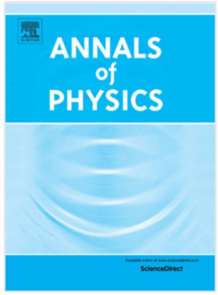
Accepted Manuscript



Perturbation theory for short-range weakly-attractive potentials in one dimension

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PII: S0003-4916(17)30032-5
DOI: http://dx.doi.org/10.1016/j.aop.2017.01.022
Reference: YAPHY 67320

To appear in: *Annals of Physics*

Received date: 9 October 2016
Accepted date: 20 January 2017

Perturbation theory for short-range weakly-attractive potentials in one dimension

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Abstract

We have obtained the perturbative expressions up to sixth order for the energy of the bound state in a one dimensional, arbitrarily weak, short range finite well, applying a method originally developed by Gat and Rosenstein Ref. [3]. The expressions up to fifth order reproduce the results already known in the literature, while the sixth order had not been calculated before. As an illustration of our formulas we have applied them to two exactly solvable problems and to a nontrivial problem.

Keywords: bound states in the continuum; perturbation theory; quantum wells

1. Introduction

We consider the Schrödinger equation in one dimension

$$\hat{H}\psi(x) = E\psi(x) \tag{1}$$

with

$$\hat{H} = -\frac{d^2}{dx^2} + \lambda V(x) \tag{2}$$

where $V(x)$ is a potential of finite depth ($\lim_{|x|\to\infty} V(x) = 0$ and $V(x) < 0$ for $x \in (-\infty, \infty)$).

For this problem Simon[4] has stated the necessary and sufficient conditions for a bound state to exist for $\lambda \to 0$, proving the analyticity of the lowest energy eigenvalue at $\lambda = 0$, in one dimension (in two dimensions, on the other hand, Simon has also proved the non-analyticity of the eigenvalue). The work of Simon was stimulated by the findings of Abarbanel, Callan and Goldberger [5], who had obtained the expression for the lowest eigenvalue to order λ^3, when

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