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The existence of solutions for quasilinear elliptic problems with multiple Hardy terms

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Abstract

In this paper, we investigate the quasilinear elliptic equations involving multiple Hardy terms with Dirichlet boundary conditions on bounded smooth domains $\Omega \subset \mathbb{R}^N$ $(N \geq 3)$, and prove the multiplicity of solutions by employing Ekeland's variational principle.

Keywords: quasilinear elliptic equation, Hardy potential, nontrivial weak solution, Ekeland's variational principle

2010 MSC: 35D30, 35J20

1. Introduction

In this paper, we consider the following quasilinear elliptic problem:

$$\begin{cases} -\Delta_p u - \sum\limits_{i=1}^{n} \mu_i \frac{|u|^{p-2}u}{|x-a_i|^p} = |u|^{p^*-2}u + \lambda f(x,u) & x \in \Omega, \\ u = 0 & x \in \partial\Omega, \end{cases} \tag{1.1}$$

where $\Omega \subset \mathbb{R}^N$ $(N \geq 3)$ is a bounded smooth domain such that the different points $a_i \in \Omega, i = 1, 2, ..., n$, $-\Delta_p u = -\mathrm{div}\big(|\nabla u|^{p-2}\nabla u\big)$ is the $p-$Laplacian of u. $0 \leq \mu_i < \overline{\mu} := (\frac{N-p}{p})^p$, $1 < p < N$ and λ is a positive parameter.

It is well known that the nontrivial weak solutions for the problem (1.1) are equivalent to the nonzero critical points of the energy functional

$$J(u) = \frac{1}{p}\int_\Omega \left(|\nabla u|^p - \sum_{i=1}^{n} \mu_i \frac{|u|^p}{|x-a_i|^p}\right)dx - \frac{1}{p^*}\int_\Omega |u|^{p^*}dx - \int_\Omega \lambda F(x,u)dx$$

defined on $W_0^{1,p}(\Omega)$, where $F(x,u) = \int_0^u f(x,s)ds$. But the appearance of multiple Hardy terms makes difficult to investigate the existence of nontrivial solutions for (1.1).

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