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Kink behavior in the sine-Gordon model under a variety of inhomogeneities

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Our research focuses on an extensive analysis of the dynamics of kink solutions in a modified sine-Gordon model, including a comprehensive study of the effects of breaking translational invariance due to the presence of periodic and localized inhomogeneities.

We present a significant advancement in understanding the behavior of kink solutions within the sine-Gordon model, particularly in these complex environments. By introducing a novel ansatz, we have successfully constructed an effective model with two degrees of freedom. This model achieves remarkable accuracy in predicting the kink's dynamics, even in the non-perturbative regime and at relativistic velocities. The effectiveness of our model was validated through comprehensive numerical simulations, which demonstrated excellent agreement with the original partial differential equations. We also emphasize the critical influence of initial conditions on the accuracy of the effective model, offering new insights into the interaction between kinks and heterogeneous environments.

Furthermore, we explore the dynamics of kinks under additional influences, such as a switched bias current and dissipation, within environments featuring periodic heterogeneity. Our findings suggest that the effective model not only captures the kink's position and width evolution with high precision but also offers potential for manipulating the kink's trajectory and rest position through external controls. This capability could lead to innovative techniques for controlling nonlinear wave dynamics in various physical systems. The successful application of this approach to more complex environments underscores its robustness and opens new avenues for exploring kink dynamics in other non-integrable Klein-Gordon models and beyond.

The collective findings from our studies not only advance the understanding of kink dynamics in complex media but also pave the way for future research in the domain of non-linear wave motions in dispersive systems. The methodologies and results presented in this talk are anticipated to stimulate further investigations, potentially leading to novel applications in fields ranging from condensed matter physics to applied mathematics and engineering.

References

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