The Cosmic Quantum Orchestra: A Brief History of the Brain

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Abstract

We propose a cosmological framework for understanding gravitational wave influence on neural systems. Drawing from recent discoveries of nanohertz gravitational wave backgrounds and theoretical modifications of general relativity such as $f(R)$ gravity, we identify a specific strain-frequency window ($h \in [10^{-18}, 10^{-14}]$, $f \in [1\mu\text{Hz}, 1\text{Hz}]$) within which neural structures could, in principle, be perturbed. We analyze how this window evolves over cosmic time and identify a viability interval (11.4 to 29.2 Gyr post-Big Bang) during which gravity-coupled cognition could emerge. This study introduces the "Cosmic Orchestra" metaphor to capture the fleeting overlap of cosmological wave structure and biological sensitivity.

1 Introduction

Gravitational waves (GWs) from supermassive black hole binaries (SMBHBs) form a stochastic background detectable in the nanohertz regime. Recent detections by pulsar timing arrays confirm this background [1, 2, 3]. While biologically negligible in direct force, these waves may modulate axonal signal timing via metric perturbations, particularly in ephaptically coupled neural tracts [4, 5]. Neural response plausibility is constrained by wave strain and frequency alignment with axonal propagation dynamics.

2 Modified Gravity and Frequency Shifts

$f(R)$ gravity theories introduce higher-order curvature terms in the Einstein-Hilbert action, yielding scalar "breathing" modes and modifying GW dispersion. These

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modifications tend to blue-shift (increase) wave frequencies, pushing energy out of the biologically relevant (low-frequency) band (see Figure 17 in [4]). Consequently, in $f(R)$ scenarios, even strong GWs may not modulate neuronal timing significantly, effectively decoupling the brain from spacetime curvature. Whereas normal general relativity does have an impact on brain quantum computation [6, 7].

3 Cosmological Source Crowding and Temporal Window

We estimate that $\sim 10^9$ super massive black hole binaries (SMBHBs) populate the observable universe. Of these, $\sim 4 \times 10^6$ reside in the spherical shell between 5.5 Mpc and 1 Gpc from the Earth where their strains fall within the detectable range for neural interaction (please see Figure 1). Due to the acceleration of cosmic expansion, this shell dilates over time, decreasing source density and increasing GW resolvability on Earth (please see Figure 2). From modeled crowding evolution, we identify the viable window for gravity-coupled brain quantum computation to be: 11.4 Gyr (minimum resolvability) to 29.2 Gyr (maximum resolvability).

4 Discussion: The Cosmic Orchestra

We interpret these results via the "Cosmic Orchestra" analogy: SMBHBs act as instruments playing gravitational tones, with the brain as a potential listener. As the universe ages, the orchestra's clarity improves, though its volume decreases. Based on the requirement that brain-like structures must operate within a gravitational wave environment that has a strain amplitude within the band $h \in$[10−18,10−14], has a low enough source crowding to allow resolution of individual gravitational wave modes in the band $f \in [1\,\mu\mathrm{Hz}, 1\,\mathrm{Hz}]$, and using the contraction of the universe in the reverse-time direction, we find that human-like nervous systems could not have functioned before $\sim$ 11.4 Gyr after the Big Bang. Present-like human brains would cease coupling once red-shifted strain amplitudes fall below influence levels (post-29.2 Gyr). This suggests gravity-sensitive and gravity-orchestrated quantum cognition is viable only during a narrow cosmic phase.

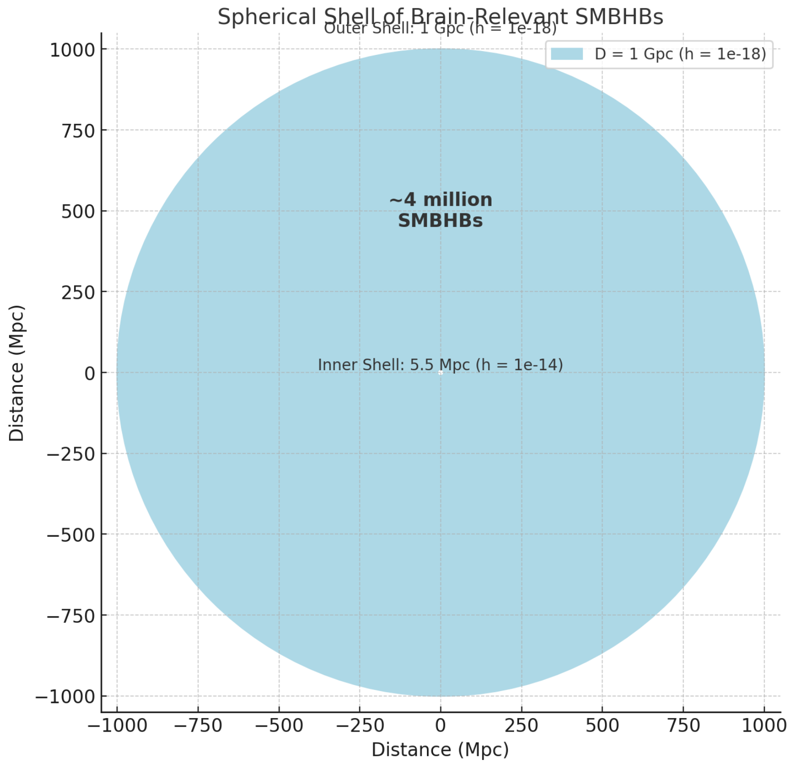

Figure 1: Shell of gravitational wave sources with strain between 10^{-18} and 10^{-14}.

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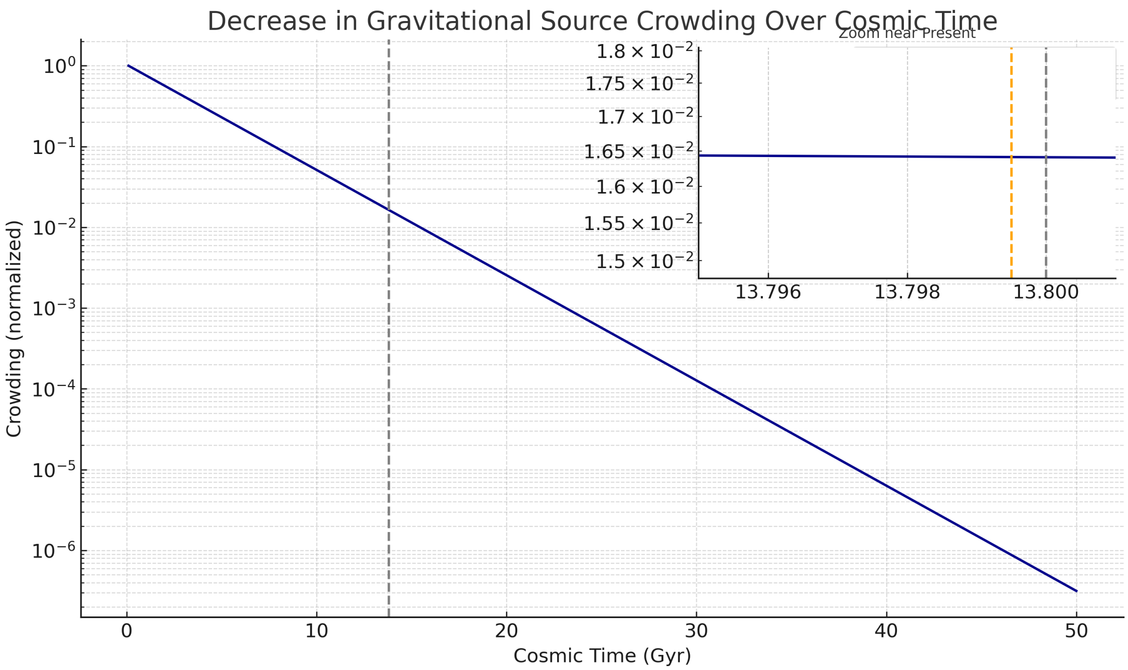

Figure 2: Time window. The vertical gray line indicates the present time and the vertical yellow line indicates the time when human-like nervous systems appeared.

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