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The semiclassical limit of focusing NLS for a family of non-analytic initial data

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The small dispersion limit of the focusing nonlinear Schro\"odinger equation (NLS) exhibits a rich structure of sharply separated regions exhibiting disparate rapid oscillations at microscopic scales. The non self-adjoint scattering problem and ill-posed limiting Whitham equa- tions associated to focusing NLS make rigorous asymptotic results difficult. Previous studies [KMM03, TVZ04, TVZ06] have focused on special classes of analytic initial data for which the limiting elliptic Whitham equations are well-posed. In this paper we consider another exactly solvable family of initial data, the family of square barriers, $\psi_0(x) = q \chi_{[-L,L]}$ for real amplitudes q. Using Riemann-Hilbert techniques we obtain rigorous pointwise asymptotics for the semiclas-sical limit of focusing NLS globally in space and up to an O(1) maximal time. In particular, we show that the discontinuities in our initial data regularize by the immediate generation of genus one oscillations emitted into the support of the initial data. To the best of our knowledge, this is the first case in which the genus structure of the semiclassical asymptotics for fNLS have been calculated for non-analytic initial data.

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