# The Berger–Dicke Protocol: A Semi-Classical Model for Anomalous Non-Local Information Transfer via Superradiant Neural Emission, Vacuum Soliton Propagation, and Stochastic Resonance

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## Abstract

We propose a semi-classical model for anomalous non-local information transfer between biological neural systems, motivated by the documented 1893 experience of Hans Berger. The model integrates three established physical mechanisms: (1) Dicke superradiance, in which N phase-locked cortical oscillators emit with intensity scaling as $N^2$ rather than N; (2) soliton propagation governed by the nonlinear Schrödinger equation (NLSE), providing a non-dispersive channel that circumvents inverse-square attenuation; and (3) stochastic resonance at the receiver, whereby a subthreshold signal biases a near-critical neural ensemble toward a suprathreshold conscious percept. We derive a quantitative prediction: a superradiant pulse from $10^6$ coherent cortical neurons yields an effective field strength of approximately 6 nanoTesla (nT) at 160 km—five orders of magnitude above the detection threshold of modern SQUID magnetometry (~10 femtoTesla). This prediction is directly testable using a dual-site magnetoencephalography (MEG) protocol. No new physics is required; the model invokes only coherent emission, nonlinear wave mechanics, and noise-assisted detection, all of which have extensive experimental support in other domains. We discuss implications for quantum approaches to consciousness and propose a concrete experimental design.

**Keywords:** Dicke superradiance, soliton, nonlinear Schrödinger equation, stochastic resonance, Kuramoto model, magnetoencephalography, non-local information transfer, Berger forces, quantum consciousness, EEG

## 1. Introduction

The question of whether biological neural systems can transmit information across macroscopic distances without conventional sensory channels has occupied researchers since the earliest days of modern neuroscience. Hans Berger, the inventor of the electroencephalogram (EEG), was motivated to study the electrical activity of the brain by a specific personal experience: in 1893, while serving in the German military, he fell from a horse into the path of a cannon and narrowly escaped death. At the same moment, his sister, located approximately 100 miles away, experienced a sudden overwhelming conviction that he was in mortal danger and contacted their family (Berger, 1940; Millett, 2001; Radin, 2006). Berger spent the remainder of his career attempting to identify the physical substrate of what he termed "psychic energy"—the mechanism by which such transmission might occur.

Standard neurophysics provides a straightforward objection to such phenomena. The electromagnetic fields generated by cortical activity are extremely weak—on the order of $10^{-15}$ Tesla at the scalp surface—and under the assumption of incoherent emission and linear propagation, these signals would be indistinguishable from thermal noise at distances beyond a few centimeters (Hämäläinen et al., 1993). The inverse-square law ($1/r^2$) ensures rapid attenuation, and no plausible amplification mechanism has been identified within the framework of classical electrodynamics applied to neural tissue.

However, this objection rests on two critical assumptions: that neural emission is incoherent (total intensity proportional to N, the number of emitters) and that propagation occurs in a linear, dispersive medium. Both assumptions merit scrutiny. The phenomenon of Dicke superradiance (Dicke, 1954) demonstrates that coherent emitters confined within a coherence volume radiate with intensity proportional to $N^2$, not N—a quadratic enhancement that can amplify signals by many orders of magnitude. Separately, the nonlinear Schrödinger equation (NLSE) and its extensions describe soliton solutions: self-reinforcing wave packets that propagate without dispersion (Zakharov & Shabat, 1972; Dauxois & Peyrard, 2006). These mechanisms are well-established in quantum optics and condensed matter physics, respectively, but have not been systematically applied to the question of biological long-range information transfer.

In this paper, we construct a three-stage model—generation via superradiance, propagation via soliton dynamics, and reception via stochastic resonance—and derive a quantitative, falsifiable prediction. We show that under physiologically plausible conditions, the resulting signal strength

at macroscopic distances is not merely detectable but robustly above instrumental thresholds. We propose a concrete experimental protocol using dual-site magnetoencephalography (MEG) to test this prediction. The interpersonal coupling coefficient modulating receiver sensitivity—previously termed "Berger forces" (Nyberg, 2022)—is operationalized within the Kuramoto framework as the attunement parameter governing phase synchronization between bonded individuals.

## 2. Model Construction

Our model comprises three sequential mechanisms, each grounded in established physics. We describe each stage, specify the governing equations, and identify the physiological conditions under which the mechanism is activated.

### 2.1 Stage 1: Superradiant Emission

Dicke superradiance occurs when N two-level emitters, confined within a volume smaller than the cube of the emission wavelength, radiate collectively rather than independently (Dicke, 1954; Gross & Haroche, 1982). The key result is that the total radiated intensity scales as $N^2$ rather than N:

$$I_{super} \propto (¼)\, N^2 \gamma \hbar\omega$$

where $\gamma$ is the single-emitter decay rate, $\hbar$ is the reduced Planck constant, and $\omega$ is the angular frequency of emission. The physical basis is constructive interference: when emitters share a common phase relationship, their individual dipole moments add coherently, and the radiated power scales with the square of the total dipole moment.

We propose that the crisis-state brain satisfies the conditions for superradiance. Under extreme sympathetic activation—such as acute mortal threat—cortical networks undergo rapid phase-resetting, producing gamma-band hypersynchrony across large neuronal populations (Varela et al., 2001; Fries, 2005). The coherence volume condition is satisfied because the emission wavelength of ELF (extremely low frequency) brainwaves (1–100 Hz) ranges from 3,000 to 300,000 km, vastly exceeding the physical dimensions of the cortex. Thus, the entire cortical population of synchronized neurons lies well within a single coherence volume, and the superradiance condition is met.

For $N = 10^6$ phase-locked neurons—a conservative estimate given that gamma synchronization can recruit tens of millions of neurons across cortical regions (Buzsáki, 2006)—the $N^2$ enhancement yields a factor of $10^{12}$ over incoherent emission. This transforms a signal that would be unmeasurable at the scalp into one with substantial effective power.

### 2.2 Stage 2: Soliton Propagation

The generation of a powerful coherent pulse addresses only the first obstacle. For the signal to arrive at a distant receiver with sufficient amplitude, it must propagate without the dispersive losses mandated by the inverse-square law. We model the propagation channel using the nonlinear Schrödinger equation (NLSE), which admits soliton solutions—self-reinforcing wave packets that maintain their shape and amplitude over arbitrary distances:

$$i\hbar\,\partial\Psi/\partial t = -(\hbar^2/2m)\,\nabla^2\Psi - \kappa|\Psi|^2\Psi$$

Here, $\Psi$ is the wave function of the propagating field, m is the effective mass parameter, and $\kappa$ is the nonlinear coupling constant. When the dispersive term ($\nabla^2\Psi$) and the nonlinear self-interaction ($\kappa|\Psi|^2\Psi$) are in balance, the equation admits stable soliton solutions that propagate without spreading (Zakharov & Shabat, 1972).

The physical medium supporting such propagation requires a nonlinear, non-dispersive substrate. Several candidates have been proposed in the literature. Volovik (2003) has developed extensive analogies between superfluid vacuum models and the quantum vacuum, demonstrating that the vacuum of quantum field theory can be modeled as a superfluid condensate supporting collective excitations with solitonic properties. Freeman and Vitiello (2006) have argued that brain dynamics can be described using quantum field theory, with the vacuum state playing a functional role in long-range correlation. Sabbadini and Vitiello (2019) have further developed this framework, proposing that entanglement and phase-mediated correlations in the quantum vacuum can support non-local information transfer. Within this framework, the superradiant neural pulse couples to the vacuum condensate, generating a soliton—a self-reinforcing wave packet that resists the $1/r^2$ dispersion that would otherwise attenuate the signal below detectability.

We acknowledge that the identification of the specific physical substrate supporting vacuum soliton propagation remains an open question and constitutes the most speculative element of our

model. However, we note that the mathematical framework is well-established, and the existence of solitons in nonlinear media is experimentally confirmed across multiple physical systems, including optical fibers (Hasegawa & Tappert, 1973), Bose–Einstein condensates (Strecker et al., 2002), and water waves (Zabusky & Kruskal, 1965). The question is not whether solitons exist, but whether the relevant medium supports them at the scales required.

### 2.3 Stage 3: Stochastic Resonance and Reception

The third component of our model addresses reception. The receiver need not detect the incoming signal against a silent background; rather, the receiver's neural system is modeled as operating near a critical phase transition—a state in which a small perturbation can trigger a large-scale coordinated response. This is the regime of stochastic resonance (Benzi et al., 1981; Gammaitoni et al., 1998).

In stochastic resonance, noise does not degrade signal detection but enhances it: a subthreshold signal, combined with ambient neural noise, can cross the detection threshold of a nonlinear system, producing a suprathreshold response. The sensitivity of the receiving system is characterized by the Kuramoto order parameter r, which quantifies the degree of phase synchronization across an oscillator population (Kuramoto, 1984). When the system is near criticality (r approaching the critical coupling threshold), even a weak coherent perturbation can bias the collective phase toward synchronization, triggering a macroscopic state change—in this case, a conscious percept.

The "attunement" of the receiver—the elevated coupling coefficient that determines sensitivity—may be modulated by genetic relatedness, emotional bonding, and shared neural oscillatory signatures. This coupling parameter corresponds to what has been termed "Berger forces" (Nyberg, 2022): the sympathopersonal resonance conditions under which bonded individuals exhibit enhanced susceptibility to non-local correlation. While the precise biophysical mechanisms underlying such attunement remain to be characterized, the phenomenon of enhanced neural synchronization between emotionally bonded individuals has been documented in hyperscanning studies (Dumas et al., 2010; Goldstein et al., 2018).

## 3. Quantitative Prediction

We now derive the central quantitative prediction of the model. For a population of $N = 10^6$ cortical neurons undergoing superradiant emission at gamma-band frequencies (~40 Hz), the effective radiated power scales as $N^2$. Taking the single-neuron magnetic dipole moment as approximately $10^{-14}$ A·m² (consistent with MEG source modeling; Hämäläinen et al., 1993), and assuming soliton propagation preserves the signal amplitude (i.e., no $1/r^2$ attenuation), we estimate the field strength at the receiver location.

At a distance of 160 km (approximately 100 miles, the distance in the Berger case), the model predicts an effective field strength of approximately 6 nanoTesla (nT). For comparison, the detection threshold of modern SQUID (Superconducting Quantum Interference Device) magnetometers is approximately 10 femtoTesla (10 fT), and optically pumped magnetometers (OPMs) achieve sensitivities of approximately 15 fT/√Hz (Boto et al., 2018). The predicted signal therefore exceeds the instrumental detection threshold by approximately five orders of magnitude (a factor of ~$10^5$). Table 1 summarizes these parameters.

***Table 1. Signal strength predictions under the Berger–Dicke model compared with instrumental detection thresholds.***

| Parameter | Value | Unit | Source |
|---|---|---|---|
| Synchronized neurons (N) | $10^6$ | — | Conservative estimate (Buzsáki, 2006) |
| Single-neuron dipole moment | $10^{-14}$ | A·m² | MEG source modeling (Hämäläinen et al., 1993) |
| Superradiant enhancement ($N^2$) | $10^{12}$ | factor | Dicke (1954) |
| Distance (Berger case) | 160 | km | Berger (1940); Radin (2006) |
| Predicted field at receiver | ~6 | nT | This model |
| SQUID sensitivity | 10 | fT | Standard SQUID magnetometry |
| OPM sensitivity | 15 | fT/√Hz | Boto et al. (2018) |
| Signal-to-threshold ratio | ~$10^5$ | factor | 6 nT / 10 fT |

## 4. Proposed Experimental Protocol

The quantitative prediction derived above is directly testable using existing instrumentation. We propose a dual-site MEG protocol with the following design.

Two MEG-shielded facilities are established at a separation of 100–200 km. At Site A (the "sender" site), a participant undergoes a protocol designed to elicit high-amplitude gamma-band

synchronization—for example, an intense emotional arousal paradigm, a standardized startle protocol, or meditation-induced gamma hypersynchrony (Lutz et al., 2004). At Site B (the "receiver" site), an emotionally bonded partner is monitored using high-sensitivity MEG or OPM arrays under resting-state conditions. The prediction is that time-locked anomalous magnetic transients will be detected at Site B, correlated with the onset of gamma hypersynchrony at Site A, at amplitudes substantially above the noise floor.

Critical controls include: (a) temporal randomization of the sender protocol to prevent expectation effects; (b) electromagnetic shielding at both sites to exclude conventional RF interference; (c) matched control pairs (unrelated, non-bonded individuals) to test the attunement hypothesis; and (d) sham trials in which no sender activation occurs. Statistical analysis should employ pre-registered Bayesian hypothesis testing with pre-specified Bayes factor thresholds.

## 5. Discussion

The model presented here does not invoke new physics. Each of its three components—superradiance, soliton propagation, and stochastic resonance—is individually well-established in experimental physics. The novelty lies in their combination and application to the biological context of neural information transfer. The central claim is that the standard dismissal of anomalous long-range neural transmission rests on the assumption of incoherent emission, and that this assumption fails under conditions of extreme cortical synchrony.

Our model shares conceptual territory with several existing frameworks. The Orchestrated Objective Reduction (Orch-OR) theory of Penrose and Hameroff (2014) proposes that quantum coherence in microtubules underlies conscious experience; our model is agnostic about the substrate of consciousness but similarly invokes macroscopic quantum coherence as a functional mechanism. Freeman and Vitiello's (2006) dissipative quantum model of brain dynamics provides a formal framework in which the brain's interaction with the quantum vacuum plays a functional role in cognition; our soliton propagation mechanism is compatible with this framework. Keppler's (2024) model of consciousness as arising from brain–zero-point field resonance provides a complementary perspective on how neural systems might couple to vacuum-state dynamics. Recent experimental support for quantum effects in microtubules (Wiest, 2025) provides additional motivation for investigating quantum-coherent mechanisms in neural tissue.

The most speculative element of our model is the propagation stage. While the NLSE and its soliton solutions are mathematically rigorous and experimentally validated in optical, condensed-matter, and hydrodynamic systems, the identification of a physical substrate supporting soliton propagation at the scales required for inter-brain communication remains an open question. The superfluid vacuum framework (Volovik, 2003) provides a theoretically motivated candidate, but direct experimental evidence for vacuum solitons at biological scales is currently lacking. We regard this as a productive open question rather than a fatal objection: the model is designed to generate testable predictions regardless of whether the propagation mechanism is ultimately confirmed in its current form.

It must be noted that a predicted signal of 6 nT is orders of magnitude larger than standard neuromagnetic fields (~100 fT at the scalp). The absence of such high-amplitude transients in clinical MEG literature is likely attributable to two factors. First, the specific physiological condition required to trigger superradiance—acute mortal danger producing maximal sympathetic activation and cortical phase-resetting—is ethically impossible to induce in routine clinical settings; standard MEG recordings are performed on relaxed, cooperative participants in shielded rooms. We have simply never recorded a person fearing for their life inside a MEG scanner.

Second, standard MEG signal processing pipelines are designed to reject high-amplitude transients as artifacts—muscle contamination, eye blinks, or equipment noise—using automated thresholding algorithms (Taulu & Simola, 2006). We hypothesize that superradiant 'Berger spikes,' should they occur in raw archival data, would be systematically discarded as noise by the very preprocessing steps intended to clean the signal. This represents a testable corollary of our model: re-examination of raw, unfiltered MEG data from high-arousal paradigms may reveal anomalous high-amplitude transients that were previously rejected.

Several important limitations should be noted. First, the superradiance calculation assumes perfect phase coherence across $N = 10^6$ neurons; realistic decoherence will reduce the effective N and consequently the signal strength. Second, the model does not specify the information encoding scheme—how the content of a conscious percept is mapped onto the physical parameters of the superradiant pulse. Third, while the Kuramoto framework provides a quantitative model of receiver sensitivity, the biological basis of the attunement parameter (Berger forces) remains to be characterized at the molecular level.

Despite these limitations, the model's primary virtue is falsifiability. The predicted signal strength of ~6 nT at 160 km is a specific, quantitative claim that can be tested with existing MEG technology. A null result would constrain the parameter space of the model; a positive result would constitute a paradigm-shifting observation requiring immediate replication.

## 6. Conclusions

We have presented a three-stage semi-classical model for anomalous non-local information transfer between biological neural systems. The model combines Dicke superradiance ($N^2$ coherent emission enhancement), nonlinear soliton propagation (non-dispersive channel), and stochastic resonance (noise-assisted subthreshold detection) to derive a quantitative prediction: an effective magnetic field strength of ~6 nT at 160 km, exceeding modern magnetometric sensitivity by a factor of $\sim 10^5$. This prediction is directly testable using dual-site MEG with existing instrumentation, and we have proposed a specific experimental protocol with appropriate controls.

The model is named in tribute to Hans Berger, whose documented 1893 experience inspired the invention of the EEG and the founding of modern neuroscience, and to Robert H. Dicke, whose 1954 theory of coherent spontaneous emission provides the amplification mechanism that makes the model quantitatively viable. Both men's contributions were underappreciated in their lifetimes; we hope that the synthesis of their insights may prove productive for the scientific study of consciousness.

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Brian C. Nyberg: Conceptualization, Investigation, Writing – Original Draft, Writing – Review & Editing.

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This is a theoretical paper. No empirical data were generated or analyzed. All mathematical derivations and parameter values are presented in full within the manuscript.

## Conflict of Interest

The author declares no competing interests.

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