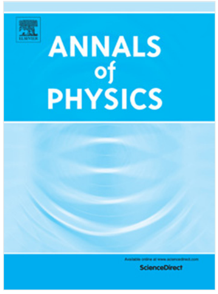

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Small Deformations of Kinks and Walls

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A Rayleigh-Schrödinger type of perturbation scheme is employed to study weak self-interacting scalar potential perturbations occurring in scalar field models describing 1D domain kinks and 3D domain walls. The solutions for the unperturbed defects are modified by the perturbing potentials. An illustration is provided by adding a cubic potential to the familiar quartic kink potential and solving for the first order correction to the kink solution, using a "slab approximation". A result is the appearance of an asymmetric scalar potential with different, nondegenerate, vacuum values and the subsequent formation of vacuum bubbles.

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1. INTRODUCTION

Exact solutions describing 1D domain kinks and 3D domain walls for φ^4 scalar field theory with a symmetric potential of the form $V_0(\varphi) = \frac{1}{4}\lambda(\varphi^2 - a^2)^2$ are well known, with vacuum values located by $\varphi = \pm a$, and static solutions assume the form $\varphi(x) = \pm a\tanh(kx) = \pm a\tanh(x/w)$, where w is a "width parameter" for the kink/wall [1]-[4]. However, the addition of a small perturbing potential $V_1(\varphi)$ will, in general, distort the simple $\tanh(kx)$ solutions in some way that depends upon the form of $V_1(\varphi)$ [5]-[9].

An effort here is made to focus upon a Rayleigh-Schrödinger type of perturbation scheme resulting in corrections to the unperturbed solutions, the corrections being due to the perturbing potential $V_1(\varphi)$. This method involves an expansion of the solution $\varphi(x)$ in terms of powers of an expansion parameter g, along with an expansion of the full potential $V(\varphi) = V_0(\varphi) + V_1(\varphi)$ about the zeroth order solution $\varphi_0(x)$ which solves the unperturbed equation of motion.

This perturbation scheme differs from the excellent one introduced by Almeida, Bazeia, Losano, and Menezes [7] for $(1+1)$ dimensional topological defects, wherein the unperturbed action $S_0(\varphi)$ is supplemented by an additional perturbing action $S_1(\varphi) = \alpha\int d^2x F(\varphi, X)$, where α is a very small parameter controlling the perturbative expansion, $X = \frac{1}{2}\partial^\mu\varphi\partial_\mu\varphi$,