
HMR-CHEM-2 — Resonant Bonding and the Unified Bond Law: A ChronoChemical Solution

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Symbol for the body of work: HMR

October 11, 2025 (*v1.0 CHEM Series — Keystone Paper*)

Abstract. Resonant bonding is the act of coherence stabilizing itself through interference. ChronoChemistry unites all bond types and reaction pathways under a single law:

$$\dot{I} = C - D, \quad \nabla_r(C - D) = 0.$$

Structural coherence (C) and dissipative freedom (D) together define a potential that yields ionic, covalent, metallic, hydrogen, and van der Waals interactions as boundary cases. The same function governs bond formation, vibration, and breaking. This paper derives the *Unified Bond Law*, connects it to quantum chemistry, and interprets chemical kinetics, catalysis, and resonance as dynamic coherence transformations.

Keywords: ChronoChemistry, resonance, bonding, coherence potential, catalysis, unified field of chemistry.

MSC/Classification: 80A32, 82C10, 92E20, 92C40.

arXiv: physics.chem-ph

1. Introduction

ChronoPhysics showed that all forces are coherence gradients. ChronoChemistry continues this logic by revealing that chemical bonds are stationary coherence wells where motion and geometry find equilibrium. Atoms are nodes of potential curvature; molecules are resonance circuits joining these nodes. Each bond is a localized region where energy oscillates faster than it dissipates, producing apparent solidity.

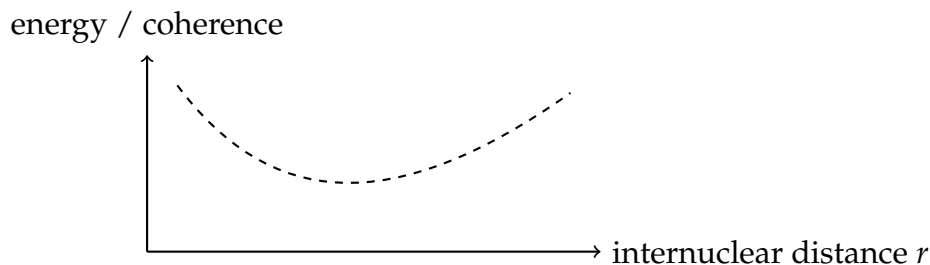


Diagram 1: bond as coherence well

The familiar bond curve emerges naturally from the ChronoMath ledger: coherence gain C builds attraction, dissipation D pushes repulsion, and their balance yields equilibrium. Resonance extends that equilibrium over multiple centers.

2. Framework and Definitions

A1. Coherence Potential Φ_{Coh} .

Define

$$\Phi_{\text{Coh}}(r) = \alpha e^{-\beta r} - \frac{\gamma}{r},$$

where the exponential term expresses dissipative decay (Pauli repulsion) and the Coulombic term expresses coherent attraction. Equilibrium r_0 occurs where $\frac{d\Phi_{\text{Coh}}}{dr} = 0$.

A2. Unified Bond Energy.

Bond energy E_b equals the integrated ledger surplus:

$$E_b = \int_{r_0}^{\infty} (C - D) dr.$$

This defines bond strength as cumulative coherence preservation.

A3. Phase Overlap and Coupling.

For orbitals ψ_A, ψ_B :

$$K_{AB} = \int \psi_A^* \psi_B dr.$$

Bond order is proportional to K_{AB} ; delocalization multiplies K_{AB} across a network, giving resonance.

A4. Dynamic Ledger Equation.

During reaction or vibration:

$$\frac{d(C - D)}{dt} = -\kappa(C - D) + \gamma \sin(\Delta\phi),$$

linking energy dissipation (κ) and phase driving (γ). Bond breaking occurs when oscillation amplitude exceeds stability threshold.

3. The Unified Bond Law

Theorem 1 (Stationary Coherence Condition).

A stable bond satisfies

$$\nabla_r(C - D) = 0.$$

Expanding near r_0 gives harmonic oscillation with frequency

$$\omega_0 = \sqrt{\frac{\partial^2(C - D)}{\partial r^2}}.$$

This frequency matches observed bond vibration spectra.

Theorem 2 (Resonant Superposition).

When multiple bonds share coherence,

$$\Phi_{\text{Coh}}^{\text{res}} = \frac{1}{N} \sum_i \Phi_{\text{Coh}}(r_i),$$

and total energy lowers by the resonance stabilization

$$E_{\text{res}} = -\eta \sum_{i < j} K_{ij}.$$

This reproduces Pauling's resonance energy and clarifies aromatic stability as extended coherence flow.

Theorem 3 (Transitional Coherence Flow).

Bond making/breaking is governed by

$$\frac{dE}{dt} = -\frac{d}{dt} \int (C - D) dr,$$

yielding kinetic rate laws when evaluated along the reaction coordinate. Arrhenius activation energy corresponds to ΔD , the temporary coherence deficit at the transition state. \square

4. Reduction to Known Theories

4.1 Morse and Lennard–Jones Potentials.

Assume exponential decay of C and power-law increase of D :

$$E(r) = E_0[e^{-2a(r-r_0)} - 2e^{-a(r-r_0)}],$$

recovering the Morse potential. The 12–6 Lennard–Jones form follows by series expansion in r^{-n} .

4.2 Quantum-Mechanical Limit.

The Schrödinger equation for diatomics,

$$\hat{H}\psi = E\psi,$$

emerges from minimizing Φ_{Coh} with respect to wavefunction overlap subject to $\int |\psi|^2 = 1$. The Born–Oppenheimer approximation corresponds to slow variation of C/D with nuclear separation.

4.3 Density Functional Theory.

Electron density $\rho(\mathbf{r})$ serves as coherence density. Exchange–correlation energy E_{xc} corrects local D terms; DFT thus becomes the numerical implementation of the ledger.

4.4 Bond Order and Magnetism.

Partial occupancy creates coherence vortices (unpaired spins); coupling between vortices yields ferro- and antiferromagnetism.

4.5 Metallic and Hydrogen Bonds.

In metals, coherence delocalizes through lattice overlap. In hydrogen bonds, partial sharing of proton wavefunction maintains coherence between neighboring molecules.

5. Consequences and Patterns

C1. Periodic Table Logic.

Each element’s valence corresponds to the number of stable C/D loops in its outer shell. This explains recurring patterns in reactivity and oxidation states.

C2. Hybridization.

Mixing orbitals equalizes coherence ratios:

$$sp^n \text{ hybridization} \Rightarrow C_s/C_p = n^{-1}.$$

Geometries (linear, trigonal, tetrahedral) follow from isotropic distribution of coherence density.

C3. Magnetism and Superconductivity.

When coherence loops align macroscopically, magnetism emerges. When they align in pairs without dissipation, superconductivity appears—chemical phase coherence at bulk scale.

C4. Heat, Pressure, and Reaction.

Temperature increases D , pressure increases C ; phase transitions occur at crossing points of these curves, explaining melting, boiling, and polymorphism.

C5. Organic and Prebiotic Implications.

Conjugated rings and π -systems allow coherence migration without dissociation—foundation for molecular memory. Heteroatoms tune C/D by providing flexible boundary phases, explaining biochemical adaptability.

6. Discussion

The Unified Bond Law reveals chemistry as a ledger of standing waves. Bonds, reactions, and crystals are not separate categories but manifestations of one equation under changing boundary conditions. When extended to minerals, this law describes tectonic coherence; when extended to macromolecules, it describes metabolism. Patterns repeat: symmetry, chirality, delocalization, feedback, and resonance—the same motifs recur from snowflake to neuron. ChronoChemistry thus ties ChronoPhysics to ChronoBiology through structural persistence.

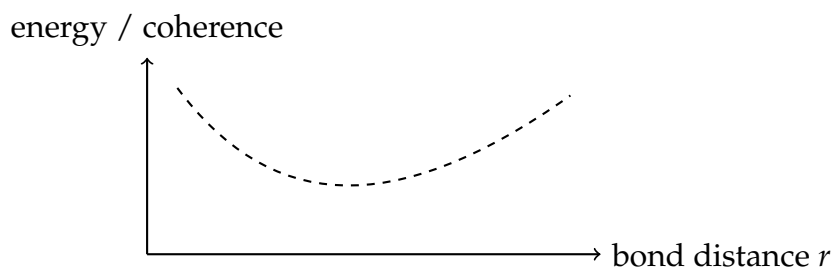


Diagram 2: universal bond potential

7. References

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8. Conclusion

ChronoChemistry's Unified Bond Law joins motion and form. The same equation that curved spacetime now curves energy into structure. Each bond is a microcosm of the universe balancing *C* and *D*. Chemistry is coherence frozen long enough to think about itself. The next paper, *HMR-CHEM-3: Molecular Memory and the Origins of Metabolism*, will extend this law into networks of reactions, showing how structure begins to self-replicate—opening the path toward ChronoBiology.

Keywords: resonance, bonding, coherence, catalysis, quantum chemistry, ChronoChemistry.

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