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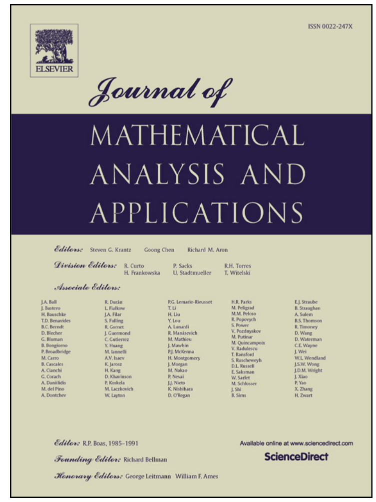

Regularity of pullback attractors for nonautonomous nonclassical diffusion equations

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Regularity of pullback attractors for nonautonomous nonclassical diffusion equations

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Abstract

In this paper, we consider the regularity of pullback attractors for a nonautonomous nonclassical diffusion equation with critical nonlinearity. In particular, under suitable assumptions, we prove that there exists a pullback attractor $\mathscr{A} = \{A(t)\}_{t\in\mathbb{R}}$ in $H_0^1(\Omega)$ for a nonautonomous nonclassical diffusion equation, and for each $t \in \mathbb{R}$, $A(t)$ is bounded in $H^2(\Omega) \cap H_0^1(\Omega)$.

Keywords: nonclassical diffusion equation; pullback attractor; regularity.

2010 Mathematics Subject Classification: 37L05, 35B40, 35B41.

1 Introduction

Let $\Omega \subset \mathbb{R}^3$ be a bounded domain with smooth boundary $\partial\Omega$. For any $r \in \mathbb{R}$, we consider the following nonautonomous nonclassical diffusion equation:

$$\begin{cases} u_t - \Delta u_t - \Delta u + f(u) = g(t), & \text{in } \Omega \times [r, \infty), \\ u(x,t) = 0, & \text{on } \partial\Omega \times [r, \infty), \\ u(x,r) = u_r, \end{cases} \tag{1.1}$$

where, $g(t)$ is a time depending external force, which will be characterized later. For the nonlinearity, we assume $f \in \mathcal{C}(\mathbb{R})$ with $f(0) = 0$, satisfies the following growth and dissipation conditions:

$$|f(u) - f(v)| \leqslant C|u - v|(1 + |u|^4 + |v|^4), \tag{1.2}$$

$$\liminf_{|u|\to\infty} \frac{f(u)}{u} > -\lambda_1. \tag{1.3}$$

Nonclassical diffusion equations arise in fluid mechanics, solid mechanics, and the theory of heat conduction, which describe that the diffusing species behaves as a linearly viscous fluid (see, e.g., [1–6]). The analysis of the dynamical system generated by equations like (1.1) have been carried out in many literatures (see, e.g., [7–20] and references therein), proving results

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