ChatGPT

Scalar Electromagnetic Waves: A Contemporary Research Survey

Introduction

Scalar electromagnetic waves – often referred to as *scalar waves* or longitudinal EM waves – are hypothetical wave phenomena distinct from conventional transverse electromagnetic radiation. In a scalar EM wave, the electric or magnetic field (or a potential field) would oscillate in line with the direction of propagation (longitudinally), or manifest as a scalar (directionless) oscillation. This concept has generated controversy: mainstream physics largely rejects free-space scalar EM waves as incompatible with Maxwell's equations, while fringe theorists and inventors have proposed alternative models and extraordinary applications. This report surveys the current understanding, contrasting established scientific perspectives with alternative theories, summarizing theoretical models, experimental efforts, and proposed applications. Relevant literature from the past ~20 years (with historical context) is cited to provide a comprehensive view.

1. Mainstream Scientific Perspectives

No Free-Space Scalar Waves in Classical EM: In classical electrodynamics, Maxwell's equations **do not permit propagating longitudinal electric or "scalar" EM waves in free space**. Any electromagnetic wave in vacuum must be transverse – the electric (E) and magnetic (B) fields oscillate perpendicular to the direction of travel. A longitudinal E-field component in a wave **is fundamentally "incompatible with Maxwell's equations"** [1] . As one review states, the concept of a "longitudinal scalar wave" is *"not well-established within mainstream physics and lacks empirical evidence or widely accepted theoretical frameworks"* [2] . In standard Maxwell theory, Gauss's law and the absence of magnetic monopoles enforce that radiation fields have $\nabla \cdot \mathbf{E} = 0$ and $\nabla \cdot \mathbf{B} = 0$ in free space, meaning no net "scalar" charge oscillation propagates outward [3] . Essentially, any time-varying charge will launch ordinary transverse EM waves (with both E and B components) rather than a pure scalar disturbance.

Special Media and Near-Field Phenomena: While free-space scalar EM waves are ruled out, **longitudinal electric oscillations can occur in certain media or constrained conditions**. For example, plasmas support **electrostatic plasma waves** (also called Langmuir waves) where electrons oscillate longitudinally – but these require the medium's charges and do not propagate in vacuum. Similarly, in guided structures or near-field zones of antennas, **longitudinal field components** can exist locally. A recent physics study notes that longitudinal EM waves (E field parallel to the wavevector) *"are very rare and appear under special conditions in a limited class of media, for example, in plasmas"* [4] . Modern research on metamaterials has even engineered structures that support longitudinal EM modes. Sakhno *et al.* (2021) demonstrated a wire-array metamaterial that propagates a longitudinal wave over a broad frequency band [5] . These effects, however, **do not violate Maxwellian physics** – they arise only when material responses permit (e.g. effectively zero permittivity or waveguide boundary conditions). In all cases, a **true scalar wave in vacuum has not been observed**. Mainstream consensus holds that reports of scalar EM waves in free space are either misinterpretations or artifacts. Indeed, numerous claimed detections have been **attributed to experimental error or conventional effects** [3].

Skepticism and Scientific Verdict: Established physics communities generally consider "scalar electromagnetic waves" to be a **fringe concept**. There is no accepted evidence of EM waves that carry energy without an accompanying transverse field (Poynting vector) in vacuum. Professional critiques have addressed this topic directly. Butterworth *et al.* (2013), after replicating a controversial experiment, flatly stated that **Maxwell's four equations "taken together, preclude the existence of a longitudinal electric field component in a free-space wave"**, and that most assertions of such waves stem from *"obvious fallacies, poor observations, or misinterpretations of data"* [1] [3]. In summary, the **prevailing scientific view** is that scalar EM waves (as described in fringe literature) either **do not exist** or cannot propagate in open space without a medium. The concept is absent from peer-reviewed electromagnetic textbooks, and when mentioned, it is often in the context of debunking or explaining why such waves are not part of classical electrodynamics [2].

2. Fringe and Alternative Theories

Despite mainstream skepticism, **scalar waves have a devoted following in fringe physics and alternative science circles**. Historically, these ideas often trace back to interpretations of **Nikola Tesla's work**. Tesla, in the 1890s, spoke of **"non-Hertzian" waves** and performed wireless power transmission experiments using high-voltage resonant coils. He claimed to have observed phenomena that conventional radio waves (Hertzian waves) could not explain. In a 1904 patent, Tesla described using loosely coupled coils to minimize ordinary EM radiation and instead send energy through the "natural medium," noting *"the rate of radiation of energy into space in the form of Hertzian waves is very small… paradoxical as it may seem, the effect will increase with distance"* [6]. Some have interpreted Tesla's method as generating **ground or etheric longitudinal waves** that propagate through the earth. **Modern Tesla-inspired theorists** often assert that *"scalar waves were found and used at first by Nikola Tesla in his wireless energy transmission experiments"* [7]. They attribute to Tesla the discovery of scalar EM energy that can travel faster than light or without loss – though these claims are speculative and not documented in Tesla's own terminology. (Tesla's actual terms were "standing waves" or "disturbances in the ether," and historians debate the extent to which he envisaged true scalar fields versus low-frequency inductive coupling.)

In the late 20th century, a number of **alternative researchers and inventors** latched onto the scalar wave concept. Terms like "scalar electrodynamics" and "Tesla waves" entered the vernacular of pseudoscientific literature. For example, **Thomas E. Bearden**, a retired U.S. Army officer, popularized the idea of scalar EM waves as **mysterious Soviet weapons** in the 1980s, linking them to everything from weather control to telekinesis (claims not substantiated by evidence). **Konstantin Meyl**, a German professor, emerged in the early 2000s as a prominent proponent with academic credentials. Meyl developed a theory he claimed was a **unified field theory based on Tesla's ideas**, involving so-called "potential vortices." According to Meyl, classical EM is incomplete and allows for longitudinal electric waves if one re-inserts neglected terms from Maxwell's original equations [8]. He built and sold "scalar wave" transmitter kits – two coupled flat coil antennas – to demonstrate the effect. Meyl's reports claim **lossless power transmission** between transmitter and receiver, independent of distance or shielding, phenomena he attributes to scalar waves rather than conventional EM induction. Indeed, Meyl asserts that *"electric charge carriers oscillating in an antenna rod form longitudinal standing waves"* and can transmit through obstacles, whereas a Faraday cage **"cannot screen the transmitted scalar waves"** (as he claims) [9].

Several **fringe publications and conferences** have propagated these ideas. Enthusiast engineers like Eric Dollard, hobbyists like Jean-Louis Naudin, and others have attempted replications of Tesla/Meyl devices. The **language used in alternative literature** is often a mix of scientific terms and speculative leaps. For instance, scalar waves are sometimes described as vacuum longitudinal vibrations or “electrostatic waves” that **carry pure potential**. Bahman Zohuri’s book *Scalar Wave Driven Energy Applications* (2019) is an example of a sympathetic take on the topic, suggesting scalar waves are *“longitudinal waves of potentials”* – a combination of the electric scalar potential (ϕ) and magnetic vector potential ($\mathbf{A}$) – forming an electromagnetic analog of sound waves [10] [7]. Fringe theorists often claim this **“More Complete Electrodynamics”** revives aspects of Maxwell’s original quaternion formulation and can resolve physics enigmas (e.g. gauge invariance issues or quantum gravity) [11] [12].

Extraordinary Claims: Alternative proponents attribute remarkable properties to scalar waves, far beyond standard physics. Common claims are that scalar waves: travel *“faster than the speed of light,” “transcend space and time,”* and can affect health and matter in profound ways [13]. For example, some write that scalar fields can *“coherently reorder”* water’s molecular structure or *“positively increase immune function in mammals”* [13]. In the realm of conspiracy and pseudoscience, scalar waves have been invoked to explain free-energy devices, antigravity propulsion, and even paranormal phenomena. It’s important to note that **these assertions lack credible experimental backing**. Fringe authors frequently cite each other or historic anecdotes rather than rigorous studies. As a result, the established scientific community views such claims with **high skepticism**, emphasizing the need for critical thinking and caution when evaluating them [14]. To date, **no peer-reviewed experiment has confirmed faster-than-light signals or exotic biological effects from “scalar energy.”** The fringe theories remain speculative and controversial, residing outside the scientific mainstream.

3. Theoretical Foundations of Scalar EM Waves

Although classical Maxwellian electrodynamics does not include free-space scalar waves, physicists have explored **extended theories** that might allow such phenomena. These theories typically introduce an additional scalar field or relax a symmetry constraint in Maxwell’s equations. One well-studied approach is based on the **Aharonov–Bohm electrodynamic Lagrangian**, which **adds an extra degree of freedom** to the field. In this extended framework (sometimes dubbed *“scalar electrodynamics”* in literature), the electromagnetic field possesses a scalar component S that can propagate. *“The extension of Maxwell’s equations according to the Aharonov–Bohm Lagrangian... is quite natural”* and in it *“a scalar field which is not present in Maxwell theory”* plays a crucial role [15]. Notably, this theory has a **reduced gauge invariance**: one cannot gauge-transform away the scalar potential entirely [16]. The scalar field S in such models is usually defined (in Lorenz gauge) as:

$$S = \mu_0 \epsilon_0 \frac{\partial \phi}{\partial t} + \nabla \cdot \mathbf{A},$$

where ϕ is the electric potential and $\mathbf{A}$ is the vector potential [17]. Under **Maxwell’s standard theory**, S is effectively zero in free space because its source term $\partial_t \rho + \nabla \cdot \mathbf{J}$ (the local charge non-conservation, sometimes called “extra-current”) is zero – electric charge is locally conserved. However, in the extended theory, if one allows situations where $\partial_t \rho + \nabla \cdot \mathbf{J} \neq 0$ (e.g. an effective charge appearing or disappearing, as might happen in certain quantum scenarios or within a complex medium), then S can be nonzero and obey a wave equation [18] [19]. In essence, this adds a **longitudinal scalar wave mode** in addition to the normal transverse modes. Researchers such as *Fernando Minotti* and *Giovanni Modanese* (2023) have analyzed this theory and found that while a scalar wave **could exist in vacuum** under those conditions, it would be *"reflected"* at the interface of any ordinary material – unable to propagate in normal media – because normal matter enforces charge continuity [20] [21]. This theoretical result implies that even if one created a scalar EM disturbance in free space, it might not penetrate or deposit energy into standard materials easily (a detail at odds with some fringe claims).

Another line of inquiry involves revisiting Maxwell's equations themselves. **Koen van Vlaenderen and André Waser** (2001) proposed a **generalized electrodynamics** that admits a scalar field and longitudinal solutions [22]. They added a scalar potential term to Maxwell's equations in potential form, yielding what they called a "scalar longitudinal wave" alongside the conventional fields. This work, published in the *Hadronic Journal*, argued that a **charge density wave** (oscillating ρ) could propagate as a scalar wave if accompanied by the new field. While intriguing, the idea did not gain widespread acceptance, partly due to Hadronic Journal's reputation for publishing speculative physics. Nevertheless, it inspired further investigations. **L.M. Hively and G.C. Giakos** (2012) built on such concepts in an effort to create a *"more complete electrodynamic theory"*. They pointed out that Maxwell's equations in their standard form are under-determined (owing to gauge freedom) and posited that including a dynamically significant scalar potential could address certain gaps [23]. Hively's extended model, consistent with van Vlaenderen's, suggests that **an EM wave with no transverse E or B field** – only potentials – could carry information and energy. This underlies proposals (discussed in the next section) for "field-free" communications.

Importantly, even **within classical Maxwell theory**, one can identify edge-case solutions that resemble scalar or longitudinal waves when unusual source distributions are used. A recent paper by **V. Simulik** (2016) demonstrated that if one assumes a **"specific gradient-type" distribution of charge and current**, the standard Maxwell equations do yield an **exact solution with a longitudinal electric field component and an accompanying scalar potential wave** [24]. In Simulik's construction, an oscillating charged density that is spatially uniform (except for a gradient in one region) can launch a wave where $\mathbf{E}$ points along the direction of propagation and $\mathbf{B} = 0$. This is consistent with earlier analyses by Umul (2008) and others. For instance, Umul studied radiation from a conducting sphere with a uniform surface charge oscillation and found that the resulting field has **both transverse and longitudinal parts**: *"the longitudinal electric field has a spatial $1/r$ dependence and does not interact with the transverse magnetic field, since it is curl-free"* [25]. That longitudinal part can be seen as a **scalar wave** emanation – it falls off as $1/r$ (in field amplitude) instead of forming the usual far-field radiation pattern. Such solutions are essentially **near-field or non-radiating modes** unless some asymmetry allows them to escape to infinity. They were *"not noticed before,"* Simulik notes, because typical textbook scenarios assume localized oscillating currents (which enforce transverse radiation) [26]. These theoretical studies indicate that **longitudinal EM modes are not outright forbidden**; however, they either require unphysical source conditions (like time-varying charge that violates charge conservation) or they manifest only in constrained setups (waveguides, near-fields, special media). So far, they **do not provide a clear path to practical free-space scalar wave transmission** – but they keep the door open for exploring EM potentials in novel ways. In summary, the theoretical foundation for scalar EM waves lies in **augmenting Maxwell's theory** (adding scalar degrees of freedom or exploiting gauge effects) and such models have been published in journals ranging from *Physics Essays* to *Symmetry*. This provides a formal vocabulary to discuss scalar waves, even if the physical reality of these waves remains unproven.

4. Experimental Evidence and Attempts

Given the contentious nature of scalar waves, **experimental evidence is crucial** – yet, convincing evidence is largely absent. Many experiments have been attempted, **ranging from early 20th-century wireless power demonstrations to modern tabletop setups**, but none have conclusively verified a scalar EM wave that defies conventional explanation. Here we outline some of the notable attempts and their outcomes:

- **Tesla's Wireless Power Experiments (1890s–1900s):** Nikola Tesla's famous demonstrations – lighting lamps wirelessly and the Colorado Springs experiment (1899) – are often cited by scalar-wave enthusiasts as evidence that Tesla was transmitting energy via longitudinal waves through the ground or atmosphere. Historically, Tesla did achieve long-distance energy transfer (e.g. powering loads miles away), but mainstream analysis explains this via *resonant inductive coupling and the formation of standing wave currents in the Earth* (in effect, a giant low-frequency radio system) rather than any exotic new wave. Tesla's setup used the Earth and ionosphere as parts of a circuit, launching what we now recognize as **low-frequency electromagnetic waves and quasi-static induction fields**. He himself noted that his system's radiation of Hertzian waves was minimal [6]. Thus, while Tesla's results were real, **there is no clear evidence he produced "pure" scalar waves**; the effects can be accounted for by known physics (ground currents, near-field coupling, and propagating radial surface waves). The lore surrounding Tesla has nonetheless fueled later experiments.

- **Monstein & Wesley's Ball Antenna Experiment (2002):** One of the few **published claims of scalar wave detection** appeared in 2002, when C. Monstein and J. P. Wesley reported observing a *"scalar longitudinal electrodynamic wave"* [27]. They used a so-called **ball antenna** (two metal spheres forming a capacitor) with a spark transmitter. By separating the spheres by more than a wavelength, they attempted to launch a longitudinal E-wave. Monstein and Wesley published in *Europhysics Letters* that they detected a signal consistent with a **longitudinal wave (E-field along propagation)**, and no corresponding magnetic field. This result was highly controversial. Follow-up scrutiny quickly emerged: other physicists pointed out theoretical and methodological flaws. In fact, a later analysis by Rebilas (2008) showed that Monstein and Wesley likely detected **ordinary transverse EM waves** induced by currents in the ground (their large sphere antenna inadvertently drove currents along the earth, essentially acting like a regular low-frequency antenna) [27]. Crucially, a team at Texas A&M (Butterworth *et al*.) **replicated the Monstein-Wesley experiment in 2013** with the same apparatus dimensions [28] [29]. They found a similar unusual radiation pattern as originally reported – lending some credibility that the setup produced repeatable results – *but* their detailed measurements did **not support the scalar wave interpretation**. They remained convinced that Maxwell's theory was correct and that some unknown conventional mechanism (perhaps a complex induction or plasma effect) was responsible [29] [30]. Butterworth *et al.* noted that Monstein and Wesley's own theoretical model was almost universally considered incorrect, and their replication, while reproducing the pattern, *"dispute[d] MW's claim on theoretical grounds"* and also found the alternative (ground current) explanation incomplete [31]. In the end, they concluded *"a yet-unidentified mechanism must be producing the observed results"* [32], but it was not a free-space longitudinal wave. This saga illustrates how initial claims of scalar waves have so far not survived rigorous testing – each apparent signal has been **explained away or left unresolved** without rewriting electrodynamics.

- **Konstantin Meyl's Scalar Wave Transmitter (2000s):** In the 2000s, Prof. Konstantin Meyl introduced a **"Tesla wave" experimental kit**, consisting of a transmitter and receiver coil system tuned to resonance. He gained attention by claiming that the device transmits energy via scalar waves that are **not bound by inverse-square loss or shielding**. One of Meyl's bold claims is that the energy transfer **does not diminish with distance** (within certain ranges) and that placing the coils in a Faraday cage does not block the signal [9] [33]. These claims were enticing, but independent tests tell a different story. Investigators at an industrial research lab (IGF in Germany) tested Meyl's setup and **found conventional explanations** for the observations. The system essentially behaves like a loosely coupled RF transformer – in the near field of the transmitter, the receiver picks up energy through normal electromagnetic induction. If both transmitter and receiver share a common ground (as in some of Meyl's demos), the coupling can occur via currents through that ground connection. The testers reported that the **"ineffectiveness of a Faraday cage"** in Meyl's demo could be explained: *"due to the developing standing waves, the energy is transported through the 'ground' connection into or out of the Faraday cage"*, *without* needing any exotic scalar wave hypothesis [33]. In short, **Meyl's experiments did not prove any violation of EM theory** – they could be replicated and understood as standard near-field phenomena (with perhaps some misinterpretation due to complex interference effects). To date, no reputable lab has validated Meyl's assertion of a new form of wave; nonetheless, his experiment remains popular among scalar wave enthusiasts and is often cited as "evidence," despite the conventional analysis.

- **Other Attempts and Observations:** Various other experiments have been tangentially related to this topic. Some laser optics experiments, for example, have created **intense longitudinal electric fields** by focusing radially polarized laser beams – but these are well-understood within Maxwell's framework (the longitudinal field appears in the focal region but does not propagate independently) [34]. There have also been claims of detecting "torsion fields" or other unconventional signals from scalar wave apparatus (e.g. using pendulums or sensors near Tesla coils), often reported in fringe outlets; these claims remain unverified and are generally not reproduced under controlled conditions [35]. It is worth mentioning that **no unequivocal "scalar wave detector"** exists in mainstream engineering – if such waves carried energy without E or B fields, they would be invisible to standard EM sensors, complicating any search. Some researchers in extended EM theory have proposed using SQUIDs (superconducting quantum interference devices) to detect subtle potential fields (as in certain patents, below), but this remains experimental. All told, **after more than a century of experimentation**, from Tesla's time to now, the balance of evidence indicates **no confirmed discovery of free-propagating scalar electromagnetic waves**. Every well-documented experiment has found a conventional explanation or left the purported scalar component unconfirmed. This lack of empirical support is a major reason the scientific community remains unconvinced by scalar wave theories.

5. Proposed and Speculative Applications

One reason scalar EM waves continue to intrigue is the **wide range of applications proposed** for them – many of which sound highly attractive or revolutionary. Below is a summary of the key speculative uses of scalar waves, as touted by proponents (alongside any relevant research or patents).

- **Communication and Signal Penetration:** A frequently cited application is in communications – especially in challenging environments like underwater, underground, or through plasma (ionized gas). **Scalar waves are theorized to penetrate media that block or attenuate normal EM waves.** Since an ideal scalar wave would have no oscillating magnetic field, it would not induce currents in conductive media (hence no skin effect losses) [36] [37]. Advocates claim this could enable highbandwidth communication with submarines or in tunnels without the massive signal loss that radio waves suffer. In fact, a U.S. patent application in 2018 described a **"field-free potential" communication system**, wherein information is encoded in the scalar potential (ϕ) and vector potential ($\mathbf{A}$) rather than in E and B fields [38]. The patent asserts that such signals would **pass through Faraday cages and dense media with minimal dispersion**, and fall off only as $1/r$ with distance instead of $1/r^2$ [38] [39]. This hints at military interest: for example, communicating with deeply submerged assets or through plasma sheaths around hypersonic vehicles. While the theory behind field-potential signaling is grounded in extended electrodynamics, it remains to be demonstrated. To date, conventional physics limits (and the lack of confirmed scalar waves) have kept these ideas in the research or speculative phase. If scalar wave communication were realized, it could provide **secure, low-attenuation links** where normal RF fails. However, mainstream engineers note that any such system might really be exploiting near-field evanescent coupling or low-frequency inductive coupling – not a new wave that breaks Maxwell's rules.

- **Wireless Power Transfer and Energy Transmission:** Scalar waves are often promoted as a means for **lossless energy transmission over great distances**. This harks back to Tesla's dream of worldwide wireless power. Proponents claim scalar waves do not radiate away energy as omnidirectional EM waves do, but instead form a direct energy conduit between transmitter and receiver. Some fringe sources even state *"it is capable of lossless energy transmission over great distances, [even] through solid metal objects"* [40] [2]. If true, this could revolutionize power distribution – imagine powering devices remotely without losses or sending energy to remote areas without wires. In practice, experiments like Meyl's have not shown truly distance-independent power transfer (energy still drops off, consistent with near-field coupling). Nonetheless, interest persists. A recent example is **a patent (WO2013155580A1) for a "scalar energy generator"** intended as a household device to improve wellbeing. It generates a 12 Hz "scalar wave" via an electronic circuit and antenna [41]. The patent defines *"scalar energy"* as an omnidirectional wave that *"has magnitude but no specific direction… in electrical equilibrium… not readily apparent to electromagnetism-based measuring instruments"* [42]. This language illustrates the idea that scalar waves could deliver energy in a form that isn't easily detected as an EM field, perhaps linking to notions of zero-point energy. It should be noted that **no peer-reviewed study has demonstrated a scalar wave power system outperforming conventional wireless power** (e.g. resonant inductive coupling or microwave beaming). Still, the concept inspires ongoing experimentation and patents, showing the allure of a *"low-loss, nonradiative"* energy transfer mode.

- **Medical and Healing Applications:** In the alternative health community, **"scalar energy" has become a buzzword** for wellness devices. The claims here venture well into pseudoscience: scalar waves are said to heal by resonating with cellular frequencies or balancing "biofields." Some devices marketed as *"scalar wave generators"* or *"scalar field healing wands"* promise benefits like improved immune function, stress reduction, and even targeted destruction of pathogens – none of which is backed by rigorous clinical evidence. These ideas often cite the work of researchers like **Dr. Valerie Hunt**, who studied human electromagnetic fields, or reference vague "quantum" effects. One patent (US **Device for Generating High-Intensity Scalar Energy**) suggests using scalar waves for therapeutics, claiming the emitted wave can have *"therapeutical effect for treatment of various aspects of health"*. The mechanism posited is that scalar fields permeate the body more deeply than EM fields and can influence cellular processes directly [43] [44]. Additionally, scalar waves have been conflated with **biophotonics and frequency therapy**; some alternative medicine practitioners assert that our body's cells communicate via scalar signals and that introducing the right scalar frequencies can promote healing. From a scientific perspective, these claims are **highly questionable** – no known scalar EM mechanism has been shown to preferentially benefit living tissue, and any effects reported are likely placebo or due to ordinary EM or electrostatic influences. Nonetheless, the idea of a gentle, penetrating energy field for medical use is attractive. Should future research validate any form of non-conventional EM wave, one could imagine applications in medical imaging or therapy. At present, however, **scalar wave healing remains a speculative, unverified application**, primarily found in wellness marketing rather than hospitals.

- **Propulsion and Energy Conversion:** Some speculative research even extends to **propulsion systems** and new energy sources using scalar waves. For instance, Zohuri (2021) writes about developing an *"all-electronic engine"* that replaces conventional electromagnetic motors, leveraging scalar electrodynamics [45]. The idea here is that if scalar waves can interact with matter differently (e.g. coupling to nuclear forces or inertia), they might be used to propel objects or improve energy conversion efficiency. There have been fringe discussions of using scalar fields to reduce the inertial mass of objects (a concept verging on sci-fi "antigravity") or to tap into the quantum vacuum energy. In the realm of nuclear fusion, a few theorists have speculated that scalar waves might assist **low-energy nuclear reactions (LENR)** – colloquially, cold fusion. The argument is that a scalar field could penetrate the Coulomb barrier by some non-electromagnetic coupling, effectively lowering the energy needed for nuclei to fuse [46] [47]. If such an effect existed, it could dramatically change energy production. So far, these notions are purely hypothetical. No reproducible experiment has shown that scalar waves can induce or enhance nuclear reactions or provide thrust. The **propulsion idea remains at the level of concept papers and patents**, often overlapping with exotic physics (zero-point energy, inertia modification) that is not accepted by mainstream science.

- **Defense and Surveillance ("Scalar Weapons"):** Scalar waves entered the geopolitical folklore during the Cold War when some individuals (like Bearden) claimed the Soviet Union had harnessed them for **"Tesla weapons"** – devices capable of causing earthquakes, massive explosions, or mind control at a distance. These claims were never substantiated, but they gave scalar waves an ominous allure. More grounded is the idea of using scalar-type fields for military communication or detection systems (as noted earlier). Zohuri (2019) discusses *"the weapon of tomorrow's battlefield"* potentially being scalar-based [48], and suggests the technology might transform **ocean surveillance, underwater imaging, power transmission, transportation, guidance, and national security** applications [49] [50]. For example, a scalar wave-based radar or sensor could, in theory, detect stealth aircraft or submarines unaffected by traditional countermeasures, since the wave would penetrate shielding. Again, these ideas are exploratory. It's telling that open scientific literature does not report any functioning "scalar beam weapon" or super-sensor; such developments, if real, would likely be classified. The **CIA did take note of foreign claims** – a declassified document reviews scalar wave theory and notes it as a "potential" area, but also questions where the energy in such a wave would go since it carries no Poynting vector [51] [52]. In sum, the defense-related applications of scalar waves remain speculative and shadowy. They serve as recurring themes in conspiracy theories but have not materialized in known, operational technology.

In summary, scalar electromagnetic waves are attributed a dazzling array of potential uses by their proponents, from **revolutionizing communication and power** to **healing and national defense**. This breadth of claimed applications is perhaps one reason the concept endures in the imagination. However, it must be emphasized that **all these applications are currently unproven**. They largely depend on the assumption that scalar waves can be produced and controlled as described – an assumption awaiting solid evidence. Mainstream science would require rigorous demonstrations (and theoretical consistency) before embracing any of these purported uses. Until then, scalar wave applications remain a fascinating mix of possibility and fantasy, driving ongoing experimentation at the fringes of science.

Conclusion

Scalar electromagnetic waves occupy a peculiar niche between established science and speculative theory. Over the last two decades, interest in them has persisted – fueled by a combination of genuine scientific curiosity (e.g. exploring extended electrodynamics and potential new wave solutions) and the more flamboyant claims of fringe scientists. On the **mainstream side**, the consensus is clear: **Maxwell's classical theory and all reliable experiments to date indicate that free-space scalar EM waves do not exist** as physically independent phenomena. When longitudinal electric fields do appear (in plasmas, waveguides, near fields), they are understood within conventional EM theory or require special conditions. No peer-reviewed study has overturned this understanding. On the **alternative side**, however, scalar waves are treated as a real (if elusive) phenomenon that could unlock transformative technologies. Proponents have crafted theories extending Maxwell's equations, and some have even gotten papers, patents, or books published on the topic in the last 20 years, suggesting a continued "underground" research interest. We have detailed those perspectives and noted that **experiments claimed to detect scalar waves have not stood up to independent scrutiny**.

Ultimately, the idea of scalar electromagnetic waves remains **unproven but not entirely unthinkable**. Science is always open to surprises – should rigorous evidence emerge of a new EM mode or field effect, the community would investigate seriously. Efforts like the extended Lagrangian approach (Aharonov–Bohm and others) show that, theoretically, *something* like a scalar wave could exist if our assumptions are expanded. The coming years may bring more clever experiments, perhaps with modern quantum sensors, to probe for subtle field effects that could hint at physics beyond Maxwell's classical equations. Until then, **scalar waves will continue to straddle the boundary of science and pseudoscience**. This survey has provided a balanced look: acknowledging the mainstream scientific stance that scalar EM waves are highly implausible given current knowledge [2], while also documenting the persistent fringe narratives, theoretical attempts, experimental forays, and imaginative applications associated with the concept.

In conclusion, the topic of scalar electromagnetic waves serves as a reminder of the importance of **evidence and reproducibility in science**. It is easy to be captivated by the promise of a new kind of wave that could change the world – but extraordinary claims require extraordinary evidence. As of 2025, that evidence has not yet materialized in the peer-reviewed scientific record. The conversation between skeptics and believers continues, driven by both the **allure of what might be possible** and the **rigor of established physical law**. Future research – if it continues – will decide whether scalar waves graduate from fringe theory to scientific fact, or remain as a curious footnote in the history of electromagnetism.

Sources: This report drew from a mix of peer-reviewed literature, conference papers, and patents to ensure a comprehensive perspective. Key references include theoretical papers on extended electrodynamics [53] [17], experimental reports both supporting and refuting scalar waves [1] [27], as well as patent literature illustrating proposed applications [38] [42]. Historical context was gleaned from Tesla's writings and analyses thereof [6]. While mainstream physics sources reiterate the impossibility of scalar EM waves in free space [3] [2], alternative sources (e.g. Zohuri 2019) describe how scalar waves might operate and be utilized [7] [36]. By juxtaposing these sources, we provided a detailed survey that highlights the divide in viewpoints and the current state of research (or lack thereof) on scalar electromagnetic waves. Each citation in the text points to the specific source material for further reading on that aspect of the topic.

---

1 3 28 29 30 31 32 Longitudinal Electromagnetic Waves The Monstein-We | PDF | Antenna (Radio) | Waves
https://www.scribd.com/document/734324941/Longitudinal-Electromagnetic-Waves-The-Monstein-We

2 14 40 48 Java Based Distributed Learning Platform
https://www.davidpublisher.com/Public/uploads/Contribute/64e8160721951.pdf

4 5 Longitudinal electromagnetic waves with extremely short wavelength | Phys. Rev. B
https://journals.aps.org/prb/abstract/10.1103/PhysRevB.104.L100304

6 Mathematics Magazine
https://www.mathematicsmagazine.com/Articles/NonHertzianWavesorTeslaWaves.php

7 8 10 11 12 (PDF) Scalar Waves
https://www.researchgate.net/publication/327447483_Scalar_Waves

9 33 Debunking Meyl PDF | PDF | Inductor | Inductance
https://www.scribd.com/document/423338585/Debunking-Meyl-pdf

13 36 37 45 46 47 49 50 52 Scalar Wave Energy As Weapon | PDF | Waves | Sound
https://www.scribd.com/document/634483709/Scalar-Wave-Energy-as-Weapon

15 16 17 18 19 20 21 53 Aharonov–Bohm Electrodynamics in Material Media: A Scalar e.m. Field Cannot Cause Dissipation in a Medium
https://www.mdpi.com/2073-8994/15/5/1119/pdf?version=1684503161

22 [PDF] A generalisation of classical electrodynamics for the prediction of ...
https://scispace.com/pdf/a-generalisation-of-classical-electrodynamics-for-the-ivw2tp56yn.pdf

23 Scalar Waves - OUCI
https://ouci.dntb.gov.ua/en/works/4vqBB1a7/

24 25 26 27 34 [1606.01738] Longitudinal electromagnetic waves in the framework of standard classical electrodynamics
https://ar5iv.org/pdf/1606.01738

35 [PDF] Attempts to detect the torsion field nature of scalar wave generated ...
https://vixra.org/pdf/1607.0130v1.pdf

38 39 US20180062765A1 - Communications system - Google Patents
https://patents.google.com/patent/US20180062765A1/en

41 42 43 44 WO2013155580A1 - Scalar energy generation device - Google Patents
https://patents.google.com/patent/WO2013155580A1/en

51 [PDF] SCALAR WAVES - CIA
https://www.cia.gov/readingroom/docs/cia-RDP96-00792R000500240001-6.pdf