Why Does a Tokamak Not Shake Protons? (And Should It?)

Arkadiusz Okupski

December 2025

Abstract

We propose the hypothesis that the Coulomb interaction is not a purely static barrier, but a dynamic process whose effectiveness may undergo temporary weakening without changing the value of the fundamental electric charge.

The mechanism does not rely on screening or neutralization, but on a temporal detuning of the charge manifestation process under the influence of rapidly varying electromagnetic fields. In such a regime, the effective charge $Q_{\text{eff}}(t)$ is reduced, and the Coulomb barrier becomes dynamically "soft."

Tokamaks, as systems enforcing stationarity and phase synchronization, are structurally blind to this effect. If the effect exists, it may manifest itself exclusively in impulsive regimes.

The key assumption is unambiguous: if the mechanism of charge manifestation possesses no internal time scale, the model loses its raison d'être. If such a scale exists, fusion ignition depends on dynamic detuning of the mechanism generating the Coulomb interaction, rather than solely on the value of temperature.

1 The Problem of Fusion Ignition in a Tokamak

The fundamental barrier to thermonuclear fusion ignition in tokamaks is the Coulomb interaction between protons, which in the classical picture is treated as fundamental and irreducible. Standard approaches to the ignition problem focus on:

- increasing plasma temperature,
- extending confinement time,
- increasing fuel density.

These approaches assume invariance of the mechanism responsible for electric charge manifestation and the resulting Coulomb interaction. The present work adopts a different perspective: instead of enhancing energetic parameters, it considers the possibility of temporarily detuning the mechanism that generates the interaction.

It is worth emphasizing that this approach differs from the author's earlier works, which analyzed the role of temporal geometry and dynamic plasma regimes. The present analysis focuses exclusively on the structure of charge and its stability, without invoking mechanisms of time dilation or time acceleration (cf. [3]).

2 Charge as an Effect of Z1 Ordering

In the pencil-case model, electric charge is not a primitive entity, but an emergent consequence of ordering of an internal structure denoted as Z1:

$$Q \neq 0 \quad \Longleftrightarrow \quad Z1_{\text{ordered}}.$$

The Coulomb interaction between protons is therefore a consequence of a stable and synchronized Z1 state in each particle. If this order is temporarily detuned, the mode of manifestation of the Coulomb interaction changes. It is not predetermined whether this change leads to weakening, strengthening, or instability of the interaction; what is essential is the disturbance of the mechanism generating it, while preserving the particle's identity and the value of the fundamental charge.

In this view, the problem of fusion ignition does not consist in "removing" the Coulomb barrier, but in a short-term reduction of its effective manifestation through disturbance of the internal Z1 ordering mechanism.

3 Hydrodynamic Analogy

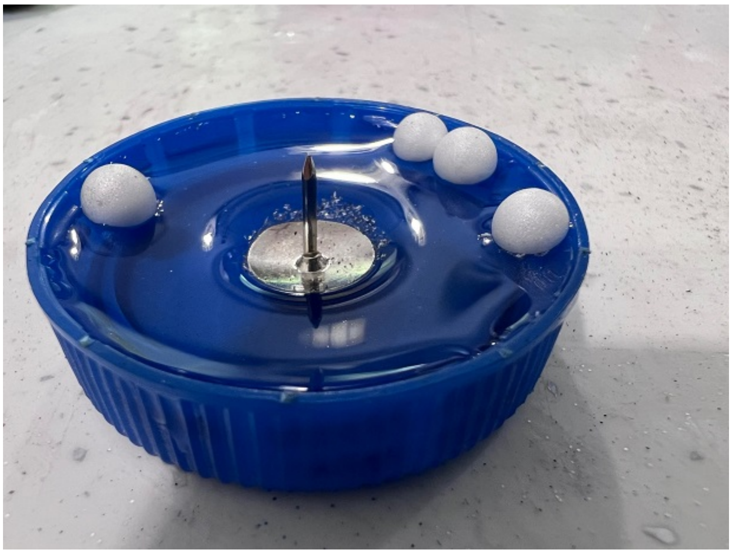

Figure 1: Pinezka, kulka PS

To build intuition, let us consider a hydrodynamic analogy:

- floating objects → charged particles,
- surface meniscus → observable manifestation of the Coulomb interaction,
- surface tension → the interaction-generating mechanism,
- Z1 ordering → the cause of this mechanism's existence.

This analogy separates cause from effect: the interaction does not arise directly from the properties of the objects themselves, but from the existence of an ordered mechanism in the medium in which the interaction manifests.

4 The Electromagnetic Field as a Z1-Detuning Agent

In the p-gluon ontology, an external, strongly oscillating electromagnetic field does not change the value or sign of the fundamental charge. Its role is to detune the ordering process of the internal structure **Z1**, which is responsible for the stable manifestation of that charge.

The EM field acts by:

- introducing **phase fluctuations**,

- creating **temporal competition** with the natural Z1 stabilization mechanism,
- shortening the time over which an ordered state can be maintained.

Formally, we distinguish two dynamic regimes:

$$\tau_{Z1} \gg T_{\mathrm{EM}} \quad \Rightarrow \quad Z1_{\mathrm{ordered}} \quad \text{(order dominates)},$$

$$\tau_{Z1} \lesssim T_{\mathrm{EM}} \quad \Rightarrow \quad Z1_{\mathrm{dynamical}} \quad \text{(forcing destabilizes)},$$

where:

- τ_{Z1} — characteristic relaxation (ordering) time of the Z1 structure,
- T_{EM} — period of the external electromagnetic forcing.

In the second regime, charge does not vanish, but its ability to generate a stable Coulomb interaction undergoes dynamic smearing.

Key analogy: dice on a shaken conveyor belt. This mechanism can be represented as dice (Z1 elements) moving on a conveyor belt, where the stable state "all sixes facing forward" corresponds to negative charge, and "ones forward" to positive charge. Rapid EM field oscillations act like **rhythmic, strong impacts from below**. The dice continuously rotate, and their orientations become randomized. The fundamental charge (the symbol on the die) remains, but the system **has no physical time to settle into a global order** necessary for the emergence of a strong Coulomb interaction.

5 Weakening of the Coulomb Interaction

The effective Coulomb interaction becomes a function of the degree of Z1 ordering:

$$F_C^{\mathrm{eff}} = F_C \cdot \langle Z1 \rangle.$$

For:

$$\langle Z1 \rangle \to 0 \quad \Rightarrow \quad F_C^{\mathrm{eff}} \to 0.$$

This is not Debye screening nor charge neutralization, but a temporary blurring of the mechanism of charge manifestation.

6 Consequences for Fusion in a Tokamak

In such a regime:

- protons may approach smaller distances,
- the Coulomb barrier undergoes dynamic modification,
- the effective probability of nuclear encounters increases,
- ignition may occur without the need for an extreme increase in temperature.

The proposed mechanism does not replace quantum tunneling, but alters the conditions under which it occurs, by dynamically detuning the effective Coulomb barrier and its temporal coherence.

7 Why a Tokamak Does Not Do This

A standard tokamak:

- uses EM fields for confinement,
- minimizes oscillations,
- strives toward a quasi-static state.

Within the p-gluon ontology, this approach is misguided: it reinforces Z1 order instead of detuning it.

8 Conclusion

Fusion ignition may require not strengthening charge, but its temporary "detuning." Strong, rapid oscillations of the electromagnetic field act like a surfactant for the Z1 structure, destroying the tension responsible for the Coulomb interaction.

We do not change the laws of nature. We change the conditions under which they have time to manifest.

9 Falsification Point: Does Charge Have a Relaxation Time?

Any model postulating the possibility of dynamic weakening of the Coulomb interaction must answer one fundamental question:

> **Does there exist a finite relaxation time of the structure responsible for the manifestation of electric charge?**

In academic physics, the answer is: *unknown*, because the Standard Model defines no internal degree of freedom to which such a time could be assigned. Charge is a field parameter, not a dynamic process.

9.1 What We Know Empirically

High-precision experiments (QED, atomic spectroscopy, scattering, energy-level stability) impose strong constraints on any possible charge dynamics:

- no observed delay in EM interactions,
- no temporal dispersion of charge,
- no dependence of interactions on EM field history.

All of this implies that if a relaxation time exists, it must be ***shorter than all time scales tested so far***.

9.2 Interpretational Gap

However, it is important that the above empirical constraints mainly concern:

- stationary states,
- quasi-static electromagnetic fields,
- weak or moderate interaction amplitudes.

There are no direct experiments probing extremely fast oscillations of the electromagnetic field in strongly nonlinear, high-energy plasmas, far from dynamic equilibrium.

The sonar model is located precisely in this interpretational gap, proposing a mechanism based on temporary detuning of the internal channel of interaction manifestation, rather than modification of its fundamental structure.

9.3 Critical Condition

If an internal ordering time of the Z1 structure exists, then the Coulomb interaction should weaken under the condition:

$$\omega_{\mathrm{EM}} \gtrsim \frac{1}{\tau_{Z1}},$$

where:

- ω_{EM} — frequency of the external field,
- τ_{Z1} — relaxation time of Z1 ordering.

If, on the other hand:

$$\tau_{Z1} \to 0,$$

then the mechanism described in this work is unequivocally excluded.

10 Equivalent Formulation: Dynamic Effective Charge

To separate the physical mechanism from the model ontology, the hypothesis can be formulated in the language of standard plasma physics, without reference to internal particle structures.

10.1 Working Postulate

We assume that under dynamic conditions the Coulomb interaction can be described by a *time-dependent effective charge*:

$$Q_{\mathrm{eff}}(t).$$

This is not a change of the fundamental charge, but a change in the system's ability to manifest electromagnetic interactions on short time scales.

10.2 Dynamic Condition

For slowly varying fields:

$$\omega_{\mathrm{EM}} \ll \frac{1}{\tau} \quad \Rightarrow \quad Q_{\mathrm{eff}} \approx Q.$$

For rapidly oscillating fields:

$$\omega_{\mathrm{EM}} \gtrsim \frac{1}{\tau} \quad \Rightarrow \quad Q_{\mathrm{eff}} \to \langle Q_{\mathrm{eff}} \rangle < Q.$$

The effective Coulomb force then takes the form:

$$F_C^{\mathrm{eff}}(r,t) = \frac{1}{4\pi\varepsilon_0} \frac{Q_{\mathrm{eff}}^2(t)}{r^2}.$$

10.3 Physical Meaning

The above formulation does not require:

- modification of QED laws,
- alteration of the fundamental charge,
- the existence of new fields.

It merely describes the fact that in strongly nonlinear, rapidly evolving plasma environments, electromagnetic interactions undergo dynamic averaging.

10.4 Relation to Existing Concepts

The dynamic effective charge is equivalent to:

- dynamic screening,
- motional averaging,
- Floquet averaging,
- nonlinear plasma response.

The difference lies in interpretation: instead of treating these effects as corrections, they are regarded as a fundamental control parameter of high-energy processes.

10.5 Consequences for Fusion

If, during the ignition phase:

$$Q_{\text{eff}} \ll Q,$$

then the Coulomb barrier undergoes temporary flattening, which increases the probability of nuclear encounters without the need for an extreme increase in temperature.

In this view, fusion ignition becomes a problem of temporal dynamics, not static energy.

11 Dynamic Ignition Criterion: A Generalization of the Lawson Condition

The classical Lawson criterion formulates the condition for thermonuclear fusion ignition as a static inequality:

$$nT\tau_E \geq L_0,$$

where n is the density, T the temperature, and τ_E the energy confinement time.

This criterion assumes that the Coulomb interaction is:

- instantaneous,
- static,
- independent of the electromagnetic field history.

Under conditions of extremely rapid dynamics, these assumptions cease to be obvious.

11.1 Dynamic Postulate

We assume that under strong electromagnetic forcing, the Coulomb interaction is described by a time-dependent effective charge $Q_{\text{eff}}(t)$.

The effective Coulomb barrier then scales as:

$$V_C^{\text{eff}}(r,t) \propto Q_{\text{eff}}^2(t).$$

11.2 Temporal Criterion

We define a characteristic relaxation time of the electromagnetic interaction, τ_{EM}.

For:

$$\omega_{\text{EM}} \ll \frac{1}{\tau_{\text{EM}}},$$

the classical behavior is recovered:

$$Q_{\text{eff}} \approx Q.$$

For:

$$\omega_{\text{EM}} \gtrsim \frac{1}{\tau_{\text{EM}}},$$

dynamic weakening of the interaction occurs:

$$Q_{\text{eff}} = \eta Q, \qquad 0 < \eta < 1.$$

11.3 Dynamic Ignition Criterion

The probability of nuclear tunneling depends exponentially on the Coulomb barrier. To leading order:

$$P \sim \exp\left[-\frac{Q_{\text{eff}}^2}{T}\right].$$

Introducing η, we obtain an effective temperature:

$$T_{\text{eff}} = \frac{T}{\eta^2}.$$

The dynamic ignition criterion therefore takes the form:

$$n\,T_{\text{eff}}\,\tau_E = n\,\frac{T}{\eta^2}\,\tau_E \;\geq\; L_0.$$

Or equivalently:

$$n\,T\,\tau_E \;\geq\; \eta^2 L_0.$$

11.4 Physical Interpretation

- For $\eta = 1$, the classical Lawson criterion is recovered.
- For $\eta < 1$, the ignition threshold is reduced.
- Ignition becomes a problem of temporal dynamics, not temperature alone.

11.5 Implications for Reactors

Tokamak. Magnetic fields are stabilized and quasi-static:

$$\omega_{\text{EM}} \ll \frac{1}{\tau_{\text{EM}}} \;\Rightarrow\; \eta \approx 1.$$

The tokamak does not exploit dynamic effects.

ICF and laser plasmas. Impulsive, violent EM fields:

$$\omega_{\text{EM}} \gtrsim \frac{1}{\tau_{\text{EM}}} \;\Rightarrow\; \eta < 1.$$

In this regime, the Coulomb barrier may undergo temporary modification, potentially including transient flattening.

Conclusion

If, during the ignition phase, the effectiveness of the Coulomb interaction described by the parameter η exhibits significant temporal dynamics, then the classical Lawson criterion—formulated for stationary interactions—may not provide a sufficient description of ignition conditions.

In such a case, fusion ignition depends not only on temperature and density, but also on the temporal dynamics of electromagnetic interactions, in particular on the relation between the characteristic time scales of the process.

12 Tokamak as a Regime Forcing $\eta \to 1$

Within the dynamic description of the Coulomb interaction, the key control parameter is the ratio of the frequencies of external electromagnetic fields to the characteristic relaxation time of the interaction.

12.1 Tokamak Architecture

A tokamak is designed as a system:

- with magnetic fields as constant in time as possible,
- with active suppression of EM fluctuations,
- with maximization of the energy confinement time τ_E.

The objective is plasma stability, not short-time dynamics.

12.2 Dynamic Consequences

In the language of the model, this means that the tokamak systematically drives the system toward the regime:

$$\omega_{\text{EM}} \ll \frac{1}{\tau},$$

which implies:

$$Q_{\text{eff}} \approx Q, \qquad \eta \to 1.$$

Dynamic weakening of the Coulomb interaction, even if it exists, is design-wise suppressed under such conditions.

12.3 Limits of the Argument

The above argument does not prove that the effect $\eta < 1$ does not exist. It only demonstrates that the tokamak is a device that:

- minimizes the amplitude of fast EM fields,
- stretches all relevant time scales,
- eliminates conditions favorable to dynamic effects.

If the characteristic relaxation time of the interaction τ is extremely short, then both tokamak and ICF may lie outside the sensitivity range of this mechanism.

12.4 Sonar Conclusion

Within the logic of the model, the tokamak is not a "bad" device, but a device that is self-consistently insensitive to dynamic modifications of electromagnetic interactions. This is a structural limitation, not a technological one.

12.5 Model Status

The proposed mechanism:

- is logically self-consistent,
- does not directly violate known laws,
- relies on an auxiliary model ontology (p-gluon), in which Z1 is a measure of the ordering of the structure responsible for the manifestation of electric charge,
- is falsifiable by the absence of any dynamic effect.

The model does not compete with QED as a computational theory. It merely proposes the hypothesis that known interactions are boundary manifestations of a deeper, dynamic structure.

13 Lower Bound on the Relaxation Time τ

Clarification of time scales. The relaxation time τ constrained by high–precision QED and scattering experiments refers to the stationarity of electromagnetic interactions in vacuum and near–equilibrium conditions. It is *not assumed to be identical* to the emergent transfer time τ_G of the internal interaction channel discussed later, which is postulated to arise only in strongly driven, non–equilibrium plasma environments.

The key parameter of the dynamic description of electromagnetic interaction is the characteristic relaxation time τ, after which the effective charge assumes its stationary value:

$$Q_{\text{eff}}(t) \to Q.$$

If τ is shorter than all accessible time scales, the mechanism of dynamic interaction weakening is empirically invisible, and the model loses physical relevance.

13.1 Strongest Existing Constraints

The strongest lower bounds on τ arise from experiments in which the Coulomb interaction is tested on extremely short time scales.

High-energy scattering. For processes with energy transfer on the order of $\Delta E \sim 1\,\text{GeV}$, the characteristic interaction time is:

$$\Delta t \sim \frac{\hbar}{\Delta E} \approx 10^{-24}\,\text{s}.$$

The absence of observed deviations implies that the Coulomb interaction behaves stationarily at least down to this scale.

Precision QED tests. Agreement between theoretical and experimental values of the magnetic anomaly $(g-2)$ at the level of 10^{-12} implies that any charge dynamics must occur faster than:

$$\tau \sim 10^{-22}\text{–}10^{-23}\,\text{s}.$$

Atomic spectroscopy. The absence of temporal dispersion of electromagnetic interactions up to optical frequencies ($\sim 10^{15}$ Hz) imposes a weaker but independent constraint:

$$\tau \ll 10^{-15}\,\mathrm{s}.$$

13.2 Lower Bound

The most stringent constraint remains high-energy scattering. A strong, conservative lower estimate reads:

$$\boxed{\tau \lesssim 10^{-24}\,\mathrm{s}}$$

If τ were larger, dynamic effects of electromagnetic interaction would have already been observed in existing data.

13.3 Consequences for the Model

Tokamak. Characteristic electromagnetic field frequencies in a tokamak (kHz–GHz) satisfy:

$$\omega_{\mathrm{tok}} \ll 10^{24}\,\mathrm{Hz}.$$

As a consequence, the tokamak is structurally incapable of testing any effects associated with τ on the order of 10^{-24} s. In this sense, the concept of dynamic weakening of the Coulomb barrier in a tokamak is internally inconsistent.

ICF and laser plasmas. Impulsive electromagnetic fields in the femto- and attosecond regime reach frequencies of order:

$$\omega_{\mathrm{laser}} \sim 10^{15}\text{–}10^{18}\,\mathrm{Hz},$$

which still remains below the hard bound of 10^{24} Hz. For this reason, the dynamic effect cannot manifest in vacuum nor in systems close to equilibrium.

13.4 One Logical Loophole

The model retains meaning only in a scenario in which the relaxation time is not a universal constant, but an emergent quantity dependent on the environment:

$$\tau = \tau_0\, f(\rho, E, \dot{E}),$$

where extreme densities, strong fields, and lack of equilibrium may, in principle, lead to a local extension of τ by many orders of magnitude. In this sense, the model does not contradict existing experimental bounds, but explicitly places the proposed dynamics outside the regime in which those bounds were established.

In such a case:

- QED tests and accelerators remain unaffected,
- the tokamak remains insensitive,
- only ICF and laser plasmas may potentially access the dynamic regime.

13.5 Conclusion

If τ is a universal quantity, the model of dynamic weakening of the Coulomb interaction must be regarded as falsified. If, however, τ is an emergent and environmentally modifiable quantity, the model remains narrowly admissible and potentially testable under extreme plasma conditions.

14 Topological Eigenmodes of the dK–G–K System and Their Coupling to an External Electromagnetic Field

14.1 Motivation

In the p–gluon model, charge and Coulomb interaction are not primitive quantities, but the result of stable topological information transfer:

$$dK \xrightarrow{G} K.$$

The element $Z1$ corresponds to the existence of ordered information, while the electromagnetic interaction is its boundary manifestation. The purpose of this section is not to "remove" or "switch off" $Z1$, but to examine whether dynamic *detuning* of the transfer channel via an external EM field is possible.

14.2 The dK–G–K System as a Resonant Object

The dK–G–K structure is a cyclic process and possesses natural time scales:

- τ_{dK} — characteristic time of the internal cycle,
- τ_G — time of topological transfer through the Möbius strip,
- τ_K — boundary response time (interaction manifestation).

From the perspective of information dynamics, this system behaves as a resonant object, analogous to a string or a cavity:

$$\omega_n \sim \frac{n}{\tau_{\text{eff}}}, \qquad \tau_{\text{eff}}^{-1} \sim \tau_{dK}^{-1} \oplus \tau_G^{-1} \oplus \tau_K^{-1}.$$

14.3 Coupling to the Electromagnetic Field

The external electromagnetic field does not act directly on $Z1$, but on the boundary K, which serves as the observable interface. The EM field introduces an additional phase modulation:

$$\phi_K(t) \;\rightarrow\; \phi_K(t) + \delta\phi_{\text{EM}}(t),$$

which propagates backward through G into the dK cycle.

The key sonar condition:

$$\omega_{\text{EM}} \gtrsim \tau_G^{-1} \quad \text{or} \quad \omega_{\text{EM}} \sim \omega_n.$$

14.4 Dynamic Regimes

Depending on the frequency relations, three qualitatively distinct regimes can be identified:

(A) Constructive Resonance The transfer phase becomes synchronized. The Coulomb interaction is enhanced. This regime is unfavorable for fusion.

(B) Detuning (Antiresonance) The boundary K attempts to follow the rapidly varying EM field, while dK retains its intrinsic dynamics. Information transfer undergoes partial decoherence:

$$\langle Q_{\text{eff}} \rangle < Q.$$

Neither the sign nor the value of the fundamental charge changes, but its effective dynamic projection is weakened.

(C) Modal Chaos Excitation of multiple modes simultaneously leads to an unstable phase relationship between dK and K. The Coulomb interaction ceases to behave as a rigid static barrier and becomes a time-dependent process.

14.5 Physical Interpretation

The proposed mechanism does not violate:

- the existence of $Z1$,
- charge quantization,
- the local structure of QED.

It merely alters the *dynamic bandwidth* of the topological channel, analogously to:

> striking the casing of an old radio receiver — without understanding all internal connections, yet with a real impact on the system's operation.

14.6 Relevance for Thermonuclear Fusion

If, in a plasma:

$$\omega_{\mathrm{EM}} \gtrsim \tau_G^{-1},$$

the Coulomb interaction between protons may undergo temporary weakening, not through static screening, but via topological decoherence. The p–p barrier is not statically screened, but may cease to behave as a rigid, temporally coherent obstacle, leading to its dynamic modification.

14.7 Limitations

- The mechanism does not operate in steady-state conditions.
- It requires impulses or rapid oscillations.
- Tokamaks, due to active field stabilization, naturally tend toward rigid phase synchronization — which acts against this effect.

14.8 Sonar Conclusion

The dK–G–K system should be treated as an object with a finite dynamic bandwidth. An external EM field does not need to destroy the structure in order to influence the interaction — it suffices that it enters into temporal competition with the topological information transfer.

15 Lower Bound on the Time Scale τ_G from ICF and Laser–Plasma Data

15.1 Meaning of the Time Scale τ_G

In the p–gluon model, the time τ_G is interpreted as the minimal time required for stable topological information transfer from the internal cycle to the boundary, which manifests as electromagnetic interaction. It is neither the Planck time nor a macroscopic relaxation time, but an intermediate scale accessible to impulsive experiments.

15.2 Empirical Lower Constraints

Data from laser–plasma and ICF experiments (NIF, OMEGA, LULI) impose hard temporal bounds:

- **Laser pulse rise time:**
$$\tau_{\text{rise}} \sim 10^{-14} - 10^{-13}\,\text{s}.$$
Shorter pulses do not couple efficiently to volumetric plasma.
- **Dynamic Coulomb screening:**
$$\tau_{\text{screen}} \sim 10^{-15} - 10^{-14}\,\text{s}.$$
Below this scale, the plasma cannot reorganize its fields fast enough.
- **Development of electromagnetic microinstabilities:**
$$\tau_{\text{inst}} \sim 10^{-13} - 10^{-12}\,\text{s}.$$
These are the shortest times at which real changes in field configuration are observed in plasma.

15.3 Sonar Lower Estimate

Combining the above constraints yields a sonar lower estimate:

$$\boxed{\tau_G^{\text{min}} \sim 10^{-14}\,\text{s}}$$

With a plausible operational bandwidth:

$$10^{-14}\,\text{s} \lesssim \tau_G \lesssim 10^{-12}\,\text{s}.$$

15.4 Implications

- The effect cannot operate in a stationary regime.
- Tokamak-type systems, with long time scales and active field stabilization, naturally suppress this mechanism.
- The environment in which the described effect could potentially manifest consists of impulsive plasmas, in particular ICF.

15.5 Conclusion

If τ_G lies within the above range, an external EM field can temporally compete with the interaction transfer mechanism, leading to its dynamic detuning without violating the fundamental structure of charge.

16 Dynamic Effective Charge $Q_{\text{eff}}(\omega)$ as an Alternative Description

16.1 Motivation

To decouple the description from p–gluon ontology, we introduce the language of an effective, dynamic charge that can be directly compared with the formalism of plasma physics and QED.

16.2 Definition

We define the dynamic effective charge as:

$$Q_{\text{eff}}(\omega) = Q \cdot \eta(\omega),$$

where:

- Q — the fundamental, invariant charge,
- $\eta(\omega)$ — the interaction transfer function,

$$0 < \eta(\omega) \leq 1.$$

16.3 Physical Meaning

The function $\eta(\omega)$ describes the efficiency of charge projection onto interaction in the presence of a rapidly varying EM field. It does not change the value of charge, but its ability to generate Coulomb force in a given frequency regime.

16.4 Detuning Condition

We assume the existence of a characteristic frequency:

$$\omega_G \sim \tau_G^{-1},$$

such that:

$$\eta(\omega) \approx \begin{cases} 1, & \omega \ll \omega_G, \\ < 1, & \omega \sim \omega_G, \\ \text{oscillatory}, & \omega \gg \omega_G. \end{cases}$$

In the vicinity of $\omega \sim \omega_G$, the effective charge is reduced:

$$\langle Q_{\text{eff}} \rangle < Q.$$

16.5 Coulomb Interaction

The Coulomb force takes the form:

$$F_{pp}(\omega) = \frac{1}{4\pi\varepsilon_0} \frac{Q_{\text{eff}}^2(\omega)}{r^2},$$

which implies that even a modest reduction in $\eta(\omega)$ leads to a quadratic weakening of the p–p barrier.

16.6 Dynamic Interpretation

- The Coulomb interaction is not a static barrier, but a process.
- In the impulsive regime it becomes temporally unstable.
- The mechanism does not require Debye screening nor any change in particle structure.

16.7 Tokamak vs. ICF

- Tokamak: active field stabilization $\Rightarrow \eta(\omega) \to 1$.
- ICF: impulsive drive, broadband spectrum $\Rightarrow \eta(\omega) < 1$ within short temporal windows.

16.8 Conclusion

The description in terms of $Q_{\text{eff}}(\omega)$ remains fully consistent with academic physics, while encoding the same sonar idea: weakening of the Coulomb interaction as a dynamic effect rather than a structural one.

17 Why the Tokamak Systematically Suppresses Dynamic Interaction Weakening

17.1 Introduction

In the preceding sections, the possibility of dynamically weakening the Coulomb interaction via rapid oscillations of the electromagnetic field was considered, leading either to detuning of the interaction transfer mechanism or—within the effective language—to a reduction of $Q_{\text{eff}}(\omega)$. This section is critical in nature: it demonstrates why the classical tokamak is an environment that *systematically suppresses* this effect.

17.2 The Tokamak as a Phase–Rigid System

A tokamak is not a free plasma system. It is a strongly feedback–coupled apparatus designed to maximize phase stability of magnetic fields and plasma currents. In particular:

- the magnetic field has an imposed topology and orientation,
- plasma currents are actively controlled,
- fluctuations are damped by MHD couplings and feedback loops.

From the perspective of interaction dynamics, this enforces the condition:

$$\eta(\omega) \;\to\; 1,$$

i.e. full projection of charge onto interaction.

17.3 Mismatch of Time Scales

The key issue is the mismatch of time scales:

$$\tau_{\text{tokamak}} \;\gg\; \tau_G \sim 10^{-14}\text{–}10^{-12}\,\text{s}.$$

Characteristic times in a tokamak:

- MHD evolution: 10^{-6}–10^{-3} s,
- field control: $\gtrsim 10^{-5}$ s,
- turbulent fluctuations: $\gtrsim 10^{-9}$ s.

All of these scales exceed τ_G by many orders of magnitude, far beyond the regime where detuning effects could arise.

17.4 Active Synchronization Instead of Detuning

The tokamak operates as a system with an imposed clock:

- the magnetic field enforces a global phase,
- the plasma adapts to that phase,
- local oscillations are rapidly quenched.

From the model perspective, instead of temporal competition:

$$\omega_{\mathrm{EM}} \sim \tau_G^{-1},$$

we obtain rigid synchronization:

$$\omega_{\text{plasma}} \ll \tau_G^{-1}.$$

The system neither enters resonance nor antiresonance—it is *phase–locked* into a stationary state.

17.5 The Stabilization Paradox

The tokamak is designed to:

- minimize fluctuations,
- suppress rapid phase variations,
- maintain homogeneous interactions.

Exactly these features, essential for stable tokamak operation, are simultaneously fatal to the effect of dynamic interaction weakening.

17.6 Sonar Interpretation

In sonar language, the tokamak:

> does not allow one to "strike the casing," because the entire casing is actively stiffened and damped in real time.

Any attempt to introduce rapid modulation is:

- averaged out,
- screened,
- dissipated by MHD couplings.

17.7 Consequences for Fusion

It follows that:

- the lack of ignition in tokamaks need not result solely from technological imperfections,
- it may be a consequence of a fundamental incompatibility between stationary regimes and impulsive mechanisms,
- attempts to "fix" the tokamak by further stabilization may act against ignition.

17.8 Conclusion

If dynamic interaction weakening exists, the tokamak is an environment that systemically eliminates it—not because the effect is incorrect, but because the tokamak is designed such that nothing happens quickly.

18 The Concept of an "Anti–Tokamak" in the Language of Dynamic Interaction

18.1 Working Definition

By "anti–tokamak" we do not mean a device of opposite geometry, but a *plasma system designed so as to* ***avoid imposing*** *global phase synchronization of fields and currents.* The goal is not long–term stability, but the admission of short–lived regimes of temporal competition.

18.2 Principle Opposite to the Tokamak

The tokamak enforces:

$$\eta(\omega) \to 1 \quad \text{for all relevant } \omega.$$

The anti–tokamak enforces:

$$\exists\, \omega^* :\ \eta(\omega^*) < 1 \quad \text{within short time windows.}$$

The aim is not a permanent reduction of interaction, but its *momentary phase incoherence.*

18.3 Dynamic Features of an Anti–Tokamak

An anti–tokamak satisfies as many as possible of the following:

- absence of a global phase stabilization loop,
- strong, short EM field pulses instead of stationary fields,
- broadband frequency spectrum,
- lack of long–term topological field order.

In temporal terms:

$$\Delta t_{\text{pulse}} \lesssim \tau_G.$$

18.4 Role of Controlled Chaos

Unlike the tokamak, the anti–tokamak:

- does not suppress local fluctuations,
- allows temporary loss of phase coherence,
- treats chaos as a tool rather than an error.

Here, chaos is *functional*, not destructive.

18.5 Examples of Systems Approaching the Anti–Tokamak

None of the following are full anti–tokamaks, but each implements a fragment of this logic:

- ICF (laser–driven fusion),
- impulsive Z–pinch,
- plasmas generated by ultrashort laser pulses,
- dynamic implosion chambers.

All of them:

$$\text{admit } \omega \sim \tau_G^{-1}.$$

18.6 Coulomb Interaction in an Anti–Tokamak

The effective p–p barrier takes the form:

$$F_{pp}(\omega, t) = \frac{1}{4\pi\varepsilon_0} \frac{Q^2\,\eta^2(\omega, t)}{r^2},$$

where $\eta(\omega, t)$ varies in time and space.

Ignition does not result from permanent barrier reduction, but from the fact that *the reaction occurs faster than the system can resynchronize.*

18.7 Why the Anti–Tokamak Is Not Stable

An anti–tokamak:

- does not confine plasma for long,
- is not predictable in the MHD sense,
- is unsuitable for continuous operation.

And precisely for this reason it *may* access states unavailable to tokamaks.

19 Sonar Summary and the Boundary of Model Validity

19.1 Scope and Ambition of the Model

The presented analysis is sonar–like in nature: its goal was not to construct a full theory of fusion nor an alternative to established physics, but to identify potential dynamic regimes that may remain invisible in a stationary description.

The model operates deliberately at the level of:

- competition of time scales,
- interaction dynamics rather than interaction structure,
- transient regimes rather than steady states.

19.2 Tokamak vs. Anti–Tokamak

The tokamak has been identified as a system that:

- imposes global phase order,
- actively suppresses fluctuations,
- enforces $\eta(\omega) \to 1$.

In this sense, the tokamak is a device of order, not of time. If ignition requires momentary interaction incoherence, the tokamak systemically eliminates such regimes.

The anti–tokamak is not a competing technology, but a different class of systems: impulsive, unsynchronized, and short–lived, where temporal competition may arise.

19.3 The $Q_{\text{eff}}(\omega)$ Language

Recasting the idea in the language of dynamic effective charge allows one to detach from model ontology and retain compatibility with the apparatus of academic physics.

In this formulation:

- the fundamental charge remains unchanged,
- only the effectiveness of interaction is modified,
- weakening of the Coulomb barrier is dynamic rather than structural.

The model does not postulate "switching off" interactions, but their temporary detuning.

19.4 Key Falsification Condition

The entire reasoning reduces to a single sharp condition:

> If electric charge possesses no internal relaxation time scale, the model collapses.

If, however, even an extremely short time τ_G exists, on the order of 10^{-14}–10^{-12} s, then dynamic control of the Coulomb interaction becomes a logical—though difficult—possibility.

19.5 Final Status

The model:

- does not prove the existence of the effect,
- does not guarantee ignition,
- does not replace calculation or experiment.

It serves as a conceptual probe indicating:

- where to look,
- which time scales are relevant,
- why certain classes of devices may be intrinsically blind to a given mechanism.

In this sense, the sonar has fulfilled its role.

References

[1] J. D. Lawson, *Some Criteria for a Power Producing Thermonuclear Reactor*, Proceedings of the Physical Society. Section B **70**, 6 (1957).

[2] E. E. Salpeter, *Electron Screening and Thermonuclear Reactions*, Australian Journal of Physics **7**, 373 (1954).

[3] A. Okupski, *The Electron from a Pencil Case*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17781652`.

[4] A. Okupski, *Intuitive Physics*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17665571`.

[5] A. Okupski, *Gravitomagnetism as an Emergent Geometric Phenomenon*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17508247`.

[6] A. Okupski, *Cube in the Land of Quanta*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17866908`.

[7] A. Okupski, *The Proton from a Pencil Case*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17841644`.

[8] A. Okupski, *Why Tokamaks Cannot Ignite Thermonuclear Fusion*. Zenodo, 2025. `https://doi.org/10.5281/zenodo.17790253`.