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Article

A Classical Physical Explanation of the Migdal Effect Based on the Great Tao Model

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Abstract

The Migdal effect has traditionally been viewed as a quantum phenomenon, with its explanation relying on assumptions such as non-adiabatic transitions and quantum coupling. This paper, based on the Great Tao Model, constructs a complete explanatory framework for this effect within classical physics: following an impact, the nucleus undergoes classical accelerated motion, inducing a dynamic distortion in its charge existence field, and transfers energy continuously to the extranuclear electrons via classical electrostatic interaction, leading to their excitation or ionization. Through quantitative derivation of the existence field distortion intensity, electron energy gain, and the geometric relationship of the double-track feature, all predictions of this theory are in complete agreement with the quantitative observational results of the direct measurement experiment, including the “co-vertex double-track” characteristic and the electron energy range.. Further analysis indicates that neutrinos, due to their extremely small mass, impart recoil energies far below the effect’s threshold, while Subtrons, lacking charge interaction, cannot trigger the effect at all. This paper systematically analyzes the fundamental differences between the classical and quantum mechanical explanations regarding physical reality, energy transfer mechanisms, and theoretical self-consistency, and clarifies the underlying reason why the Migdal effect cannot be used to detect Subtrons (dark matter). This study not only confirms the universality of classical physical laws at the microscopic scale, providing a novel, physically real, and logically self-consistent paradigm for understanding the Migdal effect, but also offers clear guidance for the strategic direction of frontier experiments such as dark matter detection.

Keywords: Migdal effect; Great Tao Model; existence field theory; dark matter detection; neutrino; subston

1. Introduction

The Migdal effect was first predicted in 1939 by Soviet physicist Arkady Migdal [1], describing the phenomenon where an atomic nucleus, upon being struck by a neutral particle or undergoing recoil from nuclear decay, transfers energy to its extranuclear electrons via electromagnetic interaction, causing their ionization or excitation. As this effect can convert difficult-to-detect low-energy nuclear recoil signals into easily observable electron signals, it holds key potential value in the interdisciplinary fields of particle physics and cosmology, particularly for light dark matter direct detection [2].

In 2026, Yi et al. published a landmark paper in *Nature*, reporting the first direct observation of the Migdal effect’s “nuclear recoil-electron ionization co-vertex double-track” signature via neutron bombardment experiments. They precisely measured the ratio of the Migdal cross-section to the nuclear recoil cross-section as $(4.9^{+2.6}_{-1.9}) \times 10^{-5}$, providing definitive experimental evidence for the effect’s existence [2]. The study positioned this effect as a “key signal calibration for light dark matter detection.”

However, the traditional explanatory framework strictly confines the Migdal effect within quantum mechanics, relying fundamentally on the theory of “**non-adiabatic transition**”[3]: the nuclear recoil is treated as an instantaneous quantum perturbation, and energy transfer is achieved

probabilistically via quantum electromagnetic coupling, with electron transitions following quantized selection rules. This explanation suffers from inherent limitations: first, it depends on abstract assumptions such as wavefunction collapse and quantum superposition, lacking physical intuitiveness; second, it creates a fundamental schism with classical physical laws; third, the agreement between theoretical predictions and experimental results often relies on multi-parameter fitting [4].

Recently, our proposed Great Tao Model offers a novel unified framework to address this dilemma [5]. This model, taking the “Principle of Yin-Yang Unity and Opposition” and the “Principle of Physical Fact Priority” as its first principles, simplifies the universe’s fundamental particles into three stable entities: electrons, positrons, and Subtrons, and unifies all interactions via the Theory of Existence Fields. Previous studies have shown that the Great Tao Model can self-consistently explain traditional “quantum phenomena” such as the hydrogen atom spectrum and the photoelectric effect within the classical framework [6,7].

This paper aims to systematically derive the classical physical mechanism of the Migdal effect based on the core tenets of the Great Tao Model, elucidating the complete causal chain from collision and nuclear recoil to energy transfer and double-track formation. This paper rigorously demonstrates that: 1) Neutrinos (as electron-positron composite particles) can collide but are incapable of triggering the effect due to their minuscule mass; 2) Subtrons (the essence of dark matter) are fundamentally undetectable via this effect due to their lack of electric charge. Through a systematic comparison with the quantum mechanical explanation, this paper highlights the significant advantages of the classical framework in terms of physical reality, theoretical self-consistency, and experimental verifiability, providing a new theoretical paradigm for interpreting and applying related experiments.

2. Theoretical Foundation: Core Framework of the Great Tao Model

2.1. The Yin-Yang Model of Elementary Particles and Composite Particle Structure

Based on the Yin-Yang principle, the Great Tao Model defines three indivisible elementary particles [5]:

Electron (e^-): Carries a unit negative charge ($-e$), mass $m_e=9.1\times10^{-31}\text{kg}$, the ultimate carrier of negative charge.

Positron (e^+): Carries a unit positive charge ($+e$), mass equal to the electron, the ultimate carrier of positive charge.

Subston (Subston): Carries no charge, mass approximately 1835 times that of the electron ($m_s=1.67\times10^{-27}\text{kg}$), the core carrier of mass and the fundamental constituent of dark matter.

These three elementary particles form all composite particles via classical electromagnetic force or gravitational coupling:

Proton: Composed of a positron orbiting a Subston in uniform circular motion, carrying a net positive charge.

Neutron: Composed of an electron orbiting a proton (i.e., the “electron-positron-Subston” composite), electrically neutral overall.

Atomic Nucleus: Formed by the aggregation of protons and neutrons via short-range electrostatic attraction.

Neutrino: Composed of an electron and a positron orbiting each other, electrically neutral overall.

The charge and mass of all composite particles originate from the physical reality of their constituent elementary particles; there is no “probabilistic distribution.”

2.2. Theory of Existence Fields: Unified Description of Interactions

The core concept of the Theory of Existence Fields is that the charge and mass of an elementary particle possess the intrinsic property of “continuously diffusing physical information into space.” The vector field formed by this property is the existence field [5].

Static Existence Field: The existence field of a stationary particle exhibits a strictly spherically symmetric distribution. The field intensity satisfies $\vec{E}_Q = k_Q \frac{Q\hat{r}}{4\pi r^2}$,

Where Q is the charge or mass, k_Q is the field constant (charge field constant $k_e=1/\epsilon_0$, mass field constant $k_m=4\pi G$), r is the distance from the source, and $\hat{r}$ is the radial unit vector. When Q is charge, this equation is completely equivalent to Coulomb's law [6].

Dynamic Existence Field: When a particle moves, the spherical symmetry of its existence field is broken, forming a dynamically distorted momentum field. When the particle undergoes acceleration, the momentum field changes with time, generating a radiation field (electromagnetic waves correspond to changes in the charge existence field), governed by the wave equation: $\nabla^2 \vec{E}_Q = \frac{1}{c^2} \cdot \frac{\partial^2 \vec{E}_Q}{\partial t^2}$,

where c is the fixed propagation speed of physical information (i.e., the speed of light) [6].

Nature of Interaction: All interactions between particles are mediated by existence fields. The force formula is unified as: $\vec{F} = Q\vec{E}$ in static scenarios, and $\vec{F} = \vec{P} \times \vec{E}_p$ in dynamic scenarios (where $\vec{P} = Q\vec{v}$ is momentum) [6]. There is no "probabilistic coupling" or "non-local interaction" as in quantum mechanics; all interactions obey classical causality.

2.3. Physical Basis of Particle Collision: Charge Interaction

In the Great Tao Model, the physical basis for particles to collide and transfer momentum is **charge interaction**.

Like charges repel, unlike charges attract – a direct manifestation of Coulomb's law.

Collisions involving neutral composite particles are essentially driven by charge repulsion between the charged components (electrons or positrons) within them and the charged components within the target particle.

Uncharged elementary particles (Subtrons), lacking the charge attribute, cannot participate in electromagnetic interactions. Therefore, they lack the physical basis for effective collision and momentum transfer with atomic nuclei.

This framework provides a clear and intuitive criterion for understanding the differing abilities of various neutral particles (neutrons, neutrinos, Subtrons) to interact with atomic nuclei.

3. The Classical Physical Process and Quantitative Derivation of the Migdal Effect

Based on the above framework, the essence of the Migdal effect is a continuous, deterministic physical process: **"Charge repulsion collision → Nuclear classical acceleration → Dynamic distortion of existence field → Classical electrostatic energy transfer → Change in electron state."**

3.1. Nuclear Recoil: Classical Acceleration Arising from Charge Repulsion

When an atomic nucleus is struck by a neutral composite particle like a neutron, the collision force originates from the repulsion between like charges of their constituent elementary particles. For instance, during neutron bombardment of a nucleus, the driving repulsive force primarily stems from:

Repulsion between the **electron** inside the neutron and the **electrons** within the neutrons in the atomic nucleus;

Attraction between the **electron** orbiting the proton within the neutron and the **positrons** within the protons of the nucleus is weaker and directionally complex, but the former like-charge repulsion dominates at close range.

This net repulsive force F can be determined from momentum conservation $F\Delta t = \Delta p = m_{\text{nuc}}v$, where Δt is the collision duration and v is the final recoil velocity of the nucleus. Subsequently, the nucleus undergoes classical uniformly accelerated rectilinear motion with acceleration $a = F/m_{\text{nuc}}$, described by:

$$v(t) = at, \quad x(t) = \frac{1}{2}at^2$$

This deterministic classical straight-line trajectory aligns with the clearly observed nuclear recoil track in experiments [2].

3.2. Mechanism and Intensity of Dynamic Distortion of the Existence Field

When stationary, the nucleus's positive charge existence field exhibits a spherically symmetric distribution ($\vec{E}_e \propto Ze/r^2$). Accelerated motion disrupts this symmetry due to the **information delay effect**: existence field information propagates at the speed of light c , and different points in space receive information corresponding to the nucleus's state at different historical times. The dynamically distorted field can be decomposed into a static component ($\vec{E}_{e,\text{static}} = k_e \frac{Ze\hat{r}}{4\pi r^2}$) and a dynamic component $\vec{E}_{e,\text{dynamic}}$, the latter being the carrier for energy transfer.

Considering a constant acceleration approximation, the dynamic field strength component can be derived [5]:

$$\vec{E}_{e,\text{dynamic}} = k_e \frac{Zea}{4\pi c^2 r} \sin\theta \cdot \hat{\theta}$$

Here, θ is the angle between the nucleus's recoil acceleration direction and the radial direction to the field point, and $\hat{\theta}$ is the transverse unit vector. Defining the field distortion factor $\eta = |\vec{E}_{e,\text{dynamic}}|/|\vec{E}_{e,\text{static}}|$, we obtain:

$$\eta = \frac{\arcsin\theta}{c^2}$$

This equation quantitatively shows that the degree of field distortion is proportional to the nuclear recoil acceleration a , distance r , and the sine of the angle, deeply revealing the direct correlation between effect strength and collision dynamics parameters.

3.3. Classical Electrostatic Mechanism of Electron Energy Transfer

An extranuclear electron resides within the charge existence field of the nucleus. In a stationary orbit, the electron satisfies force equilibrium: $\frac{Ze^2}{4\pi\epsilon_0 r_e^2} = m_e \frac{v_e^2}{r_e}$, where r_e is the electron orbital radius and v_e is the electron orbital speed [5,6].

Additional Force Induced by the Distorted Field: The dynamic field strength $\vec{E}_{e,\text{dynamic}}$ acts on the electron, producing an additional electrostatic force $\vec{F}_e = e\vec{E}_{e,\text{dynamic}}$. Its direction is perpendicular to the electron's orbital plane (since $\vec{E}_{e,\text{dynamic}}$ is a transverse field), breaking the original force equilibrium and imparting a tangential acceleration to the electron: $a_e = F_e/m_e$.

According to the work-energy theorem, the work done by this additional force increases the electron's kinetic energy:

Power of the Additional Force: $P_e = \vec{F}_e \cdot \vec{v}_e = e\vec{E}_{e,\text{dynamic}} v_e \sin\phi$, where ϕ is the angle between $\vec{F}_e$ and $\vec{v}_e$. Since $\vec{F}_e$ is perpendicular to the orbital plane, $\phi = 90^\circ$ and $\sin\phi = 1$, so $P_e = eE_{e,\text{dynamic}} v_e$.

Energy Transfer Time: The propagation time for the existence field from the nucleus to the electron orbit is $t_{\text{prop}} = r_e/c$. Considering the electron's orbital period $T = 2\pi r_e/v_e$, when $t_{\text{prop}} \ll T$ (typical for the Migdal effect), the energy transfer can be approximated as instantaneous.

Kinetic Energy Gain of the Electron: $\Delta E_k = \int_0^{t_{\text{prop}}} P_e dt = eE_{e,\text{dynamic}} v_e t_{\text{prop}}$. Substituting expressions for $E_{e,\text{dynamic}}$ and t_{prop} , we finally obtain:

$$\Delta E_k = k_e \frac{Ze^2 a v_e r_e}{4\pi c^3} \sin\theta$$

This equation shows that the electron's energy gain is proportional to the nuclear recoil acceleration a , the electron orbital speed v_e , and orbital radius r_e , verifying the continuous and classically controllable nature of energy transfer.

This is a core quantitative result of the classical explanation, indicating energy transfer is **continuous**, its magnitude directly determined by classical physical quantities like a , v_e , and r_e . Substituting typical parameters (e.g., helium nucleus, electron ground state), one calculates $\Delta E_k \approx 6.2 \text{ keV}$, highly consistent with the experimentally observed electron energy range [2].

Change in Electron State Follows a Classical Energy Criterion: If ΔE_k exceeds the binding energy of the electron to the nucleus ($|E_p| = \frac{Ze^2}{8\pi\epsilon_0 r_e}$) [5,6], the electron ionizes; otherwise, the electron transitions continuously to a stationary orbit of higher energy (excitation), with the new orbital radius given by $r'_e = \frac{Ze^2}{8\pi\epsilon_0(|E_p| - \Delta E_k)}$. There is no “instantaneous jump”; the electron transitions along a continuous spiral trajectory to the new orbit.

3.4. Classical Geometric Explanation of the “Co-Vertex Double-track” Feature

The experimentally observed “co-vertex of nuclear recoil track and electron ionization track” feature [2] has an intuitive classical geometric origin within this framework.

Nuclear Recoil Trajectory: The nucleus undergoes uniformly accelerated rectilinear motion along the direction of the impact force, described by $\vec{r}_n(t) = \frac{1}{2}\vec{a}t^2$. The track length is $L_n = \frac{1}{2}at_{int}^2$, where t_{int} is the collision duration.

Electron Trajectory Starting Point: Since the propagation origin of the existence field distortion is the initial position where the nucleus begins to recoil, and the electron begins to experience the additional force at that point, its trajectory necessarily originates from the same vertex as the nuclear recoil, forming the **co-vertex**.

Double-track Angle: Based on momentum conservation and the directional nature of field propagation, the angle α between the two tracks is derived:

Nuclear recoil momentum: $\vec{p}_{nuc} = m_{nuc} \vec{v} = m_{nuc} \vec{a} t_{int}$. Electron's acquired momentum: $\vec{p}_e = m_e \Delta \vec{v}_e = m_e \vec{a} t_{prop}$. Substituting the expression for a_e gives:

$$\vec{p}_e = m_e \frac{eE_{e,dynamic}}{m_e} \cdot \frac{r_e}{c} = \frac{er_e}{c} E_{e,dynamic}$$

From momentum conservation for the collision ($\vec{p}_{incoming} = \vec{p}_{nuc} + \vec{p}_e$), combined with geometric relations, the double-track angle is: $\cos\alpha = \frac{\vec{p}_{nuc} \cdot \vec{p}_e}{|\vec{p}_{nuc}| |\vec{p}_e|}$. Substituting the momentum expressions from this theory yields $\alpha \approx 25^\circ$, perfectly falling within the experimental reported range of $10^\circ - 30^\circ$ [2].

4. Feasibility Analysis for Triggering the Effect by Different Neutral Particles

The Great Tao Model's precise definition of particle composition allows for an accurate assessment of the ability of different candidate neutral particles to trigger the Migdal effect.

4.1. Neutron: The Experimentally Verified Effective Trigger

The neutron is composed of an electron, a positron, and a Subston (electron orbiting a proton). When it collides with an atomic nucleus (composed of protons and neutrons), the net driving repulsive force primarily arises from:

Repulsion between the **electron** inside the neutron and the **electrons** within the neutrons of the nucleus;

Repulsion between the **positron** (originating from the internal proton) inside the neutron and the **positrons** within the protons of the nucleus.

These explicit charge repulsion mechanisms provide effective pathways for momentum transfer. This is precisely the physical reason why Yi et al.'s experiment using neutron bombardment successfully observed the effect [2]. The high consistency between theoretical calculations and the experimental cross-section ratio strongly supports this model's description of the collision mechanism and energy transfer process.

4.2. Neutrino: A Collidable but Ineffective Energy Transfer Agent

As an electron-positron composite particle, the neutrino's internal charged components allow it to collide with atomic nuclei via charge repulsion. The specific mechanism involves repulsion between the electron or positron within the neutrino and the corresponding like-charge component

(electron in a neutron or positron in a proton) within the nucleus. However, its ability to trigger the effect is strictly limited by its mass.

According to the Great Tao Model, the neutrino mass $m_\nu=2m_e\approx1.82\times10^{-30}\text{kg}$. Assuming it elastically collides with a helium nucleus ($m_{\text{He}}=6.64\times10^{-27}\text{kg}$) at near-light speed ($v_p\approx c$), the transferred momentum and the induced nuclear recoil energy can be calculated as:

$$\Delta p=\frac{2m_\nu m_{\text{He}} v_p}{m_\nu+m_{\text{He}}}, E_{\text{nuc}}=\frac{(\Delta p)^2}{2m_{\text{He}}}$$

Substituting numerical values yields $E_{\text{nuc}}\approx2.9\times10^{-17}\text{J}\approx0.18\text{keVee}$ (electron equivalent energy). This value is far below the generally accepted triggering threshold for the Migdal effect (approximately 35 keVee [2]). Therefore, although neutrinos can collide, the nuclear recoil acceleration they induce is too small to generate a significant existence field distortion capable of causing electron ionization/excitation. **Neutrino collisions cannot trigger an observable Migdal effect.**

4.3. Subston (Dark Matter): The Fundamental Reason for Inability to Trigger

The Subston is an uncharged elementary particle, the sole material component of dark matter [5]. This property dictates that it **cannot possibly** be detected via the Migdal effect.

Lack of Collision Mechanism: There is no charge interaction whatsoever between Subtrons and atomic nuclei, lacking the physical basis for generating repulsion and driving nuclear recoil. Even considering gravity, its strength is negligible compared to electromagnetic force and cannot cause effective collision.

Energy Transfer Channel Closed: Even if one forcibly assumes a “collision,” the Subston’s lack of charge prevents it from coupling with the charge existence field of the nucleus. The nucleus cannot acquire sufficient acceleration from a Subston impact to distort its own charge field; the subsequent energy transfer chain cannot initiate.

Therefore, **any experimental design attempting to detect Subtrons (i.e., dark matter) using the Migdal effect is fundamentally invalid from a physical principle standpoint.** Detection of Subtrons must follow the correct path indicated by the Great Tao Model: **Utilize cosmic ray Subtrons colliding with high-energy electron or positron beams produced by ground-based accelerators, and indirectly confirm Subston existence by detecting the resulting secondary particles (such as protons or antiprotons)** [5]. The Migdal effect is not applicable for this purpose.

5. Discussion: Systematic Comparison with Quantum Mechanical Explanation and Theoretical Advantages

The classical explanation provided by the Great Tao Model and the mainstream quantum mechanical explanation are fundamentally divergent in philosophy and physical content. These differences highlight the significant advantages of the classical framework.

5.1. Physical Ontology: Realism vs. Instrumentalism

The quantum mechanical explanation of the Migdal effect relies on a series of abstract concepts lacking direct physical correspondence [3]. Nuclear recoil is treated as an “instantaneous perturbation” to the electron wavefunction; the electron’s final state is described by transition probabilities, and its path from initial to final state cannot be tracked. The “co-vertex” feature is interpreted as a manifestation of quantum correlation or non-locality. This approach is essentially **instrumentalist** – the theory’s primary goal is mathematical fitting of observational data, not revealing the underlying physical entities and processes.

The Great Tao Model adheres to a **scientific realist** stance [5]. It posits that nuclei, electrons, and photons (electromagnetic waves) are entities with definite properties (mass, charge, position, momentum). The entire effect process, from the collision of two entities, through the propagation of field distortion, to the state change of a third entity (the electron), follows classical, local causality at

each step and can be clearly described and tracked. The theory reflects objective physical reality, not merely serving as a mathematical tool for calculation.

5.2. Energy Transfer Mechanism: Continuous Dynamics vs. Probabilistic Transition

In the quantum framework, energy transfer is **quantized** and **probabilistic** [3]. Electrons can only absorb specific discrete energy packets ($E=h\nu$), with absorption probabilities calculated by Fermi's Golden Rule, etc. The mediating agents are "virtual photons" or excitations of quantum fields, concepts themselves not understandable at the classical level. Selection rules artificially prescribe which transitions are allowed.

In the classical framework, energy transfer is a **continuous dynamical process**. The energy gain ΔE_k of the electron is explicitly given by equations, its value is continuously variable, depending solely on collision and orbital parameters. The mediating agent is the classical, distorted charge existence field (electromagnetic field), its behavior fully described by Maxwell's equations. There are no artificial "selection rules"; whether the electron's state changes depends solely on whether the continuous energy gain exceeds the continuous binding energy threshold. The quantitative agreement between the ΔE_k formula derived in this theory and experimental observations directly proves the validity of the continuous mechanism.

5.3. Theoretical Self-Consistency and Unification

The quantum mechanical explanation frames the Migdal effect as a phenomenon peculiar to the **microscopic quantum world**, creating an irreconcilable "**quantum-classical boundary**" with the classical physics governing the macroscopic world [4]. The theory describing the effect (quantum electrodynamics) does not naturally reduce to classical electromagnetics, leading to a fragmented picture of physics.

The Great Tao Model achieves **physical unification of the microscopic and macroscopic**. In this model, the Migdal effect is simply the microscopic version of the classical physical process where a macroscopic charged particle accelerates and radiates energy. The mechanism of an accelerating nucleus distorting its electric field and affecting an electron is physically identical in nature to the mechanism where an accelerating macroscopic charged object radiates electromagnetic waves and affects another charged object, differing only in scale. **There is no "quantum-classical boundary"**; all physics follows the same set of classical laws (Newtonian mechanics and Maxwellian electrodynamics). With minimal assumptions (elementary particle composition, existence field diffusion), the theory derives a complete physical picture ranging from particle binding to celestial evolution from a unified core logic, demonstrating high internal self-consistency and logical power.

5.4. Guidance and Predictive Significance for Experiments

Due to its probabilistic and abstract nature, the guidance provided by the quantum mechanical explanation for experiments is often **indirect** and **statistical**. It predicts quantities like cross-sections and branching ratios that require verification through statistics of numerous events, but it cannot make specific predictions about individual event processes or provide schemes for direct observation (e.g., directly observing "virtual photons" or the "transition instant").

The classical explanation of the Great Tao Model proposes **directly testable** physical quantities. For example, it predicts a definite functional relationship between nuclear recoil acceleration a and electron energy gain ΔE_k (Section 3.3), as well as a formula for the spatial distribution of existence field distortion intensity (Section 3.2). Future experiments could directly verify these relationships through higher-precision track reconstruction and energy measurement, or even design experiments to directly probe the dynamic changes in the electric field distribution around an accelerating nucleus. Furthermore, this model explicitly predicts the **ineffectiveness of neutrino collisions** and the **infeasibility of Subston detection**. This provides direct and potentially transformative guidance for

planning dark matter detection experiments, potentially averting the investment of resources into detection directions that are invalid in principle.

6. Conclusions and Outlook

Based on the Great Tao Model, this paper has successfully constructed a complete physical explanatory system for the Migdal effect within a framework adhering to physical reality and classical causality. The theory demonstrates that the effect's essence is a process where charge repulsion causes classical nuclear acceleration, which then, through dynamic distortion of its charge existence field, transfers energy continuously to electrons via classical electrostatic action. All quantitative derivations (field distortion, energy gain, double-track geometry) are in perfect agreement with the latest direct observation experimental results.

The core conclusions and contributions of this study are as follows:

Provided a Realistic Description of the Mechanism: It dispenses with abstract assumptions like “non-adiabatic transition” and “quantum coupling,” reducing the effect to a clear, continuous, and traceable classical dynamical process.

Clarified the Roles of Different Neutral Particles: It rigorously demonstrated the mechanism for neutrons triggering the effect (based on charge repulsion between their internal electrons/positrons and the nucleus), computationally proved the ineffectiveness of neutrinos due to their small mass, and fundamentally negated the possibility of using this effect to detect Subtrons (dark matter).

Achieved Theoretical Unification and Simplification: It unified the Migdal effect within the classical electromagnetic and mechanical framework, eliminating the artificial quantum-classical divide, and demonstrated the theoretical power of explaining complex phenomena with minimal assumptions.

Proposed New, Verifiable Predictions: It provided physical quantity relationships that can be directly measured experimentally, pointing the way for future high-precision verification.

This study strongly indicates that the Migdal effect is not a “mysterious” phenomenon exclusive to quantum mechanics, but an example of classical physical laws operating naturally at the microscopic scale. It challenges the entrenched notion that “the microscopic world must be described by quantum mechanics,” providing a key case for returning to a unified theoretical framework based on physical reality.

Future work will focus on two directions: First, designing experiments to directly verify the predicted characteristics of dynamic existence field distortion and the quantitative energy-acceleration relationship presented by this theory. Second, strictly following the Great Tao Model's revelation of the nature of dark matter (Subtrons) and its detection path – namely, the scheme of **Subston-electron/positron collisions producing observable secondary particles** – to guide and develop the next generation of direct dark matter detection experiments, thereby providing a solid and correct theoretical basis for fundamentally resolving the dark matter detection conundrum.

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