Semiclassical study of shape resonances in the Stark effect

Kentaro Kameoka

Abstract. Semiclassical behavior of Stark resonances is studied. The complex distortion outside a cone is introduced to study resonances in any energy region for the Stark Hamiltonians with non-globally analytic potentials. The non-trapping resolvent estimate is proved by the escape function method. The Weyl law and the resonance expansion of the propagator are proved in the shape resonance model. To prove the resonance expansion theorem, the functional pseudodifferential calculus in the Stark effect is established, which is also useful in the study of the spectral shift function.

Mathematics Subject Classification (2020). Primary: 81Q20; Secondary: 47A10.

Keywords, Resonance, semiclassical limit, Stark effect, Weyl law, resonance expansion.

1. Introduction

In this paper, we study the semiclassical behavior of the resonances for the Stark Hamiltonian:

$$P(\hbar) = -\hbar^2 \Delta + \beta x_1 + V(x).$$

where $V(x) \in C^{\infty}(\mathbb{R}^n; \mathbb{R})$ is a non-globally analytic potential and $\beta > 0$. Throughout this paper, the constant $\beta > 0$ is fixed.

We set the cone

$$C(K, \rho) = \{x \in \mathbb{R}^n \mid |x'| \le K(x_1 + \rho)\},\$$

where $x' = (x_2, \dots, x_n)$, and denote its complement by $C(K, \rho)^c$. We denote the set of all bounded smooth functions with bounded derivatives by C_b^{∞} . Our assumption on the potential V is as follows:

Assumption 1. The potential $V(x) \in C_b^{\infty}(\mathbb{R}^n; \mathbb{R})$ has an analytic continuation to the region $\{x \in \mathbb{C}^n \mid \operatorname{Re} x \in C(K_0, \rho_0)^c, |\operatorname{Im} x| < \delta_0\}$ for some $\rho_0 \in \mathbb{R}, K_0 > 0$ and $\delta_0 > 0$, and $\partial V(x)$ goes to zero when $\operatorname{Re} x \to \infty$ in this region.

Semiclassical Theory Of Shape Resonances

Michael Rajnik

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Table of Contents Semiclassical Theory Of Shape Resonances

- 1. Understanding the eBook Semiclassical Theory Of Shape Resonances
 - The Rise of Digital Reading Semiclassical Theory Of Shape Resonances
 - o Advantages of eBooks Over Traditional Books
- 2. Identifying Semiclassical Theory Of Shape Resonances
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
- 3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Semiclassical Theory Of Shape Resonances
 - User-Friendly Interface
- 4. Exploring eBook Recommendations from Semiclassical Theory Of Shape Resonances
 - Personalized Recommendations
 - Semiclassical Theory Of Shape Resonances User Reviews and Ratings
 - Semiclassical Theory Of Shape Resonances and Bestseller Lists

- 5. Accessing Semiclassical Theory Of Shape Resonances Free and Paid eBooks
 - Semiclassical Theory Of Shape Resonances Public Domain eBooks
 - Semiclassical Theory Of Shape Resonances eBook Subscription Services
 - Semiclassical Theory Of Shape Resonances Budget-Friendly Options
- 6. Navigating Semiclassical Theory Of Shape Resonances eBook Formats
 - o ePub, PDF, MOBI, and More
 - Semiclassical Theory Of Shape Resonances Compatibility with Devices
 - Semiclassical Theory Of Shape Resonances Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Semiclassical Theory Of Shape Resonances
 - Highlighting and Note-Taking Semiclassical Theory Of Shape Resonances
 - Interactive Elements Semiclassical Theory Of Shape Resonances
- 8. Staying Engaged with Semiclassical Theory Of Shape Resonances
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - $\circ\,$ Following Authors and Publishers Semiclassical Theory Of Shape Resonances
- 9. Balancing eBooks and Physical Books Semiclassical Theory Of Shape Resonances
 - \circ Benefits of a Digital Library
 - Creating a Diverse Reading Collection Semiclassical Theory Of Shape Resonances
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Semiclassical Theory Of Shape Resonances
 - Setting Reading Goals Semiclassical Theory Of Shape Resonances
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Semiclassical Theory Of Shape Resonances
 - Fact-Checking eBook Content of Semiclassical Theory Of Shape Resonances
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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