Free-Fall Framework (FFF) and the Double-Slit Experiment

FFF uses Spacetime (position-time, classical) and Timespace (momentum-energy, quantum) linked via the Fourier transform. The Fourier transform underpins Heisenberg's uncertainty principle ($\Delta x \cdot \Delta p \geq \hbar/2$), which is central to the double-slit experiment's wave-particle duality.

Information is preserved across Spacetime and Timespace, even during interactions like measurement. This ensures that the system's state (wavefunction) remains fully describable, with measurement redistributing information between position and momentum.

FFF treats forces not as traditional vector sums but as adjustments to maintain the free-fall state ($\sum s_i = 1$). In the double-slit experiment, interactions (e.g., particle-slit, particle-detector) adjust the normalized influences, affecting the observed outcome.

Pre-Interaction State (Particle Approaching Slits)

Before reaching the slits, a particle (e.g., an electron) exists in a free-fall state defined by its scaling parameter λ, which is small due to the quantum scale ($\lambda \sim 10^{-10}$ m for electrons). The particle's state is described in both Spacetime (position-space wavefunction $\psi(x, t)$) and Timespace (momentum-space wavefunction $\tilde{\psi}(k, \omega)$), linked by the Fourier transform. The wavefunction $\psi(x, t)$ encodes a broad range of possible positions, reflecting a large Δx, while $\tilde{\psi}(k)$ has a narrow Δp, consistent with Heisenberg's uncertainty principle.

Interaction (Particle Coupling with Slits)

Interaction between the particle and the slits is modeled as a coupling of two systems with distinct λ-values: the particle ($\lambda_{particle} \sim 10^{-10}$ m) and the slits (macroscopic, $\lambda_{slit} >> 1$). The FFF posits that this interaction adjusts the system to a new effective scaling parameter λ_{eff}, determined by a function $\lambda_{eff} = f(\lambda_{particle}, \lambda_{slit}, \Delta x, \Delta t)$.

Without Measurement (Wave-Like Behavior)

In Spacetime, the particle's wavefunction $\psi(x, t)$ splits into two components, each passing through a slit. These components interfere, producing the characteristic interference pattern on the screen. The Fourier transform maps this to Timespace, where the momentum distribution $\tilde{\psi}(k)$ reflects the superposition of momentum states corresponding to both slit paths.

The small λ_{eff} ensures that quantum effects dominate, with s_{em} governing the wave-like propagation. The Scaling Transformation Symmetry preserves the action, ensuring that the interference pattern is consistent across scales.

A superposition of paths preserves all information about the particle's state. The Fourier transform ensures that the position-space interference pattern corresponds to a well-defined momentum-space distribution, with no information loss.

An interference pattern emerges because the system maintains its free-fall state ($\sum s_i = 1$) without a measurement forcing a specific path, allowing the wavefunction to evolve coherently.

With Measurement (Particle-Like Behavior)

When a detector measures which slit the particle passes through, the interference pattern collapses to a particle-like pattern. The measurement introduces a new interaction between the particle, slits, and detector (macroscopic, $\lambda_{detector} >> 1$). This interaction forces a rapid adjustment of the free-fall state, updating λ_{eff} to reflect the measurement's influence. The detector's large λ shifts the system toward a classical regime, where s_{em} still dominates but the wavefunction collapses.

In Spacetime, the wavefunction ψ(x, t) collapses to a state localized at one slit (e.g., ψ(x) ≈ δ(x - x_1)). The Fourier transform maps this to Timespace, where the momentum distribution $\tilde{\psi}(k)$ broadens (Δp increases), satisfying $\Delta x \cdot \Delta p \geq \hbar/2$. This reflects the loss of interference due to precise position measurement.

Information is conserved during collapse. The measurement redistributes information from a superposed state (both slits) to a definite state (one slit). In Timespace, the broad $\tilde{\psi}(k)$ encodes the particle's momentum correlations, ensuring that the system remains fully describable.

The measurement's large $\lambda_{detector}$ forces λ_{eff} to increase, reducing the influence of quantum superpositions and emphasizing classical, particle-like behavior. The free-fall state adjusts so that $\sum s_i = 1$, with s_{em} governing the particle's trajectory post-measurement. The particle-like pattern (two bands) results from the measurement's disruption of the coherent superposition, rebalancing the free-fall state to favor a localized outcome.

Post-Interaction State (Detection at the Screen)

After passing the slits, the particle reaches the detection screen. The screen detects the particle at a position determined by the interference of the two slit paths. The probability distribution |ψ(x)|^2 reflects the wave-like interference, governed by s_{em} and the small λ_{eff}. The Fourier transform ensures that the momentum distribution in Timespace is consistent with the observed pattern.

The screen detects the particle in one of two bands, reflecting the collapsed wavefunction. The large λ_{eff} post-measurement ensures a classical trajectory, with s_{em} dominating and other forces negligible.

In both cases, the detection process preserves information. The screen's measurement (large λ) maps the final state to a definite position in Spacetime, with the corresponding momentum distribution in Timespace preserving the system's full description via the Fourier transform.

Implications

FFF reframes the double-slit experiment as a manifestation of dynamic equilibrium adjustments. The duality arises from the interplay of Spacetime (position, wave-like) and Timespace (momentum, particle-like) descriptions, linked by the Fourier transform. The scaling parameter λ determines whether wave-like (small λ) or particle-like (large λ) behavior dominates.

Measurement is an equilibrium adjustment driven by the detector's large λ, forcing the system to a new λ_{eff} that favors classical outcomes. This avoids invoking a mysterious "collapse" by framing it as a natural rebalancing of the free-fall state.

The conservation of information ensures that the transition from interference to particle-like behavior is lossless, with the Fourier transform mediating the redistribution of information between position and momentum.

FFF unifies classical and quantum interpretations by treating the double-slit experiment as a scale-dependent phenomenon. Small λ emphasizes quantum coherence (interference), while large λ (via measurement) enforces classical localization.

Unlike quantum mechanics, which treats forces (e.g., electromagnetic) as operators, the FFF views them as adjustments to maintain $\sum s_i = 1$, providing a unified force framework. FFF's use of Spacetime and Timespace, linked by the Fourier transform, formalizes the wave-particle duality in a way that aligns with quantum mechanics but extends to include all forces.

The FFF avoids the measurement problem's ambiguity by treating measurement as an interaction that adjusts λ_{eff}, consistent with quantum mechanics' outcomes but grounded in a physical mechanism. Both frameworks preserve information, but FFF explicitly ties this to the free-fall state and scaling symmetry, offering a potential resolution to information paradoxes (e.g., in black hole analogs).

See paper for further context: *The Law of Universal Free-Fall: A Unified Framework Through Scaling Transformation Symmetry and Information Conservation*