Bio-Assisted Nuclear Energy Extraction (BANEE): A Low-Energy Approach to Nuclear Power Generation

André Matos Rogaciano Mendonça

March 2025

Abstract

Traditional nuclear power generation involves high-energy fission reactions requiring extreme temperatures and neutron bombardment. Here we propose a speculative yet theoretically grounded approach called Bio-Assisted Nuclear Energy Extraction (BANEE), leveraging biological confinement, quantum tunneling phenomena, and THz-assisted nuclear destabilization. Inspired by radiotrophic fungi and quantum effects in biological systems, BANEE could enable room-temperature, low-energy nuclear energy extraction with improved efficiency and safety.

1 Introduction

Nuclear energy today relies heavily on fission reactions, characterized by high operational complexity, safety risks, and substantial thermal waste. Radioisotope Thermoelectric Generators (RTGs) demonstrate reliability but suffer from low thermoelectric conversion efficiency (5-8%). Inspired by natural systems, we explore a potential alternative: biological manipulation of nuclear decay rates.

2 Theoretical Basis

2.1 Quantum Tunneling and Proton Emission

Quantum tunneling allows particles to bypass classical energy barriers. Enzymes such as hydrogenases exploit tunneling for electron and proton transfer. Extending this principle to nuclear proton tunneling, especially via vibrational resonance at THz frequencies, may increase decay probabilities.

2.2 THz Vibrations in Biological Systems

Biological molecules naturally vibrate in the THz frequency domain (0.1–10 THz). Studies have demonstrated that THz radiation influences proton tunneling in DNA hydrogen bonds and electron tunneling in single-molecule transistors. Exploiting these natural frequencies may allow induced nuclear transitions in unstable isotopes.

3 Proposed Mechanism

3.1 Bio-Confinement of Isotopes

Biological or synthetic protein structures could selectively trap radioactive isotopes, increasing nuclear stress via nano-confinement. Such structures may stabilize decay products and safely control reaction rates.

3.2 Energy Harvesting

Energy from decay events (alpha/beta emissions) would stimulate bioengineered THz resonators, enhancing further nuclear transitions. Excess energy can be captured via bioelectronic interfaces, creating a self-sustaining, cyclic energy extraction system.

4 Experimental Roadmap

4.1 Initial Feasibility Studies

- Measure isotope responses to THz stimulation.
- Model bio-nano confinement effects on nuclear stability.

4.2 Prototype Design

- Develop bioelectronic interfaces for efficient energy harvesting.
- Test self-healing biomaterials under sustained radiation exposure.

4.3 Long-term Applications

- Ultra-long-life nuclear batteries.
- Deep-space autonomous power systems.
- Nuclear waste transmutation reactors.

5 Potential Challenges

1. Practical demonstration of THz-induced nuclear tunneling.
2. Biological material resilience under sustained nuclear exposure.
3. Ethical and environmental safety of bio-nuclear hybrid technologies.

6 Speculative Biological Implications

An intriguing possibility emerges: a biological organism capable of harnessing nuclear decay actively. Such an organism could self-power indefinitely with radiation, regulating nuclear transitions biologically. Though speculative, such lifeforms would dramatically expand our understanding of life's potential energy strategies.

7 Conclusion

Bio-Assisted Nuclear Energy Extraction (BANEE) offers a visionary yet plausible route toward efficient, safe, and sustainable nuclear energy production. By merging biological innovation with quantum-assisted nuclear physics, this concept may revolutionize energy harvesting and inspire novel biological discoveries.

Appendix: Potential Isotopes

Isotope	**Decay Mode**	**Half-life**	**Energy Released**
Plutonium-238	Alpha	87.7 years	5.6 MeV
Bismuth-213	Alpha	45.6 min	5.9 MeV
Thorium-229	Alpha/Isomeric	7,300 years	8 eV (isomeric state)
Nickel-63	Beta	100.1 years	0.07 MeV
Tritium (^{3}H)	Beta	12.3 years	0.018 MeV

Future Work

Future research should validate these concepts experimentally, explore bioelectronic and quantum-assisted energy extraction further, and assess practical applications in real-world nuclear energy contexts.