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Boundedness for solutions of equations of the Chern-Simons-Higgs type

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Abstract This paper is concerned with a priori estimate of an equation of the Chern-Simons-Higgs type. We study the uniform bound of classical solutions u of the semilinear equation and integrable solutions u of the fractional order equation. We prove $|u| \leq 1$ in R^n , which comes into play in studying the quantization effects of those equations.

Keywords: Chern-Simons-Higgs equation, fractional Laplacian, uniform bound

MSC2010: 35Q56, 35R11, 35J61, 35B45

1 Introduction

In 1994, Brezis, Merle and Riviere [1] studied the quantization effects of the following equation

$$-\Delta u = (1 - |u|^2)u \quad \text{in } R^2.$$

It is the Euler-Lagrange equation of the Ginzburg-Landau energy

$$E_{GL}(u) = \frac{1}{2} \|\nabla u\|_{L^2(R^2)}^2 + \frac{1}{4} \|1 - |u|^2\|_{L^2(R^2)}^2.$$

Here $u : R^2 \rightarrow R^2$ is a vector value function. In particular, they proved $|u| \leq 1$ in R^2 (see also [6] and [12]). Afterwards, the same conclusion was obtained in [11] for the following equation

$$-\Delta u = |u|^2(1 - |u|^2)u - \frac{1}{2}(1 - |u|^2)^2u \quad \text{in } R^n \quad (1.1)$$

under the assumption

$$\nabla u \in L^2(R^n), \quad \text{or} \quad |u|^2 - 1 \rightarrow 0 \quad \text{when} \quad |x| \rightarrow \infty \quad (1.2)$$

in the case of $n = 2$. Such an equation appears in the study of the variant of the Ginzburg-Landau energy (cf. [9], [10] and [11]) and the Chern-Simons-Higgs (CSH) energy (cf. [7] and [8])

$$E_{CSH}(u) = \frac{1}{2} \|\nabla u\|_{L^2(R^2)}^2 + \frac{1}{4} \|u(1 - |u|^2)\|_{L^2(R^2)}^2.$$

It is also related to the study of the Maxwell-Chern-Simons model (cf. [3], [4], [5]). In this paper, we will prove

$$|u| \leq 1, \quad \text{in } R^n \quad (n \geq 2) \quad (1.3)$$

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