

A Pursuit of Quantum Neuroscience's Principles: Coherence Field Theory and the Physics of Mind

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Abstract

Some basic physics of burgeoning quantum neuroscience is described. Anatomy of the neuron suggests that nonsynaptic mechanisms of signal transmission occur via electric current acceleration and companion electromagnetic field fluctuation. I have named this mechanism of solution chemistry the ebb effect. Phase-locking between neural structure and electric fields that are emergent from cellular EM field fluctuations, in addition to feedback loops within neural networks, are the probable driver of macroscopic oscillation and flow shapes in the brain. CEMI (conscious electromagnetic information) theory is a promising framework for explaining intentionality and the spectrum of arousal as EM field effects. Relatively low frequency electromagnetic radiation is emitted by the accelerating electric currents of neurons. It is hypothesized that this EM radiation superpositions with molecular structure as it spreads to comprise percepts, the hybrid wavelengths of which form subjective images while wavelength vibrations result in subjective feel. These superposition arrays are termed a coherence field, and in combination with the synchronizing influence of quantum entanglement and electromagnetic fluctuations may constitute much of awareness' substance. If conclusively verified, coherence field theory should have significance ranging from the treatment of perceptual disorders such as anosognosia to advancing foundational constructs like atomic theory.

Keywords

Quantum Coherence, Wave Particle Duality, Superposition, Entanglement, Electromagnetic Field, Electromagnetic Radiation, Ebb Effect, CEMI, Atomic Theory

1. Introduction: Quantum Coherence and the Brain

Historically, as it became apparent that our brains are the primary seat of aware-

ness, composed of around 100 billion cells which interact by way of 100 trillion connections for transmitting electrical signals, mystery surrounding the explanatory gap between matter and mind deepened. This conceptual gap can be generalized as a couple of core issues. The combination problem refers to uncertainty associated with how a vast quantity of separate components integrates to produce the seemingly indivisible and fluid qualities of subjective perception. More enigmatic still is how a mechanistic system of electrical signaling mediated by voltage gradients and chemical concentrations can be this intimately involved in generating a perceptual medium of colors, shapes, textures, feelings, thoughts, etc. which manifests so distinctly from the composition of physical matter as we know it. For centuries it has seemed as if physiological and conscious substance are incompatible domains, but science has made such great strides in the 21st century that it is finally possible to outline preliminaries of a plausible theory describing the connection between matter and mind.

The key to explaining linkage of consciousness with the brain in a comprehensive way, from the cellular to organwide scale, is forming a solid picture of the basic physics involved, and this requires understanding quantum properties of neuronal tissue. Electromagnetic energy transfer between charged particles, electric field influences on the magnetism of atoms and molecules, and substance of awareness to the extent that it emerges from brain function are all at base tied to quantum processes.

Three main quantum phenomena must be considered in this context. Wave/particle duality permits energy to flow amongst or through cellular structures and solutions as wavelike currents even when these structures are composed of chemically stable particles with well-defined shapes and sizes. Quantum superposition allows relatively wavelike electromagnetic radiation to blend into hybrid structures such as colors of the visible spectrum. Superposition occurs between atoms to a more limited degree, and I hypothesize that EM radiation can superposition with atoms when it flows through them, in addition to the spectral signatures created by atomic orbitals while fully absorbing or emitting light as photons of specific energy. This would mean that electromagnetic matter essentially consists of atomic nodes within photonic fields, all more or less cohering as an extremely complex and heterogeneous breadth of energy density. Entanglement is the name given to a dynamic by which constituents of these fields, specifically subatomic particles such as photons, electrons and nucleons, can synchronize in a near-instantaneous way. To this point entanglement is modeled only probabilistically, so statistically significant relationships are observed between large quantities of particles, relatively more wavelike or particle like, as correlations of for instance spin among electrons or phase among photons. Experiments with entanglement suggest that it propagates faster than light across many kilometers and can even happen in a retroactive manner, presumably as a consequence of what are termed “nonlocal” forces still largely shrouded in scientific mystery.

The way subatomic waves and particles superposition and entangle within energy fields is called “quantum coherence”. Since photons, electrons and nucleons all have wavelike properties, they are commonly thought of as wavicles. At the macroatomic scale, at least on Earth, atomic wavicles form agglomerations buzzing with an energy that is typically heterogeneous enough to make the presence of destructive interference an intrinsic aspect of the baseline condition. Thus, optically inspectable particles for instance tend to behave classically, as relatively inert masses whose charges balance and which fluctuate thermodynamically, in line with the traditional concept of deterministic space and time. But though thermodynamism, the state of “decoherence” [1], exists as a sort of structural chassis for Earthbound matter and human physiology, the environment is still in essence subatomic, so decoherence can coexist with small or large durations and expanses of coherence. Postulating in a general sense how quantum coherence coordinates with the brain’s electrical features is the first step in fashioning a model of the interface between substance of physiology and mind.

2. Influence of Quantum Coherence on the Electromagnetic Mechanisms of Neurons

The neuron’s axon is a bodily structure where coherence plays an important role. Textbook introductions describe how voltage gradients are maintained by Na^+ and K^+ ion concentration differentials across the axon’s cell membrane, modulated via selective diffusion through ion channels. But lengthwise voltage gradients within the axon might be even more vital to action potentials, and quantum coherence in aqueous solution drives this mechanism of rapid jumping between membrane nodes.

Na^+ ions are most concentrated outside the axon’s cell membrane, and K^+ ions inside. The myelin sheath, an insulating layer of fat enveloping the axon that increases conductance speed, is punctuated by a node of Ranvier at regular intervals, where voltage-gated Na^+ channels are located. The next region of cellular space on an action potential’s path is the paranode, where myelin attaches to the cell membrane. Once the paranode has been traversed, the juxtaparanode is reached, where voltage-gated K^+ channels are located. Then comes internodal space, with K^+ leakage channels and sodium-potassium pumps to help restore ion gradients of the resting potential between signal transmittances. The procession arrives at a juxtaparanode and then paranode on the next node of Ranvier’s opposite side, after which Na^+ influx is once again initiated, continuing the chain reaction beyond numerous nodes to the synaptic cleft [2].

This anatomy of the neuron has been discerned with enough specificity that a fairly certain hypothesis can be made as to its mechanisms. During an action potential, Na^+ enters the axon at a node of Ranvier as stimulated by the change in voltage called depolarization. Voltage-gated K^+ channels at the juxtaparanode almost immediately begin letting K^+ diffuse out of the axon. The differential between increasingly positive charge at the node of Ranvier and decreasingly positive charge at the juxtaparanode accelerates electromagnetic energy transmit-

tance, an excess force that propels the signal through internodal space. At this point, the next node has not been completely repolarized. Once electromagnetic energy enters its sphere of influence, acceleration is renewed and depolarization occurs soon after. Because the phenomenon, once initiated, involves decelerative inertia across space when charge is constant, I have named this the “ebb effect”. What follows is a description of the mechanism in more structural detail.

An axon’s internal solution is made up mostly of water molecules and positive ions. H₂O is of course a polar molecule, with its hydrogen atoms being relatively positive and the oxygen atom relatively negative, bent somewhat at the fulcrum. A solvation shell of water molecules forms around each Na⁺ and K⁺ ion, with more negative poles of H₂O aligned on the shell’s inner surface and more positive poles facing outward. Thus, the solution contains a complex contour of electric charge, with “positive” and “negative” being relative concepts in this case because these charges all consist in electron wavicle structure. Displaceable electron energy that is more concentrated in a particular region of space, as “negative” polarity, tends to move towards regions of less concentration or “positive” polarity, and this effectuates a dynamic equilibrium of charge distribution as atoms diffuse around.

When Na⁺ enters the axon at a node of Ranvier, average electron energy concentration decreases in that region, drawing nearby electron energy towards it in what is basically a lengthwise voltage gradient. As electron energy shifts towards Na⁺, the energy concentration of adjacent regions reduces, in turn exerting a voltage effect on regions that are more remote from the Na⁺ increase, eventually reaching the paranode and then juxtaparanode. The current of electrical energy is moving towards Na⁺ increase, but its propagation begins adjacent to Na⁺ and then travels outward as a wavefront into successively distant regions. Because the wavefront spreads out while traveling through solution, its strength attenuates with distance, similar to how the intensity of a light wave diminishes as it strays from its source, except electron energy has much greater mass than light and so its shrinking rate of motion bears more resemblance to the behavior of a classical wave, with something like inertial resistance. This is in essence the transition from a state of dynamic equilibrium amongst electron wavicles which causes them to interfere, mitigating quantum coherence or conversely instating decoherence in some measure over largish regions of space, and into a more directional coherence that rapidly flows towards more positive charge, starting in adjacent regions and cascading outward.

As the wavefront shifts away from higher Na⁺ concentrations at the node of Ranvier, it is accompanied by an electromagnetic field fluctuation linked to the flow of electric current out of successively more distant regions of solution and towards the node. When electromagnetic field fluctuation reaches voltage-gated K⁺ channels at the juxtaparanode, K⁺ is triggered to diffuse out of the axon, instigating an even greater disparity in charge, electrical potential, strength of lengthwise voltage. This accelerates electric current towards the initial node of Ranvier, and the wavefront which is coupled to it along with a companion elec-

tromagnetic field fluctuation likewise accelerate in the opposite direction. Force exacted at the juxtaparanode by increase in strength of the lengthwise voltage gradient overcomes deceleration from inertia as the wavefront spreads through the rest of internodal space. In an instant, the wavefront's electromagnetic field fluctuation reaches the next node of Ranvier, prompting Na^+ to diffuse in and renewing the sequence.

The mechanism is similar in dendrites, except that myelin is not present between nodes where voltage-gated Na^+ channels are located, and inward diffusion of Cl^- ions functions to block signal transmission by the counteractive propagation of an electromagnetic wavefront which proceeds in the same direction as current flow. EPSPs (excitatory postsynaptic potentials) from Na^+ influx happen in distal regions of the dendrite, while IPSPs (inhibitory postsynaptic potentials) from Cl^- influx occur proximal to dendrite/soma junctions so less negative ions are required to prevent a dendritic potential from crossing the soma and reaching the junction between axon and soma, called the axon hillock, where an action potential begins. If the force of electron coherence propagation from synapses to dendrite/soma junctions is strong enough that a signal penetrates Cl^- blockage and reaches the soma, this wavefront of energy along with a cooccurring EM field fluctuation accelerates rapidly afterwards in the direction of current flow due to a strong voltage gradient between negative charge around the base of dendrites and the largest concentration of Na^+ channels in a neuron at the axon hillock.

Given neural anatomy, the improbability of explaining signal transmittance without reference to these currents of quantum coherence provides motivation to assert that electrons exist as diffuse waves filling the atom rather than more localized particles, at least in solution. Identifying electromagnetic field fluctuations, called LFPs (local field potentials), as the mechanism by which atoms exert somewhat remote effects to activate voltage-gated ion channels implies a cohesive picture of how extracellular phenomena such as the brain's macroscopic electric field are impacted by and can reciprocally impact intracellular functions. EM fields in the brain are not an epiphenomenon, but rather central to the mechanisms of even individual neurons. The inquiry then seems to be whether a macroscopic EM field is somehow responsible for holism of consciousness.

3. Coherence Fields as a Product of Interactions between EM Fields, EM Radiation and Atoms

A topic that comes up while considering EM fields is why some can be so much greater in magnetization than the brain. Magnetic effects are larger the more aligned the quantum spins of an object's atoms. Synchronization causes constructive interference concentrating the majority of this force in emergent magnetic field lines. The coordinated spins of an iron bar magnet's atoms of course generate this sort of pattern, and molten iron surrounding the Earth's core produces massive magnetic field lines due to a homogeneous flow induced by the

planet's rotation in addition to peculiarities of heating and cooling. Atoms of the brain are also magnetic, attracting and repelling in a comparable manner, but the haphazard orientation of quantum spins results in destructive interference so that these effects are negligible even at the cellular scale. The coherence currents of neurons punctuated by ion diffusion across membranes, which can manifest in oscillating and traveling waves as large as a dozen centimeters in length [3], are almost exclusively electric.

How can currents that propagate on an ultramicroscopic scale in billions of neurons disjoined by intricate and diverse synaptic bottlenecks synchronize tightly enough to form integrated waves of macroscopic girth as recorded by EEG? Feedback loops constructed of axon to dendrite connections running both ways between bundles of nervous tissue or brain regions can explicate this to an extent, but the organ seems more cohesive than we would expect of somewhat asymmetrical signal coupling. Evidence obtained from *in vitro* experimentation suggests that phase-locking exists among neural networks, allowing large quantities of neurons to fire with perfect in phase synchronicity. Researchers hypothesize that this mechanism depends on interaction of the electric field with ion channels, modulating diffusion in an extremely organized way. A macroscopic electric field emergent from feedback loops and widespread phase-locking could then saturate tissue as it oscillates and flows, acting upon magnetic charge of the brain's atoms to evoke holistic effects.

Molecular biologist Johnjoe McFadden's CEMI (conscious electromagnetic information) theory proposes that awareness' integration is an outcome of pervasive phase-locking of neurons with the brain's EM field. Neurons that are adapted for sensitivity to EM fields via phase-locking participate in conscious processes, while EM field insensitive neurons are responsible for unconscious processes. This explains some features of the human mind, notably that fully attentive awareness consists in serial processing as opposed to massively parallel processing of the unconscious, depicted as a segregation of CEMI fields from bordering EM fields. Even more significant is that it demystifies the experience of free will, for in CEMI theory volition is simply identical to EM field effects [4]. A theory akin to CEMI can also perhaps account for the subconscious, as a spectrum of low to high arousal arising from degree of breadth and saturation of phase-locking [5].

Coupling of neural networks in feedback loops alongside mechanisms of phase-locking with the brain's electric field hold much promise for explaining consciousness' holism, as the outcome of macroscopic forces synchronizing and binding magnetized atoms within large swaths of tissue. But puzzles remain, for it is still not apparent how this emergent unity of electrical signals mediated by chemical concentrations looks or feels like anything. Why does experience include subjective percepts such as colors, shapes, textures, rather than only objective correlates of these phenomena? Why is experience a consciousness and not merely circuitry?

Elucidation may come from modeling the superposition of light with atomic

structure. Similar to the rest of Earth's matter, the brain is filled with waves of EM radiation, ripples caused by the acceleration of electrons amongst atoms, traveling at around 300 million meters per second through permissive environments. In general, the frequency of this radiation is lower when the electrical coherence current within a given medium is larger. Acceleration of electrons in the valence shell of individual atoms tends to make perturbations that result in visible light, from 400 - 700 nm in wavelength, while radio waves caused by acceleration within relatively large electric currents have wavelengths of anywhere from 1 mm to 100 km. The brain is of course a massive repository of electric current, and since neurons are microscopic, the EM radiation emitted is higher in frequency than for instance a transmission line, but still low enough that it can flow through matter somewhat uninhibited, like radio waves and more unlike visible light.

The ebb effect in combination with neuron anatomy indicates that acceleration of electric current happens between a node of Ranvier and its juxtaparanodes, between dendrite nodes and the soma, towards Ca^{2+} concentration at the synaptic cleft, and most broadly within the soma. So each neuron emits EM radiation low enough in frequency to travel through both liquids and solids. Intensity of course diminishes quickly with distance, but individual radiative fields would probably span many micrometers irrespective of cell membranes and additional molecular structures. If low frequency light superpositions in some way with atoms as it flows through them, and since the speed of this radiation is effectively instantaneous within the brain, it might be the case that at least millions of almost steady state photonic fields bind with biochemical pathways and molecular complexes as individual units, perhaps including entanglement effects knitting these superposition arrays together even more tightly. The most compelling hypothesis to this point is that the ultrahybrid wavelengths of superposition structures do not merely correlate with percepts but actually are percepts. A mechanism of superposition would be analogous to how wavelengths of light additively blend as the visible spectrum, but in this model the spectrum of subjective percepts is much more diverse, as observation of the mind obviously supports. EM field effects could then synchronize these percepts on a macroscopic scale. I term this entire apparatus of electromagnetic energy flow, feedback loop or EM field synchronization, and wave/wavicle binding a "coherence field", and it may be possible to subsume the whole line of investigation under the heading of coherence field theory.

This model of perception is teeming with uncertainties at our present stage of knowledge, and the potential for experimentation almost untapped. Once anticipated principles of radiative/molecular binding are specified, experiments can be designed to investigate how EM radiation interacts with tissue, perhaps by parsing and identifying in greater detail the biochemistry of brain regions that are most likely to harbor coherence field effects, examining superposition properties in isolation and *in vitro*, then moving on to *in vivo* methods. This might discover novel classes of functional molecule, paving the way for a new era of

medications and supplements to treat or enhance percepts on the cellular scale.

At this point, we do not possess much direct evidence for coherence field theory beyond the fact that it fills a gap in our knowledge of the physical world quite seamlessly, almost with the force of necessity. Early research into light/matter interactions within biological systems has focused on microtubules. These cytoskeletal filaments are a likely candidate for extensive superposition between constituent molecules due to compactness, and contain regularized patterns of light-sensitive, aromatic amino acids such as tryptophan. The tryptophan molecules of a single microtubule can be stimulated by UV radiation to transmit energy between them across distances of micrometers. Anesthetics seem to inhibit this activity, hinting at a connection with consciousness. The mechanism resembles that found in photosynthetic reaction centers and may be quite common to nature. In neurons, microtubules influence receptors, ion channels and plasticity generally, so light-stimulated behavior could have a significant role for regulating cellular structure. If molecules are proven responsive to larger wavelengths of light as emitted by electric currents, the first experimental data implies that activation would occur at greater distance scales, and the proposed mechanism of percept generation is well within possibility. Much more data has been discovered for the effect of EM fields, which in addition to phase-locking and numerous further functions mediate energy transduction in transmission channels of the cytoskeleton, processes governing the entire structure of a cell along with the movement of components such as mitochondria, vesicles, etc. [6].

We have plenty of circumstantial evidence. The largest, steadiest and most rapid regions of accelerating electron coherence in a neuron are located within the soma as a flow from dendrites to axon hillock, and perhaps also around the synapse with its gradient ranging from Na^+ and K^+ to Ca^{2+} , which happen to be where molecular arrays capable of complex superposition with EM radiation most likely reside. The superposition of low frequency EM radiation with molecular structure would probably not be obstructed by factors of heat and moisture that have seemed prohibitive to widespread coherence amongst molecules alone. Within a plenitude of environments, photon entanglement is especially robust while operative at large spatial ranges, which supplies a viable binding mechanism for percept units constructed of molecular parts that are distributed somewhat widely in cellular solution. And coherence fields of this kind explain why brain matter has a darkish tint while myelin is white. Grey matter of dendrites, soma and the interior of axons is darkly shaded because it absorptively superpositions with large amounts of EM radiation to form percepts, while myelinated white matter strongly reflects the light that does not penetrate atoms so radiative fields minimally attenuate across space. From the outside neurons look greyish, but from the inside contents of these cells may superposition with EM radiation to form the substance of perception.

If a superposition mechanism amongst coherence fields is proven to exist, and methods are found to observe this in detail, it seems intuitive that researchers will find it easy to model the way percepts look, perhaps including mental im-

ages and hallucinatory artifacts of brain processes, perceptual phenomena which do not necessarily arise from direct stimulation by the environment. But what about how percepts feel? Why does perception have nondimensional qualities in addition to spatial extension and temporal duration?

Percepts of feeling might simply be a consequence of the way superpositioned wavelengths oscillate collectively as resonances, vibrations. All matter from the atomic to the macroscopic scale vibrates, and it is difficult to think of a vibration that does not feel like something. Perhaps it is intrinsic of waves and wavicles to consist in fragments of feeling as they resonate. However, matter on the nanoscale does not seem to feel with much resolution. The body has apparently adapted structures which greatly increase the resolution of these resonances, resulting in a vast spectrum of emergent feelings. The seemingly intangible quality of emotion and thought insofar as it is embodied by the brain may be no more than various patterns in how complex matter feels. Addressing the question of why matter oscillates, travels, interacts as a wave in the first place could be key to unlocking fundamental mechanisms of consciousness.

One might have derivative curiosity regarding how a coherence field in the brain can produce percepts which appear to be outside of the body. For example, if percepts of vision are located in the occipital lobe or elsewhere in the brain, why is this not introspected as such? Thinking about our optical faculties, we can reflect upon how the sharply focused visual field is only as large as the size of your thumb held at arm's length in front of the face, with the majority of human vision pieced together from eye saccading and involuntary memory. Sensory modalities consist in segregated stimuli obtained from diverse sources which are then assembled by the brain to form a perceptual world. This integrating seems almost effortless in many cases, but the process is profoundly an indirect representation rather than direct correspondence, though less so than traditional neuroscience has suggested if coherence field theory proves accurate. Just as electrochemical signaling in a neural network contributes to cognitive function, the coherence fields within those neural frameworks might actually *be* important aspects of consciousness' substance itself.

At first glance it seems as if mechanisms of superposition and entanglement among photonic fields and atomic nodes are passive compared to EM field synchronization effects, so why did evolutionary pressures cause the percepts that comprise consciousness to develop such superabundant rather than parsimonious forms? The answer would simply be that basic properties of perception, most generally feeling and appearance, are inherent in matter. When the structure of organic matter evolves towards more complex physiology, percepts also evolve into more complicated forms as an essential facet of this matter's structure. A more complex brain will ineluctably evolve more complex perceptual forms akin to the resonances of human imagination, emotion and thought. These are probably not the only types of intellectualized resonance structures possible, but in this schema matter mutates as a coherence field, not merely as nonconscious machinery from which perception emerges epiphenomenally. This is not of

course the entire story, for nonlocal forces seem to be operative upon electromagnetic matter as a further mystery, but the coherence field model of perception might nonetheless start to expand our comprehension of nature tremendously.

4. Conclusion: Implications of Coherence Field Theory for Neuroscience and Beyond

After considering the import of quantum physics for neuroscience, especially the idea of quantum coherence, preliminaries of a complete explanation for the brain's role in constituting consciousness' substance seem accessible. In the cellular solution of neurons, wavefronts of electromagnetic energy caused by currents of electron coherence rapidly move between centers of charge, accelerated by periodic increases in charge disparity between neural regions. Electromagnetic field fluctuations tied to this energy flow trigger voltage-gated ion channels to cyclically open and close. Phase-locking between EM fields and neural chemistry along with feedback loops synchronize electromagnetic energy flows on a macroscopic scale, as oscillating and traveling waves of the kind recorded by EEG. A plausible hypothesis is that EM field dynamics are responsible for holism of fully attentive consciousness and the experience of willed agency. Accelerating electric current in neurons induces EM radiation low enough in frequency to transmit through neural tissue. These waves may superposition with the brain's atomic wavelike structure as they travel to produce hybrid wavelengths entangled into at least millions of individual percepts. Combinatorial properties of wavelength might create the appearance of percepts, and vibrations of the feel. Compound percept arrays would then likely be the substance of sensations, emotions and thoughts. If entangled superpositions emergent from basic quantum mechanisms synchronize via phase-locking and feedback loops as a functional coherence field in brains, this at least partly explains why the evolution of mind has constructed such a panoply of perceptual forms, for building blocks of perception's substance are an intrinsic facet of electromagnetic matter.

If coherence field theory is proven accurate, this has significance for many domains of knowledge. As an example we can consider medical treatment. Understanding mechanisms by which percepts emerge from biochemistry might enable us to better distinguish perceptual from affective states so that medications can directly target percept disorders as they manifest in the brain, without inducing sedative, stimulant, or systemic side effects. It could become possible to treat conditions such as many types of anosognosia [7] in which the characteristics and awareness of one's own perceptual field are impaired. Psychedelic substances change the shape or direction of flow in the brain's electric field at a macroscopic level, instigating acute and temporarily incapacitating hallucinations [8], but medicine might gain the ability to micromanage a similar modifying of the perceptual field with cures or enhancements that do not include a period of nonfunctionality for the subject.

Coherence field theory may destine a reconstituted model of the atom. It

seems to be the case that electrons and electromagnetic radiation are dual aspects of a unitary electromagnetic field, with light waves an undulation in this field caused by electron motion, and electrons in orbital arrangements not essentially particulate at all but rather a wavelike perturbation of the electromagnetic field by motion of nuclear fields that are coupled to it. In consort with additional known phenomena alongside mathematical formulations, it might be possible to encompass the entire coherence concept utilizing a single wave-medium model, subsequently deriving new experiments and technologies that unite quantum matter's statistical structure with fundamental attributes of its relatively stable or unstable, perpetually transformative motions, in the brain and elsewhere. Science could be on course to fashion a synthetic model of material and psychical substance, launching society into the next era of discoveries and towards a more actualized humanity.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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