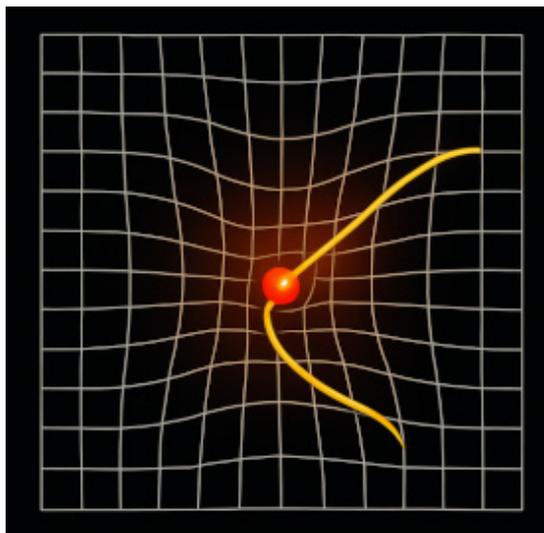
## Where Should this Energy Come from?

Information about the problem and the need for «escape» has already been «transmitted» to the edges of the spin network. An instruction is then formed for Dark Energy, requiring it to share the necessary portion with the alpha particle. This energy is transferred to the alpha particle as a loan, as a debt. The particle, having received the excess energy, leaves the parent nucleus. The entire system, after the particle's departure, pays back this debt in the form of energy through the loss of part of its initial mass.

## Geometric Realization of Kinetic Energy

Now the question arises: how exactly does the particle use the borrowed energy, and how is the status quo then restored? The answer, I believe, can be formulated as follows. Dark Energy does not provide a «push» to the particle,

but instead alters the geometry of space for it. The curved space forces the particle to move along geodesic lines, and thus it acquires acceleration, velocity, and, in essence, kinetic energy (Figure. 2).



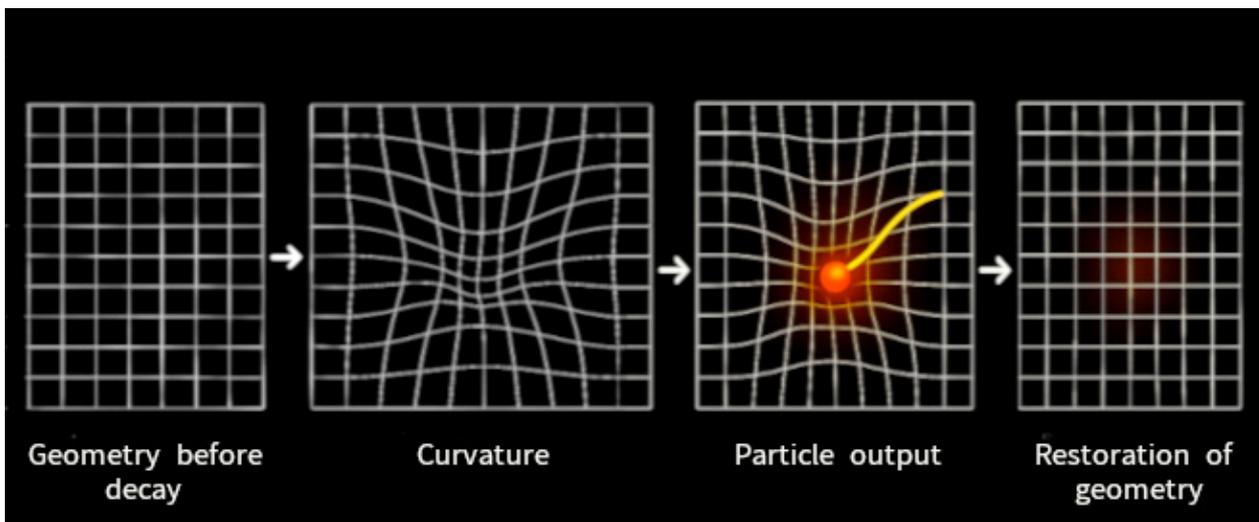
**Figure 2: Geodesic Trajectory of the  $\alpha$ -particle Arising in the Modified Geometry.**

The energy that is «returned» by the parent nucleus in repayment of the loan simply restores the geometry of space-time and brings everything back to its initial state.

*Repayment of the debt = Restoration of geometry*

This definition does not require the presence of an «carrier» of energy returning to the bank, but instead describes energetic compensation as the restoration of symmetry, form, and rhythm. And, of course, the term «loan» in this context implies that energy is provided in the form of a temporary disruption of geometric balance, which is then compensated through a change in the system’s mass (the mass defect). In this way, the process of emission and motion of the particle during radioactive decay becomes completely clear. The hierarchy is then established in the following order (Figure.3):

- Information (through the interaction of photons and the edges of the spin network) defines structural changes in the spin foam.
- These changes instruct Dark Energy to create or «issue» energy in favor of the particles.
- Energy is transferred to the particle — not from the nucleus, but from the geometric «background», which is modified and adapted to the informational request.
- The mass defect recorded by modern science is the repayment, the return of the debt. The loss of mass is not the cause of energy release but the consequence of restoring geometric balance.



**Figure 3: Temporal cycle: Geometry before Decay → Curvature → Particle Emission → Restoration of Geometry**

In this hypothesis, Dark Energy is not a passive background, but a dynamic, instruction-driven structure that participates in microphysics.

At present, Dark Energy is considered the cause of the accelerated expansion of the Universe, but its microphysical role remains unclear. However, within this interpretation, much changes: Dark Energy may be seen as an active universal mediator of transformations — a bridge between geometry and matter.

### Place in the Theory for Stable Nuclei

Modern physics draws a picture in which energy is transferred or transformed, particles are accelerated, the sum of kinetic and potential energies is conserved, and various forces act. But perhaps, in reality, everything is different: there are no forces, no acceleration, but only information and geometry.

The informational field formulates a requirement, and space «decides» that part of it will now be curved — and the particle simply follows the new path. In this view, energy is the perception of a geometric change, not the cause of motion. In other words, energy is not a thing that can be transmitted, stored, or taken away; it is a state of geometry, and motion is the reaction to its temporary disturbance.

Is there a place for stable nuclei in this theory? I believe — yes, there is.

Within this framework, unstable nuclei, in their drive toward stability, continuously send a «request» to the informational field for measures to correct the situation. In such a case, stable nuclei exist peacefully without altering the geometry of space-time, whereas unstable ones, like «restless households», cannot settle down until complete stabilization is reached. What, then, is the general logic of this theory in the light of stable and unstable states of atoms? First of all, it is as follows:

- A stable nucleus is a configuration of the spin network (nodes, edges) locally aligned with the geometry of space-time. Such a system produces no tension, does not break symmetries, and requires no modifications.
- An unstable nucleus is a geometrically mismatched structure. It is in a state of topological imbalance that:
- manifests itself in the form of internal tension, instability of energy levels, «curvature density», and so on.
- is perceived by the structure of space-time as a local disturbance disrupting overall harmony.
- This disturbance generates an informational response: local edges of the spin network form «instructions» (an internal reconfiguration triggered by energy and symmetry imbalance).
- Based on these changes, Dark Energy adapts the local geometry of space — curving it in such a way as to allow a particle (for example, an  $\alpha$ -particle) to naturally exit, moving along the new geodesic line.
- After the particle's emission, geometry is restored — the topological debt is repaid, and the system reaches a new, more stable configuration (new nucleus + particle).

### Beta Decay: A Geometric Reinterpretation

However, the path that leads an unstable nucleus to a stable state is not limited to  $\alpha$ -decay, which within the framework of the information-geometric model is interpreted as an act of profound local restructuring of space-time, but may also proceed through a less energy-intensive and more localized corrective geometric event —  $\beta$ -decay. In some cases, nuclear instability is not expressed in terms of the «pressure» of excessive mass, but rather in the imbalance of the nucleon composition, leading to a violation of the internal symmetry of the spin-network nodes. This is the most common type of radioactive decay, to which the majority of chemical elements are subject.

When an excess of neutrons or protons arises within the nucleus, a local region of the spin network signals a state of geometric tension. This tension manifests itself as abnormally curved connections (edges) that no longer correspond to a stable topological balance. The nucleus effectively «requests» a correction: it transmits along the edge structure an informational impulse reflecting the need to compensate for the excess configuration. In this case, the carriers of the quantum of information are the bosons of the weak interaction.

Just as in the case of  $\alpha$ -decay, Dark Energy executes the instruction encoded in the edges of the spin network. It rearranges the local geometry of space-time, initiating a fluctuation of the corresponding quantum field, which results in the emergence of an electron (or positron). The newly created particle leaves the nucleon, following a geodesic trajectory defined by the reshaped geometry. However, in this process an important peculiarity arises. The generation of only a single electron already violates the symmetry of the system: the center of mass shifts, momentum appears (although the nucleon initially had none), and spin asymmetry arises. To complete the geometric restructuring and to «fix» the preservation of symmetry, another quantum must arise in space as a compensating response — a neutrino or antineutrino.

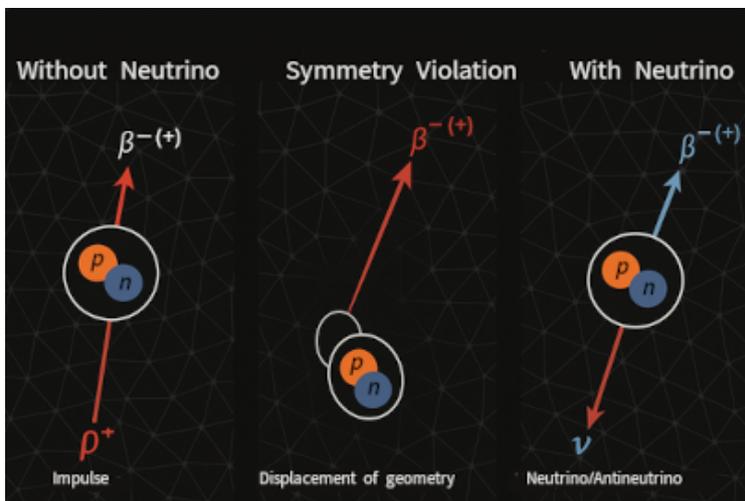
Within this model, the neutrino/antineutrino is not a byproduct but a necessary element of geometric balance. Its role in the system can be described as follows:

- *Momentum and spin stabilizer.* The electron carries away momentum  $\vec{p}_e$ , while the antineutrino carries the opposite momentum  $\vec{p}_\nu$ , thereby restoring the initial distribution along the network edges; the electron carries spin  $+\frac{1}{2}$  (conventionally), while the antineutrino carries spin  $-\frac{1}{2}$ . Their spins may mutually compensate  $\rightarrow$  preserving the total

spin of the original particle (in this case — the neutron).

- *Informational corrector.* The neutrino carries away part of the local information that is no longer compatible with the new nuclear topology. Figuratively speaking: if the photon delivered an «informational command» to the system and triggered its restructuring, then the electron is the «executed command», while the neutrino is the «report of its completion».

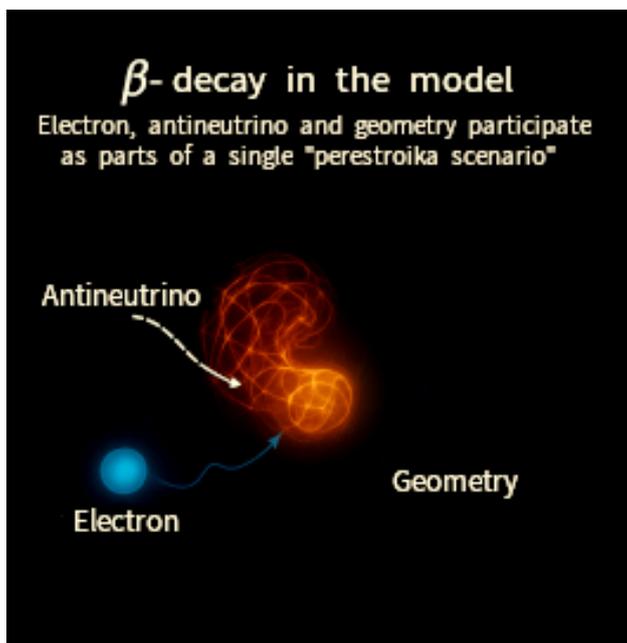
- *Geometric compensator.* (Figure.4) If the fluctuation produces only the electron, the local geometry shifts and becomes distorted — an asymmetry of the spin-network node arises. The birth of the second particle (the neutrino), however, means that the geometry effectively «straightens itself», restoring symmetry. In this case, the center of symmetry remains fixed and the space-time structure is not «tilted» to one side.



**Figure 4: Scheme of Geometric Compensation**

The weak interaction of the neutrino with matter also becomes understandable, as it reflects its topological isolation. This particle, not bound to charge or mass, is in fact connected to the informational and geometric structure of the field. Its almost complete isolation from other interactions may indicate that the neutrino does not belong to the material subsystem in the usual sense, but rather exists at the boundary between material and informational reality. Thus, in this model  $\beta$ -decay (Figure.5) is a local geometric alignment realized through the coordinated emergence of:

- the primary particle (positron or electron),
- the neutrino/antineutrino as a geometric compensation,
- the change of mass as an indicator of the completion of the geometric transformation.



**Figure 5: Beta decay**

Within this model,  $\beta$ -decay is not a chaotic event but a coordinated geometric mechanism, in which each of the emerging particles performs a strictly defined function — from momentum compensation to the transfer of residual information.

Yet, a question remains: how does the spin network itself «know» about the necessity of restructuring, and who initiates the sequence of these coordinated actions?

The answer, as it seems to me, lies in understanding the special role of the weak interaction — not as a simple particle exchange, but as a system for transmitting controlling informational commands to the geometry of the network.

### The Role of The Weak Interaction in the Information-Geometric Mechanism of Beta Decay

It is important to clarify how, within the framework of the above model of  $\beta$ -decay, the role of the weak interaction as a whole is interpreted.

In traditional physics, the  $W$  and  $Z$  bosons are regarded as force carriers, responsible for quark flavor change and for the decay mechanism itself. However, in the proposed information-geometric model their function is seen in a fundamentally different way — as the transmission of a high-level informational instruction addressed to the geometric structure of the spin network.

When a local region of the nucleus approaches a critical level of symmetry or energy imbalance, the spin network «requests» a topological adjustment. In response, a  $W$  boson emerges — a quantum of the informational field of the weak interaction, containing the instruction on how the geometry of the edges should be modified to relieve internal tension (Figure.6). This instruction includes:

- a change in the flavor of one of the quarks in the nucleon (for example, a  $d$  quark to a  $u$  quark in  $\beta^-$ -decay, or a  $u$  quark to a  $d$  quark in  $\beta^+$ -decay);
- the initiation of fluctuations of the electron and neutrino fields, leading to the emergence of the electron and antineutrino as a coordinated compensation pair.

In this interpretation, the  $W^-$  boson does not decay into an electron and an antineutrino (or the  $W^+$  into a positron and a neutrino) in the conventional sense, but merely transmits to the geometry the command to create these particles through internal fluctuations of the corresponding field. The particles themselves appear as the result of a local restructuring of space-time geometry, rather than as products of the disintegration of the  $W$  boson.

The large mass of the  $W$  and  $Z$  bosons in this model does not reflect the inertial mass of force carriers, but instead serves as an indicator of the informational density and complexity of the transmitted instruction. The deeper the required transformation, the more «informationally heavy» the quantum that initiates it.

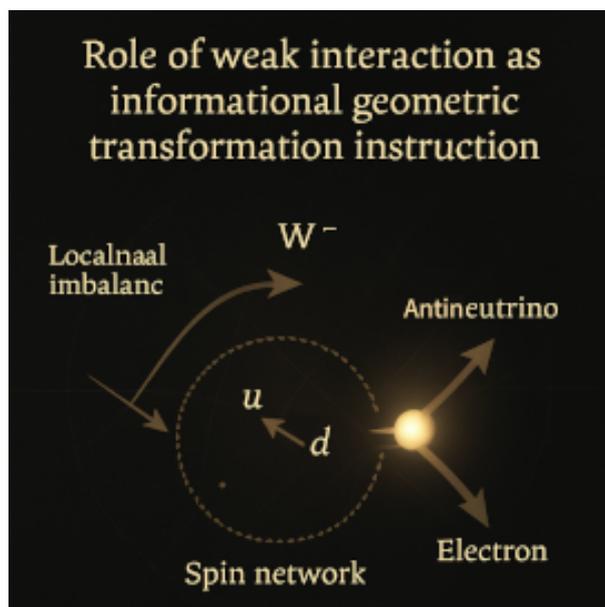
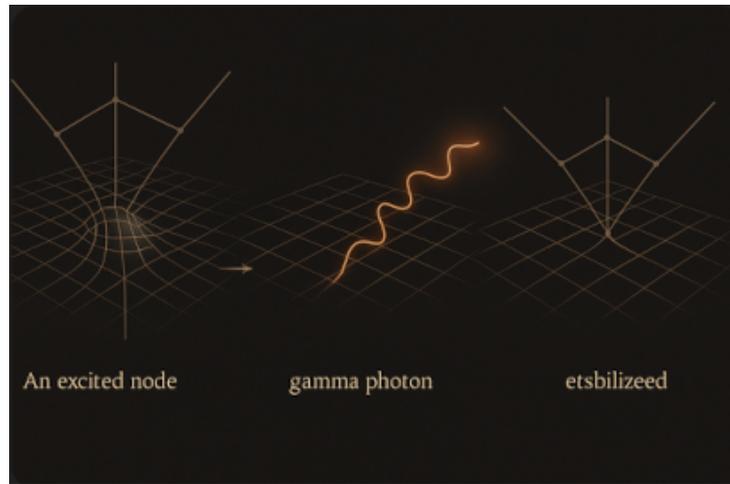


Figure 6: the Role of the Weak Interaction as an Informational Instruction for Geometric Transformation

Thus, within the information-geometric interpretation of  $\beta$ -decay, the weak interaction does not appear as «weak» in the energetic sense, but rather as a precise, selective, and deeply geometric mechanism that aligns the local topology of spin-network nodes with the global structure of space-time.

### Gamma Emission: The Final Geometric Imprint

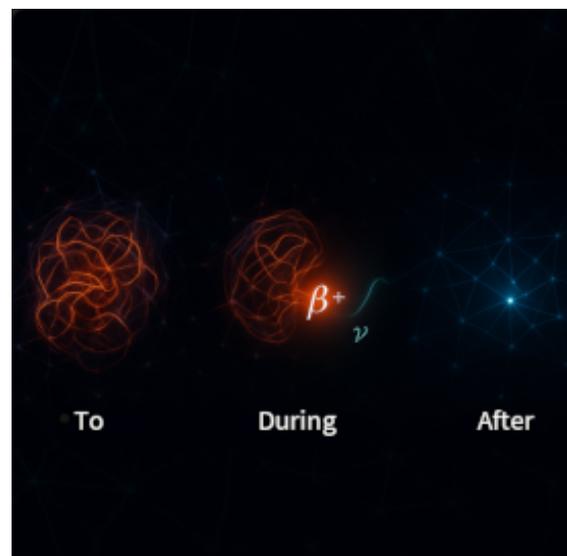
Yet another problem remains. After  $\alpha$ - or  $\beta$ -decay, the daughter nucleus is left in an excited state. This state is, of course, unstable and temporary, but why does it persist at all? The likely reason is as follows: the energy is still above the ground state (though not excessive in terms of mass), the nucleon configuration has already changed but is not yet optimally «embedded» into the spin-network structure, and in addition, a local geometric curvature remains without disturbing charge or momentum balance. Something must provide the final stroke to complete the picture of the information-geometric interpretation of radioactive decay. An agent is required that carries away neither mass, nor charge, nor momentum. The photon would fit this role — but not just any photon: a high-energy photon, acting as an agent of maximal information. This is the gamma quantum.



**Figure 7: Symmetry Restoration**

The situation can be described as follows (Figure.7):

- The edges of the spin network after  $\alpha/\beta$ -decay remain in a vibrationally unstable state.
  - Everything is already «in place», but not yet «settled». The nucleus has the correct composition, but its state is still unstable and «strained».
  - How the gamma quantum operates in our model:
  - The gamma quantum carries away precisely a «frequency code» — it does not transport mass, momentum, or charge, but it is a carrier of spin and of information encoded in frequency.
  - After its emission, the local geometry «calms down», the edges return to a state of minimal curvature, and the network becomes stable.
  - The gamma quantum is the act of completing the informational exchange between the nucleus and geometry. It carries away the message:
  - that the system has been reconfigured, – that the new topology of the node is stable,
  - that the tension has been released.
  - In this model, the photon is not merely a carrier of energy, but an «informational marker of geometric restoration».
- The gamma particle effectively closes the process of nuclear restructuring and restores the vibrational-topological equilibrium of the spin-network node (Figure.8).



**Figure 8: Completion of Informational Exchange**

## Conclusion

It is especially important to emphasize: the proposed information-geometric interpretation of radioactive decay invites us to view physics not as the interaction of particles in empty space, but as the very dynamics of space-time giving rise to processes. Decay appears not as a violation, but as an act of restoring geometric integrity, realized through an informational response. It is, in a sense, a transition — from local tension to global equilibrium, from informational request to geometric reaction.

In this model, energy is not transmitted — it arises as a manifestation of temporary geometric deformation. The particle is not «pushed out», but follows the path created by the fabric of space itself — locally curved to allow the motion, and then restored to fix the new stable state.

If the physics of the future is the physics of information and structure, then the proposed model may allow us to look not only into the nature of matter, but also into the very architecture of reality — into the principles by which it restructures itself when information demands change.

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