Thin Shell with Fictitious Oscillations and Proper Time Oscillator

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We study the gravitational field of an infinitesimally thin spherical shell with fictitious oscillations in the radial directions [1]. The system is spherically symmetric with no oscillations in other directions. Analogous to introducing a fictitious force to describe gravity, we use the fictitious oscillations to explain the gravitational effects outside a thin shell. These radial fictitious oscillations are not physical vibrations of matter. They are considered as geometrical properties of spacetime that can have effects on the temporal and spatial measurements by an observer. Their total energies are conserved as typical for a spherically symmetric simple harmonic oscillating system. According to Noether's theorem, the system has a time translational symmetry. The components of the metric tensor on the time-like hypersurface derived from the fictitious oscillations are constant over time. By studying the effects of the fictitious oscillations on an observer's measurements, we show that the metric derived is equivalent to that for a time-like hypersurface with constant mass M. The external spacetime is static and satisfies the Schwarzschild solution for the gravitational field of a spherically symmetric mass. According to Birkhoff's theorem, this thin shell can be contracted to infinitesimal radius while the external spacetime is unaffected as long as the equivalent mass M of the shell remains constant. By analyzing the Fourier decomposition of an oscillation in time that has varying time rate relative to an inertial observer far away, we show that this proper time oscillator [2] can give rise to the fictitious oscillations on a thin shell with infinitesimal radius. As a result, the spacetime structure arises from a proper time oscillator can mimic the gravitational field of a point mass in relativity.

References

[1] Yau, H. Y. Thin shell with fictitious oscillations. To appear in the Proceedings of the First Hermann Minkowski Meeting on the Foundations of Spacetime Physics; Minkowski Institute, Montreal, 2019.

[2] Yau, H. Y. Temporal vibrations in a quantized field. In *Quantum Foundations, Probability and Information*; Khrennikov, A., Toni, B., Eds.; Springer, Verlag, 2018: pp. 269.