



Spectral Analysis of Discrete Metastable Diffusions

Giacomo Di Gesù

Dipartimento di Matematica, Università di Roma "La Sapienza", P.le Aldo Moro 5, 00185 Rome, Italy.
E-mail: giacomo.digesu@uniroma1.it

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Abstract: We consider a discrete Schrödinger operator $H_\varepsilon = -\varepsilon^2 \Delta_\varepsilon + V_\varepsilon$ on $\ell^2(\varepsilon\mathbb{Z}^d)$, where $\varepsilon > 0$ is a small parameter and the potential V_ε is defined in terms of a multiwell energy landscape f on \mathbb{R}^d . This operator can be seen as a discrete analog of the semiclassical Witten Laplacian of \mathbb{R}^d . It is unitarily equivalent to the generator of a diffusion on $\varepsilon\mathbb{Z}^d$, satisfying the detailed balance condition with respect to the Boltzmann weight $\exp(-f/\varepsilon)$. These type of diffusions exhibit metastable behavior and arise in the context of disordered mean field models in Statistical Mechanics. We analyze the bottom of the spectrum of H_ε in the semiclassical regime $\varepsilon \ll 1$ and show that there is a one-to-one correspondence between exponentially small eigenvalues and local minima of f . Then we analyze in more detail the bistable case and compute the precise asymptotic splitting between the two exponentially small eigenvalues. Through this purely spectral-theoretical analysis of the discrete Witten Laplacian we recover in a self-contained way the Eyring–Kramers formula for the metastable tunneling time of the underlying stochastic process.

1. Introduction

This paper derives sharp semiclassical spectral asymptotics for Schrödinger operators acting on $\ell^2(\varepsilon\mathbb{Z}^d)$ of the form

$$H_\varepsilon = -\varepsilon^2 \Delta_\varepsilon + V_\varepsilon, \quad 0 < \varepsilon \ll 1, \quad (1)$$

where Δ_ε is the discrete nearest-neighbor Laplacian of $\varepsilon\mathbb{Z}^d$ and V_ε is a possibly unbounded multiplication operator, defined in terms of a multiwell energy landscape f . More precisely, given $f \in C^2(\mathbb{R}^d)$, we identify V_ε with the function

$$V_\varepsilon(x) = e^{\frac{f(x)}{2\varepsilon}} (\varepsilon^2 \Delta_\varepsilon e^{-\frac{f}{2\varepsilon}})(x), \quad (2)$$

Discrete Spectral Analysis Solution Manual

Leslie Balmer



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