The Three-Body Problem as Retarded Spacetime Shell Interference: An Ontological Resolution to Apparent Non-Integrability

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Abstract The three-body problem has been regarded as analytically intractable in general since Poincaré demonstrated non-integrability in the late 19th century. Modern approaches rely on numerical integration or the discovery of special periodic solutions. We show that the apparent chaos and lack of closed-form solutions arise from an implicit assumption of instantaneous action-at-a-distance or static potentials. When gravity is instead modeled as retarded spacetime shells emitted at each body's Compton frequency (consistent with the finite propagation speed of gravity verified by GW170817 and the mass-energy equivalence $E = mc^2$), the dynamics reduce to deterministic retarded wave interference in three spatial dimensions. The sensitivity to initial conditions is the expected behavior of overlapping retarded spherical shells rather than a fundamental barrier to understanding. Specific symmetric solutions (e.g., figure-8 orbits) emerge naturally as resonance modes in the shell field. No new mathematics or additional postulates are required.

Introduction The Newtonian two-body problem admits elegant closed-form elliptical orbits. The addition of a third body produces equations that are non-integrable in general, leading to chaotic behavior and reliance on numerical methods. This result, pioneered by Poincaré, has stood as a cornerstone of classical dynamics and chaos theory for over a century.

We revisit the problem from the perspective that gravitational influence propagates at the speed of light (c) with strictly retarded causality, as required by observations. Each massive body emits spacetime shells at its Compton frequency $\omega_C = m c^2 / \hbar$. The gravitational field at any point is the local superposition (via RMS statistics) of all arriving retarded shells. Motion of each body is then determined by the gradient of this local shell field while the body simultaneously emits its own new shells.

Retarded Shell Formulation Let the position of body i at retarded time $t_{ret} = t - |r - r_i(t_{ret})| / c$ be the source of a spherical shell. The contribution to the local field at observation point r and time t is proportional to the retarded mass density, falling as 1/r due to spherical expansion (yielding the observed $1/r^2$ force law after taking gradients).

The acceleration of body i is $a_i(t) = -\nabla \Phi_{total}(r_i(t), t)$, where Φ_{total} is the summed retarded potential from all other bodies. Each body updates its velocity and position while emitting its own shell at its Compton frequency.

This formulation is strictly causal and retarded. No instantaneous potentials are assumed.

Resolution of Apparent Chaos In the traditional instantaneous-force picture, small changes in initial conditions lead to exponentially diverging trajectories because the mutual "forces" depend on current positions. In the retarded shell picture, the same sensitivity appears naturally as interference among overlapping spherical waves with time-delayed sources. The evolution is fully deterministic: it is simply the solution to a set of coupled retarded wave equations in three spatial dimensions.

Special periodic solutions (such as the famous figure-8 orbit) correspond to stable resonance modes where the shell emission and interference patterns repeat with a common period. General solutions do not require elementary closed forms any more than arbitrary configurations of moving charges in electromagnetism do; numerical propagation of the retarded shells is straightforward and physically transparent.

Discussion The long-standing perception of analytic intractability was an artifact of solving the wrong set of equations. Once gravity is treated consistently with its observed finite propagation speed and retarded character, the three-body problem becomes a standard (if computationally intensive) retarded wave interference problem. The apparent chaos is not a sign of fundamental unpredictability but the expected signature of multiple overlapping retarded fields in 3D space.

This perspective aligns with the broader framework in which massive particles periodically emit retarded spacetime shells at their Compton frequency, with all observables arising from RMS statistics of shell arrivals under retarded 3D energy conservation.

Conclusion The three-body problem does not require new mathematics or declarations of inherent unsolvability. It resolves cleanly when the underlying ontology is updated to strictly retarded propagation at the speed of causality. Historical efforts within the instantaneous-potential framework were heroic but ultimately limited by that implicit assumption. The retarded shell picture offers both conceptual clarity and practical computability without sacrificing determinism.