

## **Abstract**

In this paper, we complete the analysis begun by two of the authors in a previous work on the discrete quantum walk on the infinite line (Carteret *et al* 2003 *J. Phys. A: Math. Gen.* **36** 8775–95 (*Preprint* quant-ph/0303105)). We obtain uniformly convergent asymptotics for the ‘exponential decay’ regions at the leading edges of the main peaks in the Schrödinger (or wave mechanics) picture. This calculation required us to generalize the method of stationary phase and we describe this extension in some detail, including self-contained proofs of all the technical lemmas required. We also rigorously establish the exact Feynman equivalence between the path-integral and wave-mechanics representations for this system using some techniques from the theory of special functions. Taken together with the previous work, we can now prove every theorem by both routes.