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Time Evolution of Gaussian Wave Packets under Dirac Equation with Fluctuating Mass and Potential

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Localization of relativistic particles has been of great research interest over many decades. We investigate the time evolution of a Gaussian wave packet governed by the one dimensional Dirac equation. The research methodology consists of analytical approach and numerical simulations employing the Chebyshev polynomial expansion of the propagation operator. For the free Dirac equation, we obtain the evolution profiles analytically in many approximation regimes, and numerical simulations consistent with other numerical schemes. Interesting behaviors such as Zitterbewegung and Klein paradox are exhibited. In particular, the dispersion rate as a function of mass is calculated, and it yields an interesting result that the super-massive and massless particles both exhibit no dispersion in free space. For the Dirac equation with random potential or mass, we obtain the probability profiles of the displacement distribution when the potential is uniformly distributed. We observe that the widths of the Gaussian wave packets decrease approximately with the power law of order $o(r^{-1/2})$ as the randomness strength r increases. This suggests an onset of localization, but it is weaker than Anderson localization

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