

1 Semiclassical Approximation

The semiclassical approximation is a powerful approach to evaluating the propagator under the right conditions. Roughly speaking, we want a smooth potential and short de Broglie wavelengths. In the semiclassical approximation, the propagator takes the following form,

$$K_{sc}(x, x', t) = F \exp\left(\frac{i}{\hbar} S_c(x, x', t)\right), \quad (1)$$

where S_c is a strictly classical quantity, the action evaluated along the classical path from x to x' . The pre-factor F is an approximation to the path integral for paths other than the classical path. When the semiclassical approximation is working, most of the important physics is in S_c , not F . The semiclassical approximation is exact, that is not an approximation, for the free particle and the harmonic oscillator, among other examples. It is important to realize that the semiclassical approximation has to do with how close F is to the path integral around the classical path. Any path integral can be written in the form of Eq.(1). The semi-classical approximation then is an approximation to F . The general formula for F in semiclassical approximation is given at the end of these notes.

Classical Path and Classical Action Consider any path $x(t')$ which starts at x' and ends at x . This means $x(0) = x'$, and $x(t) = x$. Once we have a path, we can calculate the action for that path. This is just

$$S = \int_0^t L(x(t')) dt'.$$

The action certainly depends on the path used to calculate it. Now suppose we go to a nearby path,

$$x(t') \rightarrow x(t') + \delta(t')$$

where $\delta(t')$ is small and vanishes at the endpoints, $\delta(0) = \delta(t) = 0$. In other words, we are considering only paths which start and end at our two points. It is of interest to see how the action varies to $O(\delta)$. Putting $x(t') \rightarrow x(t') + \delta(t')$ into the Lagrangian, we have

$$L \rightarrow \frac{m}{2} \left(\frac{d}{dt}(x + \delta) \right)^2 - V(x + \delta)$$

Expanding, we have

$$L = \frac{m}{2} \left(\frac{dx}{dt} \right)^2 + m \frac{dx}{dt} \frac{d\delta}{dt} - V(x) - \delta \frac{\partial}{\partial x} V + \dots$$

Putting these terms in the action, we have for δS ,

$$\delta S = \int_0^t dt' \left(\frac{dx}{dt} \frac{d\delta}{dt} - \delta \frac{\partial}{\partial x} V \right)$$

Semiclassical Approximation In Quantum Mechanics

Thomas Griffiths



Semiclassical Approximation In Quantum Mechanics:

Semi-Classical Approximation in Quantum Mechanics Victor P. Maslov, M.V. Fedoriuk, 2001-11-30 This volume is concerned with a detailed description of the canonical operator method one of the asymptotic methods of linear mathematical physics The book is in fact an extension and continuation of the authors works 59 60 65 The basic ideas are summarized in the Introduction The book consists of two parts In the first the theory of the canonical operator is developed whereas in the second many applications of the canonical operator method to concrete problems of mathematical physics are presented The authors are pleased to express their deep gratitude to S M Tsidilin for his valuable comments THE AUTHORS IX INTRODUCTION 1 Various problems of mathematical and theoretical physics involve partial differential equations with a small parameter at the highest derivative terms For constructing approximate solutions of these equations asymptotic methods have long been used In recent decades there has been a renaissance period of the asymptotic methods of linear mathematical physics The range of their applicability has expanded the asymptotic methods have been not only continuously used in traditional branches of mathematical physics but also have had an essential impact on the development of the general theory of partial differential equations It appeared recently that there is a unified approach to a number of problems which at first sight looked rather unrelated V.P. Maslov and M.V. Fedoriuk. Semi-classical approximation in quantum mechanics (Kvaziklassičeskoe približenie dlja uravnenij kvantovoj mehaniki, engl.) Transl. from the Russian by J. Niederle and J. Tolar V. P. Maslov, Michail Vasil'evič Fedorjuk, 1981 **Semi-classical Approximation in Quantum Mechanics** Viktor Pavlovich Maslov, Mikhail Vasil'evich Fedoriuk, 1981 **Advances in One-Dimensional Wave Mechanics** Zhuangqi Cao, Cheng Yin, 2014-01-16 *Advances in One Dimensional Wave Mechanics* provides a comprehensive description of the motion of microscopic particles in one dimensional arbitrary shaped potentials based on the analogy between Quantum Mechanics and Electromagnetism Utilizing a deeper understanding of the wave nature of matter this book introduces the concept of the scattered sub waves and a series of new analytical results using the Analytical Transfer Matrix ATM method This work will be useful for graduate students majoring in physics mainly in basic quantum theory as well as for academic researchers exploring electromagnetism particle physics and wave mechanics and for experts in the field of optical waveguide and integrated optics Prof Zhuangqi Cao is a Professor of Physics at Shanghai Jiao Tong University China Dr Cheng Yin is a teacher at Jiangsu Key Laboratory of Power Transmission and Distribution Equipment Technology Hohai University China **Semi-classical Approximation in Quantum Mechanics** D. Robert, 1997 **The Physics of Energy** Robert L. Jaffe, Washington Taylor, 2018-01-25 A comprehensive and unified introduction to the science of energy sources uses and systems for students scientists engineers and professionals **The Open Semiclassical Approximation to the Density Matrix and Its Application to the Wigner Function** Michael Solomon Small, 2008 **Semiclassical Approximations for High Energy Scattering** M. Mitchell Waldrop, 1975 **Encyclopedia of Chemical Physics and**

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Semiclassical Theory of Shape Resonances in Quantum Mechanics Peter D. Hislop, Israel Michael Sigal, 1989 In this paper we prove the existence of shape resonances in the semi classical approximation for Hamiltonians of the form $H = \frac{p^2}{2m} + V(x)$ where $V(x)$ is a potential well with a barrier of height V_0 and width a and \hbar is the Planck constant **Semiclassical Theories of Molecular Scattering** B. C. Eu, 2012-12-06 The study of molecular collisions at energies from less than about 100 eV down to a few 10 eV which is roughly the range of chemical interest has greatly expanded in the last 10 to 20 years As in many fields this activity has been stimulated by parallel advances in theory which have triggered the autocatalytic positive feedback system of experiment challenging theory and vice versa Possibly the biggest driving force however has been the growing awareness that molecular collisions are important in our understanding of natural and man made environments Molecular collision dynamics is now studied in connection with molecular formation in interplanetary space upper atmosphere chemistry plasmas lasers and fusion reactors and is crucial for understanding gas dynamic flow processes gas phase chemical reactions and catalysis Despite the great strides made in studying elementary collisions in laboratory scattering experiments many of the processes in these areas are too complicated for us to hope ever

to study them in detail in the laboratory Thus in the long run we shall have to rely on theory Initially I think many of us like myself had hoped that the development of fast computers would outpace the demands on computing time so that brute force quantum mechanical exact calculations would provide all the answers Unfortunately this has not been the case and efficient approximations are needed They can be broadly classified as classical semiclassical or semiquantal **Physics Briefs** ,1993

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