Section 8: Phase Quantum Mechanics and Thermodynamics
8.1 Phase Quantum Mechanics:

GPT provides a reinterpretation of quantum mechanics, grounding its phenomena in the physical dynamics of phase vortices and the phase background, rather than relying on probabilistic interpretations or abstract mathematical constructs.

- **Phase Wave Function (ψ_{phase}):** In GPT, the wave function is not a descriptor of probabilities but represents a real physical field. It is expressed as $\psi_{phase} = Ae^{i\theta}$, where A^2 is proportional to the density of phase tension (T_{phase} or related to the phase density ρ_{phase}), and θ describes the local phase or state of phase circulation (e.g., related to the gradient of a velocity potential, $\nabla\phi_{velocity}$, or action $S/\hbar$). This physical field describes the actual distribution and dynamic state of a phase vortex.
- **Phase Evolution Equation:** The evolution of ψ_{phase} is governed by a deterministic equation analogous to the Schrödinger equation. A proposed form is $iK\frac{\partial\psi_{phase}}{\partial t} = (-C\nabla^2 + V_{phase}(x,t))\psi_{phase}$.
  - K is a phase quantum of action, analogous to $\hbar$ but derived from vortex stability.
  - C is a coefficient of phase stiffness related to the vortex's internal properties (e.g., radius R, phase density), replacing the $\frac{\hbar^2}{2m}$ term.
  - $V_{phase}(x,t)$ is the real external phase potential influencing the vortex. This equation describes how the phase tension distribution changes due to internal "elasticity" (tendency to minimize curvature) and external phase influences. An alternative formulation, drawing analogy with hydrodynamics (Madelung form), describes the phase dynamics via a continuity equation for phase density ρ_{phase} and an equation for the phase/velocity potential $\phi_{velocity}$ of Hamilton-Jacobi type: $\frac{\partial\rho_{phase}}{\partial t} + \nabla\cdot(\rho_{phase}\nabla\phi_{velocity}) = 0$ and $\frac{\partial\phi_{velocity}}{\partial t} + \frac{1}{2}|\nabla\phi_{velocity}|^2 + V_{eff} = 0$. V_{eff} includes external potentials and an internal "quantum potential" related to ρ_{phase} and its derivatives.
- **Measurement and "Collapse":** The measurement process is a physical interaction between the phase vortex and the measuring apparatus. This interaction perturbs the vortex's phase field, causing it to reorganize and settle into one of its stable configurations. The "collapse" is therefore a real, dynamic phase transition, not an observer-induced or probabilistic event. The probability of a particular outcome is related to the initial density of phase tension corresponding to that configuration.
- **Quantum Effects – Geometric and Deterministic Explanations:**
  - **Quantization:** Discrete energy levels and other quantized properties arise from the requirement of stability and phase coherence for closed phase trajectories. For a stable vortex, the total phase change along any closed loop within its structure must be an integer multiple of 2π ($\oint d\phi = 2\pi n$). This condition naturally leads to discrete solutions for energy and momentum.
  - **Tunneling:** A phase vortex can overcome a potential barrier (a region of high external phase tension V_{phase}) not by "passing through" it in a probabilistic sense, but by its phase field reconfiguring to find an energetically favorable path around or through the barrier if the external phase structure allows. The probability of this phase reorganization is described by a Gamow-like factor involving V_{phase}.
  - **Superposition:** A system described by ψ_{phase} is not in multiple abstract states simultaneously. Rather, its single phase field can encompass several potentially stable configurations or trajectories at once. Measurement localizes the dominant phase tension into one of these configurations.
  - **Entanglement:** Entangled vortices are not independent entities linked by a mysterious signal but parts of a single, globally coherent phase structure, likely formed from a common origin process. A measurement (local phase reorganization) on one part instantly alters the boundary conditions for the entire global phase structure, deterministically defining the state of other parts without superluminal information transfer. Non-locality is a property of the phase topology itself.
  - **Pauli Exclusion Principle:** This principle emerges from the topological incompatibility of identical fermion (spin-1/2) vortices occupying the same phase state in the same location. Attempting to superimpose two such identical phase structures would lead to phase flow conflicts and destructive interference, preventing the formation of a stable combined state unless their phase orientations (e.g., spins) are opposite.

8.2 Phase Thermodynamics:

GPT provides a basis for understanding thermodynamic concepts from the statistical behavior of phase fluctuations and vortex structures.

- **Temperature (T):** Temperature is a macroscopic parameter reflecting the average intensity of uncoordinated phase fluctuations ($\delta\phi$) within a system. These fluctuations include the inherent "noise" of the phase background and the "jitter" or oscillations of stable phase vortices (particles) induced by this noise. The average energy of these fluctuations is proportional to temperature: $\langle E_{fluctuation} \rangle \propto k_B^{'} T$, where $k_B^{'}$ is a phase analog of Boltzmann's constant. Thus, $T \propto \langle (\delta\phi)^2 \rangle$. In this view, heat is not just the kinetic energy of particles but also the energy of these non-particle-forming phase field oscillations.
- **Entropy (S):** Entropy in GPT is a measure of the number of accessible phase configurations (Ω_{phase}) by which a system can realize its current macroscopic state (e.g., a given total energy or overall phase tension). Analogous to Boltzmann's formula, $S = k_B^{'} \ln \Omega_{phase}$. An increase in entropy corresponds to the system exploring a larger number of possible phase configurations, leading to phase decoherence and an averaging out of phase tensions.
- **Heat (Q):** Heat is the transfer of energy via these chaotic, uncoordinated, or subcritical phase fluctuations from one region or system to another.
- **Pressure (P):** Pressure is the macroscopic manifestation of the system's tendency to minimize its total internal phase tension (T_{total} or internal phase energy U_{phase}) in response to a change in volume V. Thus, $P = -\left(\frac{\partial U_{phase}}{\partial V}\right)_{S,N}$.
- **Laws of Thermodynamics (Phase Interpretation):**
  - **Zeroth Law:** Follows from the definition of temperature via the average intensity of phase fluctuations. If two systems are in phase equilibrium with a third (i.e., their $\langle (\delta\phi)^2 \rangle$ are equal), they are in equilibrium with each other.
  - **First Law:** Represents the conservation of total phase energy (U_{phase}) in a system. Heat (Q) is the transfer of non-structured phase fluctuation energy, and work (W) is the change in phase energy due to ordered volume changes ($P\,dV$).
  - **Second Law:** The natural tendency of an isolated phase system to evolve towards states with higher Ω_{phase} (greater number of accessible phase configurations) explains the increase of entropy.
  - **Third Law:** As $T \to 0$, phase fluctuations $\delta\phi \to 0$. The system approaches a single ground state of minimal phase energy and perfect phase coherence ($\Omega_{phase} \to 1$), leading to $S \to 0$. Absolute zero is unattainable due to irreducible minimal background phase fluctuations (analogous to zero-point energy).