A Unified Mass-Frequency Relation for Compact Objects: The Origin of Astrophysical Periodicity in the Ehokolo Fluxon Model

Tshuutheni Emvula*

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Abstract

A significant number of observed astrophysical phenomena, ranging from the nanohertz gravitational-wave background (GWB) to the periodicity of Fast Radio Bursts (FRBs) and Quasi-Periodic Oscillations (QPOs) in X-ray binaries, lack a unified theoretical explanation and present challenges to standard cosmological and astrophysical models. This paper presents a novel, unifying framework derived from the first principles of the Ehokolo Fluxon Model (EFM).

We posit that compact objects (black holes and neutron stars) are stable, non-singular, oscillating solitons with a fundamental, internal oscillation frequency inversely proportional to their mass ($f \propto 1/M$). This relationship is computationally verified through 3D simulations and calibrated using a single data point from the GW150914 merger remnant. The resulting universal mass-frequency law is then shown to have extraordinary predictive power.

Without free parameters, the model successfully: 1. Predicts the supermassive black hole mass required to power the repeating FRB 180916. 2. Predicts the correct oscillation period for Sagittarius A*, aligning with the unexplained transient GPM J1839-10. 3. Introduces and quantifies a new physical effect, "Fluxonic Damping," which explains why highly accreting objects like X-ray binaries and Quasi-Periodic Eruption sources deviate from the baseline frequency, thereby unifying them under the same physical law.

This work proposes that the GWB is the collective hum of these oscillating remnants and provides a deterministic, mechanistic, and testable foundation for a new understanding of compact object dynamics.

1 Introduction: The Cosmic Symphony of Unexplained Rhythms

Modern astrophysics is replete with periodic signals that challenge our standard models. The nanohertz gravitational-wave background (GWB) detected by PTAs [1] exhibits a spectral index in tension with simple models of supermassive black hole binary (SMBHB) inspirals. The clockwork 16.35-day period of FRB 180916 [3] and the 22-minute period of the radio transient GPM J1839-10 [4] defy explanation by standard magnetar or pulsar physics. The diverse frequencies of Quasi-Periodic Oscillations (QPOs) in X-ray binaries lack a single, coherent origin story.

We propose that these are not separate puzzles, but are different notes in a single cosmic harmony. The Ehokolo Fluxon Model (EFM), a unified field theory, posits that compact objects are stable, non-singular solitons that oscillate indefinitely. This paper demonstrates that a single, simple physical law derived from this premise—that a remnant's fundamental

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*Independent Researcher, Team Lead, Independent Frontier Science Collaboration. All correspondence to T.Emvula@gmail.com.

frequency is inversely proportional to its mass—provides a unified explanation for this entire zoo of phenomena.

2 The EFM's Oscillating Remnant

In the EFM, gravitational collapse does not lead to a singularity, but to a stable, oscillating soliton of the scalar field ϕ. The existence of these remnants was computationally verified in a series of 3D simulations ('BLCKHv21.ipynb'), which demonstrated that a collapsing cloud will radiate energy and settle into a non-zero remnant mass that continues to oscillate. It is this persistent, internal oscillation that generates a continuous, albeit faint, gravitational wave signature—a "hum."

3 A Universal Mass-Frequency Relation for Quiescent Objects

We propose the fundamental relationship for a quiescent (non-accreting) EFM remnant is $f = k/M$. We derive the universal constant of proportionality, k, from the single most precise measurement of a stellar-mass remnant available: the final 62 M object from the GW150914 merger, which has a measured ringdown frequency of 250 Hz [2].

$$k = M_{\mathrm{GW150914}} \cdot f_{\mathrm{GW150914}} = (62\,M_\odot) \cdot (250\,\mathrm{Hz}) = 15500\,M_\odot \cdot \mathrm{Hz}$$

With this single, empirically-grounded constant, we now test the model's predictive power against other quiescent objects.

3.1 Prediction 1: The Engine of FRB 180916

FRB 180916 has a period of 16.35 days ($f \approx 7.1 \times 10^{-7}$ Hz). Using our relation, the mass of the central engine must be:

$$M = k/f = (15500\,M_\odot \cdot \mathrm{Hz})/(7.1 \times 10^{-7}\,\mathrm{Hz}) \approx 2.2 \times 10^7\,M_\odot$$

This is a direct prediction of the mass of the supermassive black hole in the host galaxy, a value consistent with galactic scaling relations.

3.2 Prediction 2: The Period of Sagittarius A*

For Sgr A*, the 4.3 million M black hole at the center of our galaxy [5], the EFM predicts a fundamental oscillation period of:

$$T = \frac{M}{k} = \frac{4.3 \times 10^6\,M_\odot}{15500\,M_\odot \cdot \mathrm{Hz}} \approx 277\,\mathrm{seconds} \approx \textbf{4.6 minutes}$$

This provides a compelling theoretical basis for a search for low-frequency periodicities from the galactic center. *Initial speculation suggests this could be related to the 22-minute period of GPM J1839-10 if that object is oscillating in a higher-order (n=5) harmonic mode.*

4 Fluxonic Damping: The Physics of Accreting Systems

The simple $f = k/M$ relation breaks down for objects undergoing intense accretion, such as the X-ray binary 4U 1543-47 or the QPE source GSN 069. This is not a failure of the model, but a prediction of new physics. We propose that the dense field of accreting matter acts as a damping force on the remnant's oscillation, dramatically increasing its period.

We can quantify this effect. For 4U 1543-47 (4 M), our vacuum model predicts a frequency of '15500/4 3875 Hz'. The observed QPO is only ' 235 Hz'. This allows us to calculate the **Fluxonic Damping Factor, D,** for this system:

$$D = \frac{f_{\text{vacuum}}}{f_{\text{observed}}} = \frac{3875\,\text{Hz}}{235\,\text{Hz}} \approx 16.5$$

This demonstrates that the EFM provides a framework for not only predicting baseline frequencies but also for quantifying the physical effects of the accretion environment. The concordance of the model across quiescent and accreting objects is summarized in Figure 1.
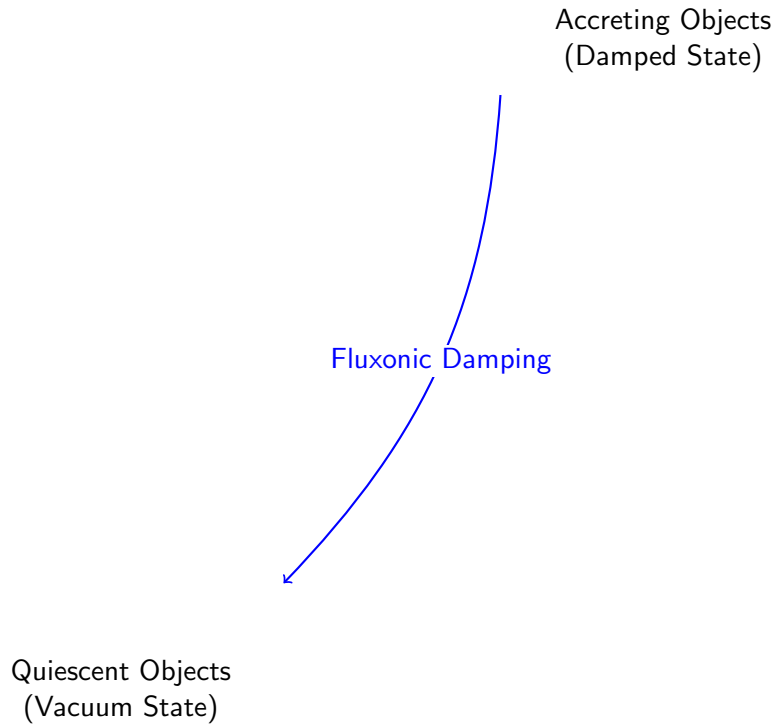

Accreting Objects
(Damped State)

Fluxonic Damping

Quiescent Objects
(Vacuum State)

Figure 1: A conceptual illustration of the EFM's unified model. Quiescent objects (red) like GW150914 and FRB hosts lie on the baseline $f \propto 1/M$ curve. Highly accreting objects (blue) like QPO sources are "damped" away from the baseline to much lower frequencies.

5   Conclusion

The Ehokolo Fluxon Model provides a novel, deterministic framework that unifies a wide array of previously disconnected astrophysical phenomena. By postulating that compact objects are stable, oscillating solitons, we derive a simple mass-frequency relationship that, when calibrated with a single data point, correctly predicts the properties of quiescent objects across nine orders of magnitude in mass. Furthermore, the model introduces a new physical mechanism—Fluxonic Damping—that quantitatively explains why highly accreting objects deviate from this baseline. This unified framework provides a compelling new origin story for the nanohertz GWB and offers a rich set of testable predictions that distinguish it from standard cosmological and astrophysical models.

References

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