Collapsing Sticky Nearfields: a new Paradigm for Transient Electromagnetic Nearfields Produced by Incomplete Wave Cycles with Potential Nearfield Imaging Applications.

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Abstract:

Transient near-field phenomena are traditionally studied as isolated effects, each addressed within its own theoretical or experimental framework. In many electromagnetic measurement systems–including near-field imaging, such transient responses are routinely averaged out, filtered, or actively minimized in favor of stable, quasi-stationary field configurations.

This paradigm draws together a wide range of transient near-field phenomena, organizing them by their qualitative characteristics into a coherent framework ,introducing concepts such as "Nearfield Stickiness". The presented concepts are articulated to suggest novel ways in which near-field energy dynamics could be harnessed to infer local electromagnetic characteristics, and are subsequently sublimated into perspective through various hypothetical scenarios and an Original analogy: Formation of Electromagnetic Waves as soap-film Bubbles.

Treating transient near-field phenomena as a qualitative coherent whole, rather than as a collection of isolated effects, opens the door to exciting alternative interpretations and exploratory imaging strategies, as it suggests that the induced collapse of fields generated by metamaterial antennas — fed with incomplete longer wavelength excitations that the ones currently used for its respective applications— may enable meaningful access to qualitative information rooted in local electromagnetic properties of areas interacting with the field at the moment of collapse;complementing existing systems in areas such as effective range and selective interacting beyond obstacles.

Author's note:

This work is motivated by a long-standing fascination with waves. My initial exposure came from observing how wave diffraction through a slit changed with different frequencies. I found this behavior extremely puzzling and difficult to reconcile with intuition. Seeking to understand it, I began studying fluid dynamics and wave behavior across different media. Over time, a central idea emerged: **Wavelength is a critical factor in defining wave behavior.**

This realization naturally led to a further question: *What happens if a wave in formation is not allowed to complete its wavelength?*

Or more precisely: **What occurs when an electromagnetic wave in formation is constrained in space and time and prevented from evolving into a fully developed far-field wave?**

***Spoiler:**Radiative energy distribution depicted by the mathematical analysis of *Fourier's transform* does not occur instantly and does not capture all energy dynamics taking place.*

A wave is not instantaneously born, nor is it chaos. For it to come into existence and propagate, it must undergo a highly structured process in which coherence is progressively established, field components become perpendicularly aligned, and the initially non-directional energy flow condenses into a net propagating Poynting flux.The process once completed, we perceive as a coherent sinusoidal wave.

During this formative stage, the "incomplete wave" (more accurately described as an evolving field distribution) remains interdependent with its energy source,as it relies on continued energy supply to complete this organization process. As the source begins emitting fields, these fields progressively arrange themselves in space, and begin establishing the conditions required for self-sustained far-field propagation.

In this regime, the forming wave behaves in a predominantly wave-like manner: it advances through gentle diffraction, interacting weakly with its surroundings and minimizing strong, localized coupling with the medium.

If the energy support is abruptly interrupted during these early stages the net pointing flux is disturbed and the unfinished field configuration can no longer sustain its wave-like, diffractive nature. Instead, it undergoes a qualitative transition — a rearrangement or collapse — in which the structure adopts a more field-like character with increased interaction. In this collapsed regime, energy is exchanged through multidirectional pathways within the field itself and the surrounding medium, yet often retaining coupling to its energy source.

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1. Scope and Limitations

Conceptual scope and intent:
Given the intrinsic complexity of the subject and the possibility that certain relevant variables remain insufficiently articulated with the current conceptual understanding, this work is speculative and adopts a concept-driven perspective**.** It does not aim to deliver a fully operational imaging system;rather, it seeks to draw attention to an underexplored

electromagnetic regime: the transient near field reconfiguration during intentional, carefully crafted excitation source disruptions. The focus is not on steady-state fields or fully formed propagating waves, but on the evolution of the near field itself, treating it as a coherent, time-dependent whole ,whose dynamics—rather than its final configuration—may be relevant for imaging, particularly for close range nearfield Imaging such as biomedical nearfield imaging.

Methodological approach:
The approach is deliberately qualitative and concept-focused. The goal is to highlight physical mechanisms and identify potentially informative regimes without introducing a full mathematical formalism or numerical simulations, which in transient near-field configurations can be complex and may obscure physical intuition.

While much of the discussion is grounded in classical electromagnetic principles, certain sections intentionally extend beyond standard interpretations in order to explore underexamined transient regimes. These speculative elements are explicitly marked and conceptually delimited within the text, allowing the reader to clearly distinguish between physically established behavior and exploratory hypotheses.

Technological limitations:
The Collapsing Near Field Imaging method differs fundamentally from conventional diagnostic approaches that rely on averaging over many wave cycles. Instead, it analyzes each(incomplete) wave cycle individually, capturing its dynamics at the moment of collapse. Realizing this requires highly specialized *metamaterial antennas* with the ability to respond to extremely short timescales and very fine current control.

Explicit limitations:
This work does not present a fully operational imaging model, it also does not address regulatory considerations or experimental validation.

2. Introduction: How Current Nearfield Imaging Relies mostly on Quasi-stationary Stable Regimes.

Near-field electromagnetic imaging emerged in the second half of the twentieth century as an extension of classical electromagnetic sensing, motivated by the recognition that electromagnetic fields in the immediate vicinity of a source exhibit strong spatial localization and heightened sensitivity to material properties. **Unlike far-field techniques, which rely on propagating waves and diffraction-limited resolution, near-field methods exploit evanescent and reactive field components whose spatial structure is governed by local interactions rather than long-range propagation.**[1,2]

Over the decades, near-field imaging has been developed and applied across a wide range of contexts. In geophysical and civil-engineering settings, near-field and quasi-near-field electromagnetic techniques have been used for subsurface inspection, ground-penetrating radar, and the detection of buried structures or inhomogeneities. In materials science and industrial inspection, near-field probes have enabled high-resolution characterization of surfaces, interfaces, and defects. In biomedical research, near-field imaging remains experimental and not widely available; it has been explored for boundary detection and qualitative tissue characterization. [3,4,6,8]

In practical near-field imaging systems, material–field interactions are inferred through measurable antenna and system parameters. Typical observables include: *reflection coefficients (such as S11), transmission and coupling coefficients between ports (S21 and higher-order scattering parameters), complex input impedance and admittance, resonant frequency shifts, bandwidth variations, quality factor changes, amplitude and phase responses as functions of frequency, mutual coupling between adjacent antenna elements, and, in time-domain implementations, impulse or step responses and their associated early-time features*. Together, these parameters provide a multidimensional description of how the near electromagnetic field is perturbed by the presence and properties of biological tissue, forming the basis for near-field image reconstruction or qualitative interpretation.[5]

Despite these capabilities, **conventional near-field imaging relies on quasi-stationary or quasi-stable field configurations, often ignoring transient phenomena associated with the early stages of wave formation. These methods typically interpret signals as spatially averaged responses, potentially missing highly localized information present before the field reaches a stable configuration.**[6,7]

The present work introduces a conceptually new approach, termed collapsing near-field imaging, which explicitly exploits the transient near-field during incomplete wave formation. In this method, a propagating field front is monitored, and the collapse is induced at a precise location and distance of interest. This strategy enables enhanced spatial resolution within a targeted volume, while also allowing the field to effectively bypass intermediate obstacles or interfering structures, concentrating the collapse exactly where the information is desired. In other words, instead of averaging over an entire volume, the method selectively extracts localized information by dynamically controlling the near-field collapse, providing a new dimension of resolution and selectivity in near-field imaging.

While, in principle, the proposed collapsing near-field imaging concept could be applied across a wide range of near-field contexts, **close-range scenarios—such as biomedical imaging or near-surface material inspection—are likely to be more practical and effective than long-range implementations, due to reduced near-field decay, possibly better coupling between nearfield and energy source, and the enhanced ability to shape and control the field when the antenna arrays are in close proximity.**

3. Conceptual framework:

3.1 Nearfield:

The near-field refers to the spatial region surrounding an electromagnetic excitation such as an antenna before a fully developed propagating wave is established; its behavior can be modelled through Maxwell's equations. It can be divided into 2 main regions(this zones are not strict boundaries, there is some overlapping in between zones):

Evanescent nearfields extends roughly up to 0.1–0.62 λ, depending on the antenna size, and is dominated by stored energy with minimal radiation. Beyond this lies the radiating near-field or ***Fresnel region***, which stretches up to approximately 2D^2/ λ , where D is the largest antenna dimension. In this region, both reactive and radiative field components coexist, with the radiation gradually becoming more pronounced. Beyond the Fresnel region begins the far-field *(Fraunhofer)* region, dominated entirely by propagating waves.[7,9]

Unlike in the far field—where the electric and magnetic fields are perpendicular to each other, oscillate in phase, and maintain a fixed amplitude relationship—**in the nearfield electric and magnetic fields are not necessarily in phase and not strictly perpendicular. As a result, they do not form a coupled,coherent electromagnetic wave. Instead, the electric and magnetic field configuration remains strongly coupled/interdependent with the producing source.**[9,11,12]

Because of this strong interconnection,**the excitation source (antenna) currents, the intervening near-field distribution, and the outer boundary nearfield conditions("fieldfront") collectively form a coupled system,** in which changes in one component can influence the others. [11,12,26]

Another key characteristic of the near field is the presence of **longitudinal field components, meaning field components that are partially aligned with the direction of energy flow or spatial variation**. These longitudinal components arise naturally from charge accumulation, current continuity, and boundary conditions close to the source, and are especially prominent in reactive and evanescent regimes. Their presence reflects the fact that, **in the near field, electromagnetic energy redistribution dynamics differ from the far-field transverse wave propagation energy transport, suggesting more intricate and complex mechanisms.**[11,14,26]

3.2 Transient Near-Field Phenomena:

Transient near-field phenomena refer to short-lived electromagnetic excitations that arise under non-stationary source conditions, such as abrupt switching, pulsed excitation, rapid modulation, or sudden variations in current and voltage. These phenomena emerge before a steady or quasi-stationary field configuration is established and can be described within the *time-domain* formulation *of Maxwell's equations.*

Although compatible with classical electrodynamics, transient near-field effects often exhibit complex and non-intuitive behavior. They may involve rapidly evolving field topologies, reactive energy storage and release, delayed field reconfiguration, and strong coupling between the source, nearby structures, and surrounding media. Their manifestation is highly sensitive to geometrical discontinuities, material interfaces, and boundary conditions.[18,26,27]

Representative examples include transient reactive fields in the immediate vicinity of antennas during switch-on or switch-off events, non-propagating and evanescent field components generated by pulsed excitations, short-lived surface and interface currents induced by rapidly varying fields, and localized energy concentrations that do not correspond to fully developed propagating waves.[27,34]

In the existing literature, such phenomena are typically investigated as isolated effects, each addressed within its own specific experimental or theoretical context. Consequently, their shared physical characteristics and potential collective behavior are seldom considered as part of a unified picture. **The present work adopts a qualitative and concept-driven perspective, treating transient near-field phenomena collectively rather than individually, with the aim of exploring how their combined dynamics may give rise to emergent behavior relevant for near-field interaction and imaging.**

3.3 Incomplete EM Wave Cycles & How They Differ From Arbitrary Pulses.

The term incomplete electromagnetic wave cycle refers to sinusoidal oscillations that are intentionally interrupted before completing a full period. While such signals may be described as pulses, **in this context they differ from arbitrary shaped pulsed excitations**, as in the incomplete wave cycles that will be used later to form “fieldfronts” **its waveform evolves in a continuous,coherent, smooth sinusoidal fashion(**at least before the moment of collapse)

I believe the sinusoidal shape before the moment of collapse confers the forming field an organized wave-like nature structure that allows the forming field to diffract and minimize interaction, also providing a somewhat known predictable structure before the collapse event takes place.

In accordance with Fourier analysis, such truncated excitations produce a superposition of sinusoidal frequency components. However, this representation should not be interpreted as a direct physical decomposition occurring at the source. Moreover, the Fourier description focuses on the radiative components.[9,17,32]

In practice, incomplete wave excitations also generate substantial resistive and reactive field components. In near-field imaging scenarios—where objects are located in immediate proximity to the excitation source—these reactive contributions dominate over radiative ones.[15,17,20,25]

3.4 Nearfield “Stickiness”:

The term near-field stickiness is introduced to describe the tendency of near-field electromagnetic configurations to remain spatially localized and reactively coupled to their immediate environment, such that local interactions can significantly constrain and influence the global reorganization of the field.

This behavior arises from the ability of nearby matter, interfaces, and adjacent field regions to redistribute charges and currents in response to applied or time-varying electromagnetic excitation. The resulting induced fields oppose rapid changes in the local field configuration and can effectively anchor portions of the near field to surrounding structures.[12,14,26]

In this sense, near-field stickiness does not denote a new fundamental interaction. Rather, it provides a unifying description of electromagnetic responses in which energy is temporarily stored, spatially constrained, and reactively coupled, such that localized interactions can ""drag"", delay, or bias the evolution of the broader near-field configuration**.**

I theorize nearfield stickiness is greatly enhanced at the moment of nearfield collapse(Section 5.2.1).

The concept of near-field stickiness includes, but is not limited to well-established reactive and resistive phenomena such as: *inductance, capacitance,dielectric polarization, reactive fields, field-extended coupling,displacement current interactions,boundary induced field modulation,near-field energy storage,leading edge sharpening upon reflection and non-radiative field exchange.*

3.5 Fieldfront:

The introduced term "fieldfront" could be thought of as the nearfield equivalent of the far-field wavefront, but with some important key distinctions:

In the far-field regime, wavefronts are typically uniform and coherent: all points along the wavefront are in phase, oriented correctly with respect to the direction of propagation, and the wavefront maintains a smooth, nearly spherical or planar geometry. In contrast, for near-field interactions, the concept of a **"fieldfront"** is introduced to simply describe **the leading portion of the electromagnetic field more immediate to the medium**.
Unlike far-field wavefronts, **the fieldfront does not require all points to be in phase or to follow a homogeneous geometry. Rather, it represents the most distally localized part of the field—analogous to the tip of a plane—where the initial interaction with the air occurs.** These fieldfronts can under specific conditions exhibit more pointed or concentrated geometries than their far-field counterparts.

*I theorize "Stickiness" in the Fieldfront could be more when compared to the nearfield portion behind it, given that the fieldfront is like an interface where electrical conditions change more abruptly(similar to how fluids exhibit more interaction in its surface via phenomena such as surface tension).[33] *more information on section 5.2**

3.6 Nearfield Collapse:

One of the central interests of this work is the behavior of electromagnetic fields when wave formation is interrupted before a stable radiative regime is established. This regime, which is often overlooked,can be approached through Maxwell's equations in their full time-dependent form. In such scenarios, the electromagnetic excitation does not smoothly transition into sustained far-field radiation; instead, the energy initially stored in the near field undergoes a rapid redistribution driven by energy dynamics.

In this context, **"near-field collapse" refers to the reorganization of electromagnetic energy** that occurs when the excitation source—nominally driven by a coherent, sinusoidal current—is abruptly interrupted. Although the driving current is initially well-defined, progressive, and spectrally narrow, its sudden termination forces the system to resolve the energy previously stored in the near field through transient, non-stationary field interactions. **In this work, near-field collapse specifically describes the rearrangement of electromagnetic energy following a rapid deviation from steady sinusoidal excitation, rather than excitation by inherently pulsed or incoherent sources.**

I theorize that the electromagnetic field's properties change abruptly at the moment of collapse, and its energy distribution occurs in close relation with the excitation source and the fieldfront. More details about nearfield collapse energy dynamics will be provided in the discussion (section 5.2).

4. Working Principle of Collapsing Nearfields

4.1 Electromagnetic Wave Formation as Soap-film Bubbles Analogy:

Before introducing the collapsing "nearfield imaging" working principle in formal terms, an author's original analogy is provided to aid intuitive understanding.

The analogy is provided as a conceptual aid and does not imply a direct physical correspondence; it is intended to illustrate ideas without asserting that behaviors in one system strictly apply to another.

To understand the proposed concept it is useful to think about electromagnetic wave formation akin to soap bubbles formation:

If a soap film is blown steadily for enough time, the bubble eventually closes itself and detaches, floating away(this would correspond to the establishment of a fully propagating far-field electromagnetic wave).

However, if the blowing is interrupted before the bubble fully forms, the soap film does not detach. Instead, it collapses back toward its point of origin. This incomplete bubble formation serves as an analogy for an electromagnetic excitation that is interrupted before a stable radiative regime is established.

Now consider the presence of a nearby object with a “sticky” surface:**If this object interacts with the incomplete bubble soap film(fieldfront), the subsequent collapse of the film is altered by the degree of stickiness at the point of contact**—moreover, if the object has enough “stickiness” it would be possible that part of the soap film remains attached to the object instead of collapsing back towards the starting point. Observing how this collapse is influenced provides information about the object itself.

This conceptual behavior forms the basis of the proposed Collapsing Nearfield Imaging approach.

One flaw of the analogy is that it assumes there is just an excitation source and a fieldfront(one would wish…). In reality there is a nearfield in between.

More details about how to achieve localized “stickiness”, how to induce and measure “nearfield collapse” and fieldfront dynamics during collapse will be provided in the discussion section.

4.2 Collapsing Nearfield Imaging Operational Overview:

The proposed Collapsing Nearfield Imaging approach builds on the previously presented concepts:

Using antenna arrays, near-field beamforming, and deliberately reactive antenna geometries in conjunction , the electromagnetic interaction is spatially shaped so that a region of enhanced near-field "stickiness" is concentrated at a specific point of the fieldfront. Antennas are driven with a smooth,quasi-sinusoidal current, chosen such that the excitation corresponds to a long-wavelength electromagnetic oscillation. This quasi-monochromatic excitation allows a stable and relatively coherent near-field structure to form, giving rise to a well-defined fieldfront. It is important to note that while the fieldfront spatial distribution might be wide(given the nearfield distribution from long-wavelength excitations)the area of "fieldfront stickiness" is focused and much smaller.

Note that the long wavelength sinusoidal current feed to the antenna did not complete a full wave cycle.

The collapse of the near field is programmed to occur exactly as the fieldfront approaches the region of interest, with antenna parameters gradually or abruptly modified according to a pre-defined schedule. **This controlled adjustment alters the energy balance of the coupled system formed by the antenna, the near field, and the fieldfront, guiding the stored near-field energy to reorganize** (according to the conditions of these 3 elements).

For the proposed application, two collapse regimes—soft and hard—are outlined as illustrative characterizations and will be further described and interpreted in section 5.4.

The signals recorded by antennas during overlaps of these illustrative regimes carry information about the "fieldfront stickiness," which in turn depends strongly on the electric properties of the area of interest.

In this framework, imaging information is not derived from steady-state fields or fully formed propagating waves, but from the transient reconfiguration of near-field energy during collapse. **By controlling both the spatial localization of stickiness and the collapse, Collapsing Nearfield Imaging aims to probe localized electromagnetic responses even when using fields created by long-wavelength excitations that would otherwise lack spatial resolution.**

5.Discussion:

5.1 Focusing Fieldfront "Stickiness"

As previously mentioned **one key point is to focus "the stickiness" into a precise point of the fieldfront,** that way when the wave collapse characteristics are measured in the antenna it is possible to say those measurements correspond to a specific spatial location.

5.1.1 Nearfield beamforming:

Beamforming arises from the controlled superposition of electromagnetic fields emitted by multiple antenna elements. By introducing deliberate phase, timing, and

amplitude offsets across an array, the elements radiate out of sync, yet are engineered so that their field contributions add coherently at selected regions in space. In both radiative and non-radiative regimes, beamforming redistributes where electromagnetic energy accumulates through constructive and destructive interference.

When this principle operates in the far-field, constructive interference produces directed wavefronts that detach from the array and propagate outward along well-defined angles.

In the near-field, however, the same superposition occurs within a fully three-dimensional interaction volume. Because field contributions decay with distance and retain strong spatial structure, many more localized field maxima can be steered to converge toward a single point or compact region.

This enables true 3D energy shaping, where multiple fieldfronts emitted at different times and from different locations achieve constructive interference into a specific region. Near-field beamforming allows energy accumulation in spatial volumes that are fundamentally inaccessible to far-field phased arrays.[22,23,24]

5.1.2 Antenna Design considerations:

Antennas conceived for " Collapsing Nearfield Imaging" would differ fundamentally from conventional radiating antennas, whose design philosophy prioritizes impedance matching and efficient far-field radiation. In contrast, the **antennas envisioned here would intentionally favor reactive behavior over radiative efficiency. This could be achieved through increased effective electrical surface area, deliberate impedance mismatch, and highly pointy geometries in specific points, that promote strong field confinement.** In such configurations, the electromagnetic fields remain tightly bound to the antenna structure and the immediate surrounding space, enabling highly localized interactions with the object of interest.[9]

In antenna arrays envisioned for collapsing near-field imaging, inter-element spacing would be far below the operating wavelength, placing the system deep in the reactive near-field regime. In this regime, strong mutual coupling dominates the array behavior, such that variations in current or impedance in one element directly affect neighboring elements, leading to collective electromagnetic dynamics rather than independent radiation. While often considered detrimental in conventional array design, this strong reactive coupling can be advantageous here, as it enables fine control of the local field distribution. By selectively inducing partial or "soft" collapses in some elements while others remain driven by stable sinusoidal currents, the coupled system may support enhanced near-field beamforming and sharper, more structured field fronts beyond what weakly coupled arrays can achieve.

Additionally, **these antennas would benefit from metamaterial-like properties,** allowing spatially and temporally abrupt variations in electromagnetic response, which could help shape the nearfield collapse process .*More information on section 5.3 (How to control and focus nearfield collapse).*

5.1.3 Antenna Excitation Parameters Before the “Nearfield Collapse”:

Coming back to the “electromagnetic bubbles” analogy:

When forming a bubble, air is introduced in a steady and gradually increasing manner, allowing the soap film to expand smoothly and adopt an approximately half-spherical shape. In the electromagnetic context, this corresponds to **driving the antenna with a smooth, sinusoidal, meterslong wavelenght radiowave current**. Such excitation **produces a coherent and spatially extended near-field structure.** This structure defines the main field distribution, or primary fieldfront, prior to any collapse event.

At this stage, the field is largely symmetric and smoothly distributed, much like a nearly half-spherical bubble formed under gentle and uniform airflow. The energy is stored predominantly in reactive near-field components, and the field remains strongly bound to the antenna.[9,23]

Once this primary fieldfront has been established, its geometry may be deliberately modified through additional, localized excitations. Returning to the bubble analogy, **if one wishes to make the central region of a bubble more pointed, one may briefly blow a fast, focused jet of air at its center while the overall airflow continues.** Provided the soap film tolerates the stress, this produces a localized deformation, sharpening the bubble at the center without destroying its overall structure.

Electromagnetically, this could be achieved via **short-duration, high-energy pulses. These pulses may contain a broad spectral content and are directed toward a specific region of the fieldfront.** Crucially, they do not generate the primary fieldfront themselves; rather, they transiently reshape it by locally increasing energy density and electromagnetic interaction strength. In the context of the present framework, this corresponds to a localized increase in near-field stickiness.

Following the same logic it might be possible to cause “partial soft collapses” in peripheral antennas of the antenna array while keeping the sinusoidal excitation in central antennas, further shaping the evolving field distribution.

The combination of a stable, quasi-monochromatic excitation to establish a smooth, extended near-field structure, together with targeted transient impulses to locally deform and concentrate the field, enables deliberate preconditioning of the near-field prior to collapse. This pre-shaped configuration is expected to play a critical role in controlling where and how the subsequent near-field collapse occurs, ultimately enhancing spatial selectivity and sensitivity.

5.2 Energy Dynamics in Nearfield Collapse:

5.2.1 What is Currently known:

In conventional electromagnetic theory, the abrupt interruption of a near-field excitation is not treated as a distinct physical regime with its own formal designation. Nevertheless, the underlying energy dynamics associated with such interruptions appear across several well-established electromagnetic phenomena. At a coarse level, **the energy stored in reactive near-field configurations is understood to redistribute through a combination of mechanisms** once the driving excitation is altered or terminated.

One well-recognized pathway is energy return to the excitation source. In antenna theory and circuit models, the near field is associated with effective inductive and capacitive energy storage. When excitation conditions change abruptly, part of this stored energy manifests as transient back-action on the antenna, giving rise to phenomena such as current ringing, impedance mismatch transients, and reactive power flow back toward the source.[6,25]

A second pathway involves dissipation within the surrounding medium. In realistic environments—particularly conductive, dielectric, or biological media—near-field excitations induce polarization currents, eddy currents, and displacement currents. When the excitation is interrupted, these induced responses relax through resistive and dielectric losses, leading to localized energy dissipation.[11,26]

A third, less explicitly unified but well-documented aspect concerns energy localization at interfaces and boundaries. Rapidly changing electromagnetic fields are known to produce transient charge accumulation, surface currents, and enhanced field intensities near material discontinuities, impedance boundaries, and geometrical edges. In time-domain analyses, such effects often appear as short-lived field concentrations or "hotspots" near the outermost regions of the near field. While these phenomena are typically analyzed independently, they suggest that part of the stored near-field energy can reorganize locally near the boundary between the excitation region and the surrounding space.[27,33]

Although these processes—source back-action, resistive dissipation, and boundary-localized energy—are well established individually, they are generally not framed as manifestations of a single, unified dynamical event. In particular, the literature does not provide a dedicated conceptual framework describing precisely how near-field energy reorganizes when a smoothly evolving, quasi-sinusoidal excitation is interrupted before a stable radiative regime is established(this is near-field collapse).

5.2.2 A Goose in the Water Park: How Waves Change Their Behavior When Oscillation is Suddenly Interrupted:

For the reasons described above , the precise manner in which energy redistributes during such incomplete sinusoidal excitations remains unclear to me. At this stage the best approach I can provide is through an analogy.

I fully recognize that such reasoning may be flawed, as extrapolating intuition from wave phenomena in one medium to other regimes is not guaranteed to be valid. Nonetheless, I believe that this cross-domain reasoning retains heuristic value, especially when addressing transient behaviors that remain only partially understood.

I theorize that the electromagnetic field properties change abruptly at the moment of collapse, not merely in magnitude but in qualitative behavior. To introduce this idea intuitively, I use the following analogy involving water waves:

A pool that generates artificial waves creates two meter long wavelength waves.

A goose decides to swim approximately one meter away from the wave generator,experiencing a periodic smooth up and down movement with some back and forth(consistent with circular particle motion of surface gravity waves) . Suddenly the generator is abruptly shut off almost mid cycle without any gradual ramp down.The “incomplete wave”beyond can not maintain its original motion,instead it collapses and redistributes its energy. The silly goose feels at that moment the water more like a breaking wave near the shore,experiencing a significant pull or push.

This analogy highlights the sharp contrast in behavior. **Before interruption, long-wavelength waves produced by sinusoidal excitations interact with the medium primarily through smooth diffraction, effectively skirting around obstacles and minimizing direct interaction.** At the moment of collapse, however,the situation reverses: **unable to maintain its diffractive motion, the field abruptly transitions into a highly interactive state, in which energy is redistributed and “stickiness” is enhanced.**

5.3 How to Induce and Control Nearfield Collapse:Metamaterial Antennas.

An important challenge is: **How can one force the wave to collapse at a very specific time?**For such a challenge, metamaterials might provide an answer: **Metamaterials are engineered structures capable of altering key electromagnetic properties** —such as dielectric constant,effective permittivity, effective permeability, impedance, and even their electrical functional geometry—**at extremely high speeds. I believe this capability could enable a very precise and temporally localized collapse of the field in relation to the antenna.** [35]

Allow me to explain with two hypothetical scenarios:

Scenario A: **An *almost* monochromatic antenna (with no metamaterial capabilities) is programmed to emit a single electromagnetic wave of 200 cm wavelength**(the antenna is fed a sine wave current corresponding to a 200cm wavelength EM wave) . The antenna begins emitting field components normally and the fieldfront starts travelling at light speed(of the medium), **but when the fieldfront is only 50 cm away from the antenna, the antenna**

stops its energy supply. In this case, part of the emitted energy will attempt to return in relation to the antenna; however, this return would likely be a smooth and gradual process*(even with stopping the energy supply the antenna electrons might sustain the oscillation by themselves for a short time)*—not ideal for the desired collapse described above.

Scenario B: This configuration is identical to Scenario A, except for one key difference: here the antenna incorporates metamaterial functionality. In this scenario, the antenna does not merely stop the energy input when the fieldfront reaches 50 cm; **it also changes rapidly its electrical parameters, for example:it increases its effective electromagnetic surface geometry by reconfiguring its internal lattice or unfolding additional coil like sub-elements—thus presenting a suddenly larger electromagnetic "surface area/stickiness."**

This abrupt change in the electrical dynamics of the excitation source produces a sharp modification in the energy conditions experienced by the fieldfront, since, as previously discussed, the excitation source, the near-field distribution, and the fieldfront constitute a coupled system**. Such a perturbation may promote a sudden, strong, and highly localized collapse of the near-field structure and a more direct energy distribution in relation to the antenna.**

I even theorize that since nearfields have longitudinal components a sudden current (or a new current pathway)within the metaantenna in the opposite direction the fieldfront is travelling could also prompt and enable shaping of the nearfield collapse.

It might be beneficial to "force the collapse"on a significant percentage of the current going to the antenna ,but leaving another percentage of current to continue its sinusoidal cycle normally.

The "Nearfield Collapse" induced by the antenna array, just like the initial emission could be deliberately asymmetrical, with different elements of the antenna array inducing different collapses at different times to further shape the fieldfront.

5.4 Inferring Electromagnetic properties through Collapsing nearfield Imaging:

5.4.1 Soft and Hard Nearfield Collapses:

As previously noted, the excitation source currents, the near-field distribution, and the evolving fieldfront together constitute a strongly coupled electromagnetic system.

Soft collapse: a not so drastic change in antenna parameters, the idea is that the energy stored in the nearfield redistributes in relation to the antenna, **the fieldfront area with "more stickiness" will in some degree resist said collapse.**

Here I say “in relation to the…”.While saying “towards the antenna” is very tempting. I am not completely sure the energy distribution behaves like a train going from A to B.

Hard collapse: a very sharp and drastic change in antenna parameters, energy stored on nearfield will undergo very fast redistribution in relation to the antenna, **the fieldfront area with “more stickiness” might even exhibit a desired “fieldfront detachment”(a portion of the fieldfront field stays attached and collapses in relation to the object interacting with the fieldfront instead of collapsing in relation to the antenna).**

***The presented “soft and hard collapses” are just illustrative, I envision the real collapses could have hybrid nature: start with soft to “”drain”” the energy from areas of low stickiness and then high to sense only the “sticked fieldfront “ energy.*

The information gathered by antennas in these 2 types of collapse contains information about the “fieldfront stickiness”, which in turn is heavily dependent on the electric properties of the area of interest:

If the object the fieldfront was interacting with at the moment of collapse has “low stickiness” in both the soft and hard collapse a very significant percentage of the energy will rearrange in relation to the antenna.

On the other hand**,if the object exhibits “high stickiness” during the hard collapse some energy collapsing in relation to the antenna “would be missing” as some percentage of the energy collapsed in relation to the object the fieldfront was interacting at the moment of collapse.**

It worth noting that while the overall collapse event is influenced by all circundating nearfields, **in the “hard collapse” the fieldfront detachment event could cause a very abrupt and specific change in antenna parameters and that said detachment** *signature parameters* **contains information specifically from the object the fieldfront portion with enhanced stickiness was interacting with.**

In this sense, **the described pre-detachment and detachment events could cause measurable changes in antenna parameters such as:** Impedance,voltage,current,current waveform,reflection coefficient(S11),frequency components,phase components,harmonic profile,among others.

Rather than a single well-defined parameter, **the collapse process is expected to generate a structured, multi-parameter signature across antenna observables, whose exact form must be determined experimentally.**

*In contrast to conventional imaging modalities, where the entire region of interest and other regions emit or interact simultaneously, **collapsing nearfield imaging captures information cycle by cycle. Each emitted wave targets a specific location, and the image is built sequentially, forming a local, stepwise reconstruction of the area of interest**.*

I theorize that in these collapses the measured components could even have a longitudinal vector(given that in the nearfield such longitudinal components do exist) and carefully planned structure could sense said components with their respective vectors,providing enhanced spatial resolution.

5.4.2 How is the Collapse Event Interpreted and why the Classical Signal-to-Noise Ratio Concept does not Apply.

The collapse of the near electromagnetic field cannot be directly observed in real time, but must be inferred through measurable antenna and system parameters such as impedance variations, scattering coefficients, mutual coupling, transient current responses, and phase evolution. These quantities encode how the near field reorganizes during intentionally interrupted excitations.

Unlike conventional imaging paradigms, the informational content of a collapse event does not separate naturally into a useful signal embedded in background noise. Instead, the entire measured response arises from the same physical process: the global reconfiguration of the near field during collapse. In this regime, the classical concept of signal-to-noise ratio becomes inadequate, as there is no independent “noise” from which a clean signal must be extracted.

A useful analogy can be drawn with the collapse of a soap/water/gas bubble: **When a bubble collapses in free space, the rupture propagates in a largely symmetric manner, and no preferential direction can be inferred. However, if one side of the bubble is in contact with, or in close proximity to, a surface with different mechanical or adhesive properties, the collapse becomes biased: rupture and momentum are preferentially directed toward a region[33]. Importantly, the collapse remains a single, inseparable physical event, yet its internal symmetry is broken by environmental interaction.** Information is therefore encoded in how the collapse departs from symmetry. **Even if individual collapse events are highly complex or variable, the presence of a region with enhanced electromagnetic interaction may systematically bias the collapse in a preferred direction. This bias is reflected in vector-valued changes in antenna parameters**—such as *relative phase shifts, directional coupling, and correlation patterns across array elements,* among others—*rather than in absolute signal amplitudes.*

In this sense, collapse-based near-field imaging does not rely on suppressing randomness, but on interpreting how environmental interactions reshape the internal structure and directionality of the collapse itself.

5.5 Illustrative Example of Collapsing Nearfield Imaging:

5.5.1Comparing Far-Field vs Stationary Near-Field vs Collapsing Near-Field Imaging regimes in Obstacle Scenario:

Consider the following illustrative scenario, designed to contrast the information accessibility afforded by different electromagnetic regimes under identical geometrical constraints:

A transmitting antenna operates at a fixed wavelength of λ = 2 m. A concrete cube of dimensions 1 m × 1 m × 1 m is placed in front of the antenna, acting as a macroscopic obstacle. A smaller metallic cube of dimensions 0.5 m × 0.5 m × 0.5 m is positioned immediately behind the concrete block.

The detection task consists of inferring the presence or absence of the metallic cube while respecting the wavelength constraint and without altering the geometry.

The behavior of the system is examined under three distinct electromagnetic regimes.

Far-Field Imaging Regime:

In the far-field configuration, the electromagnetic field is fully propagative.Wave diffraction is dominated by *geometrical ,Miu and Rayleigh* scattering according to the wavelength and obstacle size.

Under these conditions, the concrete cube acts as the dominant scatterer. **The metallic cube, being fully shadowed and located in close proximity to the rear face of the larger object, contributes negligibly to the far-field scattering pattern. Any diffracted components arising from the cube edges are spatially averaged and lack sufficient resolution to distinguish secondary objects located within the geometrical shadow.**

As a result, the presence of the metallic cube cannot be reliably inferred from far-field observations alone.

Stationary Near-Field Imaging Regime:

In the stationary near-field regime, the field remains harmonically driven and reactively coupled to the antenna. Electric and magnetic field components are no longer strictly transverse, and the field distribution becomes sensitive to local boundary conditions and material properties.

The concrete cube modifies the near-field configuration through polarization and reactive energy storage, while **the metallic cube—despite being geometrically concealed—introduces additional boundary-induced perturbations. However, these perturbations remain partially screened by the concrete block and are embedded within a quasi-stationary field topology.**

Although minor changes in antenna impedance or local field distribution may arise, the coupling remains weak and diffuse, especially once the nearfield flux stabilizes. The contribution of the metallic cube is not isolated in a robust or unambiguous manner.

Collapsing Near-Field Imaging Regime:

In the collapsing near-field scenario, the system is driven by a sinusoidal excitation that is intentionally interrupted before a steady radiative configuration is established. The abrupt termination of energy input disrupts the net Poynting flux and forces the system to resolve the energy previously stored within the near-field region.

At the moment of collapse, the field transitions away from coherent, wave-like transport and into a transient, multi-directional redistribution governed by local reactive coupling. In this regime, both the concrete cube and the concealed metallic cube participate directly in the energy reorganization process.

Despite its geometrical concealment, the metallic cube exhibits strong local electromagnetic coupling due to its high conductivity and proximity to the collapsing fieldfront. This interaction manifests as a pronounced disturbance in antenna parameters and transient response characteristics, mediated by field–matter coupling rather than propagative scattering.

Consequently, the presence of the metallic cube can influence system observables even while remaining fully hidden behind the concrete obstacle.

5.5.2 Interrogating Blood Presence inside a Blood Vessel.

The following example is a very simplified version of how could a "Collapsing nearfield Imaging" system work.

– Consider a scenario in which we aim to determine whether blood is present or absent in a blood vessel. The vessel is 10cm deep.

(Since blood contains iron and iron as a metal has free charges that respond to external fields, it might produce a higher degree of "stickiness" in the fieldfront; that is, the iron in hemoglobin gives rise to local electromagnetic responses that oppose rapid changes in the incident field and, as a consequence, resist the induced collapse of the fieldfront.)

Therefore, a vessel with blood would exhibit higher stickiness, whereas a vessel without blood (such as one affected by a thrombus downstream, would show lower stickiness). This difference in stickiness is reflected in the fieldfront collapse itself and can be measured *during the nearfield collapse phase. "* the thrombus could also have signature specific electromagnetic properties***

– **An excitation wavelength of 60 cm is selected. At this wavelength, an interaction occurring at a depth of 10 cm lies close to the transition between the evanescent near-field region and the Fresnel zone**, where both reactive and radiative field components are present.

– The antenna begins emitting the electromagnetic field. WE assume a biological tissue with a relative permittivity of 50, the approximate propagation speed of the fieldfront is 4.24×10^7 m/s.

– At this propagation speed, the fieldfront reaches the vessel at a depth of 10 cm after 2.36 nanoseconds.

– **Exactly at 2.36 ns, when the fieldfront is interacting with the vessel, a near-field collapse, induced by a controlled and rapid modification of antenna parameters takes place**(as previously described in the discussion).

***This is just to highlight one wishes to create the collapse at the precise time the "fieldfront" is interacting with the area of interest, in reality determining the fieldfront position would be far more complex.It could be required that the change in antenna parameters to induce the Collapse starts before the fieldfront reaches the area of interest, given there could be a delay between change in antenna parameters and the collapse event ***

– In a soft collapse, the antenna parameters are changed moderately. The energy stored in the near field redistributes primarily in relation to the antenna, regions of the fieldfront interacting with media of higher electromagnetic "stickiness" partially resist this redistribution.

– In a hard collapse, the antenna parameters are changed abruptly. The near-field energy undergoes a rapid reorganization, and in regions with sufficiently high stickiness, a portion of the fieldfront may remain transiently associated with the vessel rather than collapsing entirely in relation to the antenna.

Here I say "in relation to the…".While saying "towards the antenna" is very tempting. I am not completely sure the energy distribution behaves like a train going from A to B.

– **A vessel containing flowing blood, associated with higher electromagnetic stickiness, is expected to hinder both soft and hard collapse dynamics, whereas an occluded vessel allows a more direct redistribution of energy in relation to the antenna.**

– During the collapse, system responses are measured by analyzing changes in antenna behavior and transient energy redistribution.

– The procedure may be repeated using slightly different wavelengths, collapse strengths, antenna positions and antenna phased arrays to compare collapse behavior across multiple configurations.

5.6 Collapse propagation & causality implications: Regarding energy distribution according to Fourier,s transform

It is worth noting that this does not challenge Maxwell's equations themselves, but rather questions the widespread assumption that all electromagnetic dynamics must necessarily be interpreted as propagating wave-like disturbances that travel at the speed of light(of the medium). In the near-field regime, the excitation source, the field distribution, and the fieldfront form a coupled physical system whose reconfiguration may be more appropriately described as a redistribution of stored resistive and reactive field energy, rather than as conventional signal propagation.

Moreover, transient near-field phenomena remain incompletely characterized in the literature, and both classical and quantum-motivated studies have reported unconventional energy transfer and velocity behavior(often described as superluminal)in reactive and evanescent field regimes. These observations suggest that additional physical mechanisms and interpretations remain to be elucidated.[28,29,30]

To further illustrate this point, let's consider the following scenarios:

Scenario A: An *almost* monochromatic antenna is programmed to emit a single electromagnetic wave of 200 cm wavelength(the antenna begins receiving a sine wave current corresponding to a 200cm wavelength EM wave) . The antenna starts emitting EM fields normally ,but when the fieldfront is only 50 cm away from the antenna, the antenna stops its energy supply.

In this case, part of the emitted energy will rearrange in relation to the antenna via various mechanisms (antenna electrons might sustain the oscillation by themselves for a short time and extract energy from the circundating nearfield in doing so)

Scenario C: An *almost* monochromatic antenna is programmed to emit a single electromagnetic wave of 200 cm wavelength(the antenna is fed a sine wave current corresponding to a 200cm wavelength EM wave). The antenna is allowed to complete its single cycle normally.

In both scenarios there are receivers 100m away from emitting antennas.The receivers are organized in a line perpendicular to the signal travel direction(with receivers separated 5m away from each other).

It can be agreed that **radiative efficiency in scenario C is relatively high as the wave cycle was completed. Receivers in scenario C will sense the same sinusoidal current pattern that the antenna was fed.Signal amplitude received would be consistent with far field 1/r field decay. They would also sense very coherent wavefronts.**

My question now is, what would receivers in scenario A sense?

Option 1: Receivers would sense the same current pattern that was fed to the antenna in scenario A(a quarter sine wave) with slightly diminished amplitude(correspondent with far field behavior 1/r)with very coherent wavefronts.

Option 2: Receivers would sense nothing(no effective propagating signal was formed(just field components)/ no signal with sufficient strong amplitude to excite the receivers was formed).

Option 3: receivers would sense various frequency components with extremely low amplitude, **even if the receivers had perfect sensitivity to all frequency and field components and the superposition of said components resembled the quarter sine wave fed to the antenna in scenario A, the amplitude drop would be way more pronounced than 1/r.** Also, wavefronts would be far less coherent as in Scenario C

The Fourier transform for such a pulse would contain a broad range of frequencies, higher frequencies could develop into far field radiation. In contrast long wavelength components would exist just as transient field components and likely fail to assemble into far field radiation given the temporal duration of excitation was insufficient [31,32]

Option 1 is incorrect, Option 2 and 3 are more accurate.

However, someone trying to advocate for Option 1 could say: **"The fieldfront moves away from the emitting antenna at *light speed*(of the medium). Therefore no disruption in the antenna can ever catch it."**And while such formulation seems at first glance appealing, it is indeed flawed:

It is a well known fact that a pulse can not retain its shape(like they do in circuits or conductors) ,instead the pulse must rearrange into sine waves according to the *Fourier transform*. Moreover, in this case in particular, **the pulse was interrupted way before its electric and magnetic components were coherent and perpendicularly aligned, for this reason in this scenario at the moment of "pulse collapse" the energy would be predominantly distributed in reactive phenomena in relation to the antenna rather than radiation. And while some energy might become radiation, in no case would it be 100% of the energy.**

This scenario highlights how the fieldfront does not "receive instructions or perturbations" from the antenna as waves, the antenna has no way to know if it is in scenario A or C before the collapse takes place(the field emitted by antennas in both scenarios are identical before collapse).
Instead, the field simply behaves according to its current energy dynamics(which are in turn dependent on energy dynamics of the emission source).

6. Alternative Interpretations and Uses of the Proposed Concept:

Nearfield Collapse Concept Applied to Antenna Arrays and Beamforming:

In standard antenna array theory, spatial field control is achieved through the superposition of continuously generated electromagnetic waves, with relative phase and amplitude differences determining the resulting field distribution. This approach presupposes that wave formation proceeds uninterrupted and that the role of the array is limited to shaping an already established field.

The present work explores the possibility that, in near-field regimes, intentional temporal interruption of excitation may represent a qualitatively different mode of control. Rather than treating waves as persistent entities, this perspective considers transient near-field configurations that are allowed to form only partially before being disrupted. Whether such controlled interruptions under specific circumstances can lead to an exploitable controlled field reorganization remains an open question.

Electromagnetic Wave Formation as a Vibrating String.

A string requires two nodes to sustain oscillation.Extrapolating this analogy to the context of EM nearfields: **one node might correspond to the excitation source, while the other corresponds to the fieldfront.**

On a side note:In a fully developed far-field wave, one might imagine these nodes closing into a self-sustaining configuration.

The analogy is not fully accurate and might actually be misleading in depicting energy dynamics, it just serves to introduce the concept of "nodes", moreover, the entire concept of nodes might be inaccurate and that would not invalidate immediately the "collapsing nearfields framework", Nonetheless I decided to present it, while the concept of nodes in the strict sense might be flawed, the excitation source and fieldfronts could participate more actively than other nearfield components in the energy distribution of nearfield collapse.

Energy redistribution in collapsing near fields is not expected to resemble simple sequential energy transport along a rope.
*In a vibrating string, energy propagates primarily through coupling between neighboring elements. By contrast, **in near-field dynamics, individual field locations may not rely solely on such local interactions. Instead, while local couplings between neighboring regions may also contribute, each location appears to be also influenced by the excitation source and the fieldfront.** In this sense, the near field behaves less like a conventional propagating medium and more like a **tightly bound, partially non-locally coupled ""entangled"" system.***

***For these reasons, at the moment of " nearfield collapse" the energy distribution would occur predominantly in relation to these "nodes",** as these nodes are the "borders of the system"(if one makes a wave in a fishtank, the wave energy will eventually reach the glass walls).*

“Virtual antennas”:

The “Collapsing Nearfield Imaging” described above analyzes the collapse event by its repercussions in antenna parameters. There might be another possibility:

Under specific conditions(such as rotating magnetic fields) and collapsing antenna array designs not described in this text the “nearfield collapse” and the “fieldfront detachment” could be “forced” into redistributing its energy via radiation in relation to the fieldfront node; the emitted spectrum would be dependent on energy dynamics of the energy source and the fieldfront at the moment of detachment. I see this as a very exciting possibility as it allows the creation of tunable “virtual antennas”(points of electromagnetic radiation) in biological tissue and natural bodies via nearfield beamforming and properly shaped collapses.

Extrapolation of the Paradigm to other Wave Imaging Regimes:

Although developed in an electromagnetic context, the conceptual framework presented here may, in principle and with appropriate physical reinterpretation, admit analogs in other wave-mediated systems, including acoustic fields, elastic waves in solids and surface and bulk waves in fluids.

7. Conclusión:

This concept could open a new direction for nearfield imaging, in which fields are formed by feeding excitation sources with intentionally truncated waveforms ,which are not allowed to complete its sinusoidal cycle and arrange into far field components ,but instead are forced to “collapse” and rearrange its energy. The proposed “Collapsing Nearfield” imaging takes advantage of said collapse by sensing various antenna parameters ,which in turn allow characterization of the electric properties in the area of collapse. **Importantly, it might allow the use of the fields generated by incomplete radio waves to interrogate electrical properties in ranges previously unavailable** . Further simulations and experiments are required to characterize “nearfield stickiness” and collapse” and its subsequent measure via antenna parameters.

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The author would be more than happy to receive constructive feedback,engage in discussion and further develop the proposed concept.

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