Numerical methods for graphene superlattice equation

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Abstract

The graphene superlattice (GSL) equation describes the propagation of the solitary electromagnetic waves in the graphene superlattice [1]. The equation for solitary electromagnetic wave in graphene superlattice (eK) is given by

$$u_{tt} - u_{xx} + \frac{\omega_0^2 b^2 \sin\alpha}{\sqrt{1+b^2(1-\cos\alpha)}} = 0, \quad (1)$$

where ω_0 and b are parameters associated to graphene superlattice (Figure 1). The solution of the nonlinear Eq. (1) corresponding to the solitary electromagnetic (EM) π-pulse is:

$$\int_{\pi}^{\alpha(\xi)} \frac{d\,\alpha}{\sqrt{\sqrt{1+b^2(1-\cos\alpha)}-1}} = 2\xi\,, \quad (2)$$

the integral (2) defines a solitary EM wave propagating across the GSL axis [2].

In this work we presented the behavior of GSL (Figure 1) with several numerical schemes [3], [4] based on stable Padé methods (Figure 2).

References

[1] Kryuchkov, Sergey V. and Kukhar', Egor I., Physica B, (2012)
[2] Martin-Vergara, F., Rus, F. and Villatoro, F.R., Springer (2018) 85-110
[3] Strauss, W and Vazquez, L. Journal of Computational Physics 28, 271-278 (1978)
[4] Fornberg, B., SIAM Rev. 40:685-691, (1998)

Figures

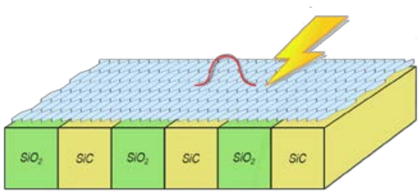

Figure 1: Graphene Superlattice

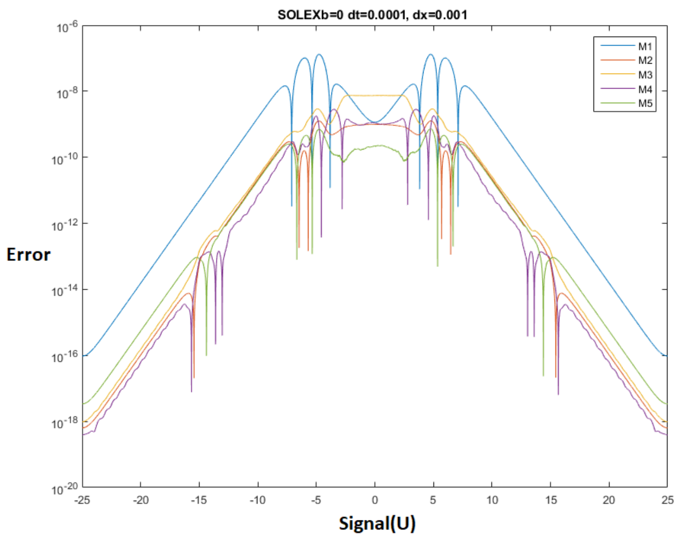

Figure 2: Error evolution with several numerical schemes for solving the GSL equation

The numerical solutions, the invariants and the stability of kink-antikink and breather solutions of the nonlinear sine-Gordon equation are analyzed as functions of the time and spatial step sizes and compared with those of the Strauss-Vazquez technique [3]. It is shown that the errors decrease as the grid size and time step are decreased, and that the most accurate, computational cost efficient and stable Padé method is the one that corresponds to an eighth-order accurate scheme.