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Coherent Reorganisation of the Energetic Medium and Quantum Stability

This document examines the idea that certain quantum behaviours may be understood as properties of coherent modes of the energetic medium.

A particle is not treated as an object external to the medium, but rather as a stable structure of that medium. Stationary states then correspond to bound and conservative configurations of the near field, while transitions and measurements involve a reorganisation that may produce a propagating far field.

In this reading, quantisation expresses a condition of coherence and non-dissipation of the medium's modes. Atomic stability, spectral lines, interference, and decoherence are all reinterpreted as different manifestations of the same underlying dynamics.

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1 General Framework

This document extends the energetic medium model by examining the possible origin of certain behaviours of a quantum nature.

The underlying hypothesis is that matter is not external to the medium. A particle is a localised and stable structure of the energetic medium. Its interactions are not transmitted through empty space, but carried by perturbations of the medium itself.

There is therefore no dichotomy between, on one side, an autonomous material particle, and on the other, a surrounding medium. There exists a configuration of the medium, locally organised in the form of a stable structure.

A free particle in uniform motion corresponds to a propagating stationary configuration of the medium. It must not lose energy — otherwise the principle of inertia would be violated.

The fundamental distinction is therefore the following:

$$\boxed{\text{near field} = \text{bound, coherent, and conservative configuration of the medium}} \tag{1}$$

$$\boxed{\text{far field} = \text{freely propagating perturbation}} \tag{2}$$

The term *near field* does not necessarily refer to a field of microscopic range. It designates the bound or coherent component of the configuration, as opposed to the freely radiated far field. A near field may therefore extend over the scale imposed by an atom, a cavity, a barrier, a slit, or an interference device.

The far field, by contrast, designates the part of the perturbation that detaches from the local system and propagates outward. For the local system, it represents an energy loss.

In this document, stable quantum states will be interpreted as coherent modes of the near field. Transitions will be interpreted as reorganisations between modes, accompanied by far-field emission when the excess energy propagates away from the local system.

The central question is therefore: can quantum behaviours be interpreted as properties of the coherent modes of the energetic medium, under the constraint of not continuously feeding a dissipative far field?

2 Dynamic Memory of the Medium

When a particle undergoes acceleration, the configuration of the energetic medium associated with it cannot reorganise instantaneously throughout all of space. The particle is not an isolated object moving through a passive vacuum. It is a local structure of the medium, surrounded by a near field that participates in its dynamic equilibrium.

A change in velocity therefore imposes a reorganisation of this extended structure. The near field must adjust to the new kinematic state of the particle. However, this adjustment is limited by the finite propagation speed of perturbations in the medium. This results in an internal delay between the localised structure and the state of the surrounding field.

The propagating field emitted during acceleration should therefore not be understood solely as an energy loss to the exterior. It also constitutes a dynamic trace of the past reorganisation of the medium. It carries information about the particle's recent history: its acceleration, the variation of its near field, and the constraints imposed on the medium during that variation.

This formulation implies that the relevant physical state contains a distributed memory within the medium. The particle may therefore interact with a trace of its own prior states. This interaction is not a mysterious action at a distance. It results simply from the fact that the medium retains, for a finite duration, the perturbations produced by past reorganisations.

Such a mechanism is particularly significant in situations where the propagating field is not immediately dissipated to infinity. This is the case when boundary conditions exist — a cavity, a barrier, a slit, an external potential, or a geometry capable of reflecting, confining, or recombining part of the perturbations produced by past reorganisations. In these situations, the particle does not encounter only an external environment. It also encounters a delayed portion of the dynamics it has itself produced.

This form of memorial wake may then modify the coherence conditions of the near field. It can reinforce certain configurations and destroy others. Stable states are therefore not merely those in which energy remains locally bound. They are also those in which the wake produced by internal reorganisations remains compatible with the global coherence of the mode.

Conversely, when a configuration produces a perturbation that returns in phase opposition, or that disperses phase information into the environment, the coherence of the mode is destroyed. The system then evolves towards another configuration, or dissipates part of its energy in the form of far-field radiation.

This idea allows for a more precise account of the role of acceleration. Acceleration is not merely a modification of the velocity of a particle. It is a breaking of the stationarity of the near field. It forces the medium to reorganise an extended structure. This reorganisation necessarily produces delayed effects, since the medium cannot transmit dynamic information instantaneously. There is therefore a physical memory of this breaking of stationarity.

In the case of uniform motion, the near field can travel with the particle in the form of a stationary configuration. There is then no continuous production of dissipative wake. Uniform motion corresponds to a compatibility between the localised structure and the field that accompanies it.

In the case of accelerated motion, this compatibility is temporarily broken. The near field must change form. Part of this modification remains bound to the particle, another part becomes propagative, and an intermediate part may retain a delayed memory capable of subsequently reacting on the structure.

The mechanism may therefore be summarised as follows:

$$\boxed{\begin{aligned} \text{acceleration} &\Longrightarrow \text{reorganisation of the near field} \\ &\Longrightarrow \text{memorial wake} \\ &\Longrightarrow \text{possible delayed reaction} \end{aligned}} \tag{3}$$

This delayed reaction provides a natural physical interpretation of several phenomena. It illuminates the origin of the inertial reaction, since accelerating a particle amounts to accelerating an extended configuration of the medium that does not follow instantaneously. It also illuminates the radiation reaction, since the particle may interact with the perturbation it has itself produced. Finally, it opens an interpretive pathway for quantum behaviours, in which a particle sometimes appears to depend on global conditions or on possible paths.

Within this framework, these effects do not arise from a point particle mystically exploring multiple trajectories. They arise from an extended structure of the medium, whose near field and memorial wake can be sensitive to the boundary conditions imposed by the experimental setup.

Thus, a slit, a double aperture, or a barrier does not only modify the possible trajectory of a corpuscle. It modifies the organisation of the near field and the propagation of the associated wake. The observed behaviour then results from the coherence or incoherence between the localised structure, its near field, and the propagating memory of the medium.

3 Atomic Stability

The atomic case is the central point.

In a classical description, an electron bound to the nucleus would be subject to Coulomb attraction. If its motion is pictured as an orbit around the nucleus, it possesses a centripetal acceleration.

An accelerated charge should radiate. It should therefore lose energy in the form of far-field radiation, spiral inward toward the nucleus, and ultimately collapse.

Yet atoms are stable.

Within the energetic medium framework, the bound electron is not a point particle external to the medium. It is a structure of the medium participating in a stationary mode of the electron-nucleus-medium system.

The nucleus imposes a central constraint:

$$V(r) = -\frac{ke^2}{r} \tag{4}$$

where:

$$k = \frac{1}{4\pi\varepsilon_0} \tag{5}$$

Stable states are those configurations of the near field that remain coherent and do not produce a net propagating field. This does not mean the absence of dynamics. It means the absence of energy loss from the stationary mode.

Quantisation then appears as a stability condition. Not all configurations are admissible. Only certain forms of the near field can remain bound, regular, normalisable, and non-dissipative.

From this perspective, a stable atomic state is not a real classical orbit. It is a coherent mode of the energetic medium under Coulomb constraint.

The distinction is essential:

$$\text{classical orbit} \Longrightarrow \text{radiating accelerated charge} \tag{6}$$

$$\text{stationary mode} \Longrightarrow \text{coherent non-dissipative near field} \tag{7}$$

The orbital description may remain useful as a semi-classical approximation, but it must not be taken as a fundamental description.

In a more complete description, the atomic state is a spatial mode:

$$\Psi(\vec{r}, t) = \psi(\vec{r})e^{-iEt/\hbar} \tag{8}$$

Its intensity is:

$$|\Psi(\vec{r},t)|^2 = |\psi(\vec{r})|^2 \tag{9}$$

It does not depend on time. The near field therefore retains a stationary form.

The fact that the phase evolves in time is not sufficient to produce far-field radiation. What would produce emission is a non-stationary variation of the configuration.

4 Semi-Classical Approximation

The Bohr approximation allows the main results to be recovered rapidly.

Consider an electron of effective mass m in the Coulomb potential of a nucleus assumed to be fixed. In a more precise description, m should be replaced by the reduced mass:

$$\mu = \frac{m_e m_N}{m_e + m_N} \tag{10}$$

For hydrogen, since $m_N \gg m_e$, we have:

$$\mu \simeq m_e \tag{11}$$

The use of m therefore remains an acceptable approximation for establishing the main results.

In the circular approximation, Coulomb equilibrium gives:

$$\frac{mv^2}{R} = \frac{ke^2}{R^2} \tag{12}$$

that is:

$$mv^2 = \frac{ke^2}{R} \tag{13}$$

This relation is classical. It is not sufficient to ensure stability. Stability requires a coherence condition on the near field.

The phase closure condition imposes:

$$\oint \vec{p} \cdot d\vec{l} = 2\pi n\hbar \tag{14}$$

For a circular configuration:

$$p\,2\pi R = 2\pi n\hbar \tag{15}$$

with:

$$p = mv \tag{16}$$

We obtain:

$$\boxed{mvR = n\hbar} \tag{17}$$

This relation does not describe a real orbit in the classical sense. It expresses the phase coherence of the mode.

From this we derive:

$$v = \frac{n\hbar}{mR} \tag{18}$$

Substituting into the Coulomb equilibrium condition:

$$m\left(\frac{n\hbar}{mR}\right)^2 = \frac{ke^2}{R} \tag{19}$$

which gives:

$$\frac{n^2\hbar^2}{mR^2} = \frac{ke^2}{R} \tag{20}$$

We obtain:

$$\boxed{R_n = \frac{n^2\hbar^2}{mke^2}} \tag{21}$$

The fundamental radius is:

$$\boxed{a_0 = \frac{\hbar^2}{mke^2}} \tag{22}$$

hence:

$$\boxed{R_n = n^2 a_0} \tag{23}$$

The total energy is:

$$E = \frac{1}{2}mv^2 - \frac{ke^2}{R} \tag{24}$$

Since:

$$mv^2 = \frac{ke^2}{R} \tag{25}$$

we have:

$$E = -\frac{ke^2}{2R} \tag{26}$$

Substituting R_n for R:

$$\boxed{E_n = -\frac{mk^2e^4}{2\hbar^2}\frac{1}{n^2}} \tag{27}$$

For hydrogen:

$$\boxed{E_n = -\frac{13.6\,\mathrm{eV}}{n^2}} \tag{28}$$

These levels are the energies of the admissible coherent modes of the near field.

The corresponding velocity is:

$$v_n = \frac{ke^2}{n\hbar} \tag{29}$$

Introducing the fine-structure constant:

$$\alpha = \frac{ke^2}{\hbar c} \tag{30}$$

we obtain:

$$\boxed{v_n = \frac{\alpha c}{n}} \tag{31}$$

For the ground state:

$$v_1 = \alpha c \tag{32}$$

with:

$$\alpha \simeq \frac{1}{137} \tag{33}$$

The non-relativistic approximation is therefore consistent for the hydrogen ground state.

5 Stationary Modes

The semi-classical description must be replaced by a modal description.

A stable state is written:

$$\Psi(\vec{r}, t) = \psi(\vec{r}) e^{-iEt/\hbar} \tag{34}$$

The intensity is:

$$|\Psi(\vec{r}, t)|^2 = |\psi(\vec{r})|^2 \tag{35}$$

It does not depend on time. The near field therefore remains stationary.

The effective equation for the modes is:

$$\boxed{-\frac{\hbar^2}{2m}\nabla^2\psi + V(\vec{r})\psi = E\psi} \tag{36}$$

For the hydrogen atom:

$$\boxed{-\frac{\hbar^2}{2m}\nabla^2\psi - \frac{ke^2}{r}\psi = E\psi} \tag{37}$$

This equation describes the stationary modes of the near field under Coulomb constraint.

The admissible solutions must be:

- regular in the vicinity of the nucleus
- normalisable
- decaying at large distances
- compatible with a stationary phase

Since the potential is spherically symmetric, the variables are separated:

$$\psi(\vec{r}) = R(r) Y_\ell^m(\theta, \phi) \tag{38}$$

The functions Y_ℓ^m describe the angular structure. The function $R(r)$ describes the radial structure.

Setting:

$$u(r) = rR(r) \tag{39}$$

the radial equation becomes:

$$\boxed{-\frac{\hbar^2}{2m}\frac{d^2u}{dr^2} + \left[\frac{\hbar^2\ell(\ell+1)}{2mr^2} - \frac{ke^2}{r}\right] u = Eu} \tag{40}$$

The term:

$$\frac{\hbar^2 \ell(\ell+1)}{2mr^2} \tag{41}$$

is an effective centrifugal barrier. In the modal interpretation, it does not describe a classical centrifugal force, but rather the angular curvature cost of the near field.

The boundary conditions impose the discretisation:

$$\boxed{E_n = -\frac{mk^2e^4}{2\hbar^2}\frac{1}{n^2}} \tag{42}$$

The modes are characterised by:

$$n, \ell, m \tag{43}$$

where n describes the radial structure, ℓ the angular structure, and m the phase orientation.

These quantum numbers do not describe trajectories. They index the admissible coherent forms of the near field.

6 Phase, Amplitude, and Coherence Potential

The field is written in the form:

$$\Psi = Ae^{iS/\hbar} \tag{44}$$

The amplitude A describes the intensity of the mode. The action S describes the phase.

We define:

$$\vec{p} = \nabla S \tag{45}$$

and:

$$E = -\frac{\partial S}{\partial t} \tag{46}$$

The phase therefore encodes the effective momentum and energy of the mode.

Separating the Schrödinger equation into amplitude and phase yields the continuity equation:

$$\boxed{\frac{\partial A^2}{\partial t} + \nabla \cdot \left(A^2 \frac{\nabla S}{m} \right) = 0} \tag{47}$$

and the modified Hamilton–Jacobi equation:

$$\boxed{\frac{\partial S}{\partial t} + \frac{(\nabla S)^2}{2m} + V + Q = 0} \tag{48}$$

with:

$$\boxed{Q = -\frac{\hbar^2}{2m} \frac{\nabla^2 A}{A}} \tag{49}$$

The term Q is not an additional potential appended to the Schrödinger equation. It arises naturally when that equation is rewritten in terms of amplitude and phase.

In the present framework, it is interpreted as a coherence potential. It expresses the dynamic cost of the spatial curvature of the near field.

A very smooth amplitude yields a weak Q term. A strongly confined or rapidly varying amplitude yields a significant Q term.

This allows one to understand why excessive localisation increases the energy of the mode.

One can write qualitatively:

$$\Delta x \text{ small} \Longrightarrow \text{strong curvature of } A \Longrightarrow \text{high coherence energy} \tag{50}$$

The uncertainty relation:

$$\Delta x \, \Delta p \gtrsim \frac{\hbar}{2} \tag{51}$$

can then be reread as a coherence constraint on the modes: a near field cannot be simultaneously strongly localised and weakly structured in phase.

The ground state of the atom results from the balance between Coulomb attraction and the coherence cost of the near field.

The Bohr radius is then the natural scale of the fundamental mode.

7 Diffraction, Interference, and Experimental Devices

A free particle in uniform motion corresponds to a propagating stationary configuration. Interference effects appear when this configuration encounters a device imposing new boundary conditions.

A slit, a double aperture, a barrier, or a potential modifies the organisation of the near field.

For a double aperture, the resulting mode is:

$$\Psi = \Psi_1 + \Psi_2 \tag{52}$$

The intensity is:

$$|\Psi|^2 = |\Psi_1|^2 + |\Psi_2|^2 + 2\mathrm{Re}\left(\Psi_1 \Psi_2^*\right) \tag{53}$$

The cross term produces the fringes.

Interference does not arise from energy loss. It arises from the coherence of the near field under constraint.

For a potential barrier:

$$V(x) = \begin{cases} 0 & \text{if } x < 0 \\ V_0 & \text{if } 0 < x < L \\ 0 & \text{if } x > L \end{cases} \tag{54}$$

if:

$$E < V_0 \tag{55}$$

the solution inside the barrier is:

$$\psi(x) \sim e^{-\kappa x} \tag{56}$$

with:

$$\kappa = \frac{\sqrt{2m(V_0 - E)}}{\hbar} \tag{57}$$

The transmission is approximately:

$$T \sim e^{-2\kappa L} \tag{58}$$

The tunnel effect reflects the continuity of the coherent near field through a classically forbidden region.

The near field can therefore be extended by the imposed configuration. It is not necessarily confined to a microscopic region around a point. It designates the coherent and bound component of the configuration, even when that configuration involves multiple paths.

8 Measurement and Decoherence

Measurement is an irreversible coupling between the near field of the system and a macroscopic device.

Prior to measurement, the system may be coherent:

$$\Psi = \Psi_1 + \Psi_2 \tag{59}$$

After interaction with a detector capable of distinguishing the two alternatives:

$$\Psi = \Psi_1 D_1 + \Psi_2 D_2 \tag{60}$$

If the detector states are distinguishable:

$$\langle D_1 | D_2 \rangle \simeq 0 \tag{61}$$

the interference term vanishes.

Decoherence corresponds to the dispersal of phase information into the degrees of freedom of the device.

The localisation of an event corresponds to the point at which the near field couples irreversibly to the detector.

The Born rule is written:

$$\boxed{P(\vec{r}) = |\Psi(\vec{r})|^2} \tag{62}$$

In this reading, $|\Psi|^2$ represents primarily the local intensity of the mode. The detection probability is proportional to this intensity.

This identification is operational: it relates the mode intensity to the statistical frequencies of measurement events. It does not yet constitute a microscopic derivation of the outcome of an individual measurement.

Measurement can therefore be described as a breaking of the near-field coherence through coupling to a macroscopic system. This breaking may produce dissipation or far-field radiation, but its primary effect is the loss of observable phase relations.

9 Conclusion

The proposed framework rests on a simple distinction.

The near field is the bound, coherent, and conservative configuration of the medium. It describes stable states.

The far field is the propagating perturbation that carries energy away from the local system. It appears during transitions, irreversible interactions, or non-stationary reorganisations.

A free particle in uniform motion produces no energy loss. It corresponds to a propagating stationary configuration of the medium.

A stable atom is not a classically radiating orbit. It is a stationary mode of the near field of the electron-nucleus-medium system.

Quantisation expresses the coherence conditions of these modes.

Transitions correspond to the passage between two modes, with possible far-field emission:

$$h\nu = E_i - E_f \tag{63}$$

Interference corresponds to coherent reorganisations imposed by boundary conditions.

Measurement corresponds to a breaking of coherence through coupling with a macroscopic device.

This reading preserves the main results:

- Bohr energy levels
- energy scaling as $1/n^2$
- Rydberg formula
- absence of radiation from stationary states
- interference
- tunnel effect
- decoherence upon measurement

It remains incomplete on several points: the origin of $\hbar$, the Born rule, the unique outcome of a measurement, spin, entanglement, and relativistic formulation.

The open question is therefore: can quantum mechanics be derived as the effective theory of the coherent modes of the energetic medium and their couplings to the far field?

10 References

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