RESEARCH ARTICLE

Ground state solutions for asymptotically linear Schrödinger equations on locally finite graphs

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We are considered with the following nonlinear Schrödinger equation:

$$-\Delta u + (\lambda a(x) + 1)u = f(u), x \in V,$$

on a locally finite graph $G = (V, E)$, where V denotes the vertex set, E denotes the edge set, $\lambda > 1$ is a parameter, $f(s)$ is asymptotically linear with respect to s at infinity, and the potential $a : V \to [0, +\infty)$ has a nonempty well Ω. By using variational methods, we prove that the above problems has a ground state solution u_λ for any $\lambda > 1$. Moreover, we show that as $\lambda \to \infty$, the ground state solution u_λ converges to a ground state solution of a Dirichlet problem defined on the potential well Ω.

KEYWORDS

asymptotically linear Schrödinger equation, ground state, locally finite graph, potential well

MSC CLASSIFICATION

35J20

1 | INTRODUCTION

In this paper, we consider the following asymptotically linear Schrödinger equation:

$$-\Delta u + (\lambda a(x) + 1)u = f(u), x \in V, \tag{1.1}$$

on a connected locally finite graph $G = (V, E)$, where V denotes the vertex set, E denotes the edge set, and $\lambda > 1$ is a parameter. We call G a locally finite graph if for any $x \in V$, there are only finite $y \in V$ such that $xy \in E$. A graph is connected if any two vertices x and y can be connected via finite edges. For any edge $xy \in E$, we assume that the weight ω_{xy} satisfies $\omega_{xy} = \omega_{yx} > 0$. The measure $\mu : V \to \mathbb{R}^+$ is a finite positive function. For any function $u : V \to \mathbb{R}$, the graph Laplacian of u is defined as

$$\Delta u(x) := \frac{1}{\mu(x)} \sum_{y \sim x} \omega_{xy}(u(y) - u(x)), \tag{1.2}$$

where $y \sim x$ stands for any vertex y connected with x by an edge $xy \in E$.

In the past decade, the study of partial differential equations on graphs, which has a wide range of applications in image processing, data analysis, and neural networks, has been receiving great attention; see [1–3] for more practical backgrounds. Recently, there are some mathematical works on geometric inequalities on graphs [4, 5] and the heat equation on graphs [6–10]. In the case of elliptic differential equations on graphs, Grigor'yan et al. [11–13] obtained the existence results by using variational methods. The existence of normalized solutions for nonlinear Schrödinger equations on metric graphs has been obtained in [14, 15]. On locally finite graphs, there are some works about nonlinear Schrödinger equations

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