

# NONLINEAR ELLIPTIC EQUATIONS WITH MEASURE DATA IN ORLICZ SPACES

A. Aberqi,<sup>1</sup> J. Bennouna,<sup>2</sup> and M. Elmassoudi<sup>3,4</sup>

UDC 517.5

We study the existence result for a unilateral problem

$$Au - \operatorname{div}(\Phi(x, u)) + H(x, u, \nabla u) = \mu,$$

where  $Au = -\operatorname{div}(a(x, u, \nabla u))$  is a Leray–Lions operator defined in the Sobolev–Orlicz space  $D(A) \subset W_0^{1,p}L_M(\Omega)$ ,  $\mu \in L^1(\Omega) + W^{-1}E_{\overline{M}}(\Omega)$ , where  $M$  and  $\overline{M}$  are two complementary  $N$ -functions. The first and second lower terms  $\Phi$  and  $H$  satisfy solely the growth condition and an arbitrary sign condition and, moreover,  $u \geq \zeta$ , where  $\zeta$  is a measurable function.

## 1. Introduction

Let  $\Omega$  be a bounded open domain in  $\mathbb{R}^N$ ,  $N \geq 2$ . We consider the following strongly nonlinear Dirichlet problem with an obstacle:

$$\begin{aligned} u &\geq \zeta \quad \text{a.e. in } \Omega, \\ -\operatorname{div}(a(x, u, \nabla u)) - \operatorname{div}(\Phi(x, u)) + H(x, u, \nabla u) &= \mu \quad \text{on } \Omega, \\ u &= 0 \quad \text{on } \partial\Omega, \end{aligned} \tag{1}$$

where

$$\mu \in L^1(\Omega) + W^{-1}E_{\overline{M}}(\Omega).$$

Under our assumptions, problem (1) does not admit, in general, a weak solution because the term  $\Phi$  may not belong to  $(L^1(\Omega))^N$  and due to the lack of coercivity for the two terms  $\Phi$  and  $H$ . Thus, in the present paper, in order to overcome this difficulty, we use the framework of entropy solution, which requires lower regularity than the ordinary weak solution. Recall that the notion of entropy solutions was developed by P. Bénilan, et al. [9] for the investigation of nonlinear elliptic problems.

In fact, in the paper [10], L. Boccardo, et al. proved the existence results in the classical Sobolev space  $W_0^{1,p}(\Omega)$  for the case where  $\Phi = 0$ ,  $H$  has polynomial growth, and  $\mu$  is a measure in  $\mathcal{M}_b(\Omega)$ . Moreover, in [11], the authors established the decomposition theorem for the Radon measure and studied the existence and uniqueness of the entropy solution. For more results, we refer the reader to [3, 4].

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# Nonlinear Equations In Abstract Spaces

**Michael Reed**



## **Nonlinear Equations In Abstract Spaces:**

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**Equations in Abstract Spaces** Dajun Guo, V. Lakshmikantham, Xinzhi Liu, 2013-11-22 Many problems arising in the physical sciences engineering biology and applied mathematics lead to mathematical models described by nonlinear integral equations in abstract spaces The theory of nonlinear integral equations in abstract spaces is a fast growing field with important applications to a number of areas of analysis as well as other branches of science This book is devoted to a comprehensive treatment of nonlinear integral equations in abstract spaces It is the first book that is dedicated to a systematic development of this subject and it includes the developments during recent years Chapter 1 introduces some basic results in analysis which will be used in later chapters Chapter 2 which is a main portion of this book deals with nonlinear integral equations in Banach spaces including equations of Fredholm type of Volterra type and equations of Hammerstein type Some applications to nonlinear differential equations in Banach spaces are given We also discuss an integral equation modelling infectious disease as a typical application In Chapter 3 we investigate the first order and second order nonlinear integro differential equations in Banach spaces including equations of Volterra type and equations of mixed type Chapter 4 is devoted to nonlinear impulsive integral equations in Banach spaces and their applications to nonlinear impulsive differential equations in Banach spaces      **Nonlinear Equations in Abstract Spaces - Proceedings of an**

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Lakshmikantham, 1972-06-16 Differential Equations in Abstract Spaces      **Nonlinear Equations in Abstract Spaces** V.

Lakshmikantham,1978      **Polynomial Operator Equations in Abstract Spaces and Applications** Ioannis K.

Argyros,2020-10-07 Polynomial operators are a natural generalization of linear operators Equations in such operators are the linear space analog of ordinary polynomials in one or several variables over the fields of real or complex numbers Such equations encompass a broad spectrum of applied problems including all linear equations Often the polynomial nature of many nonlinear problems goes unrecognized by researchers This is more likely due to the fact that polynomial operators unlike polynomials in a single variable have received little attention Consequently this comprehensive presentation is needed benefiting those working in the field as well as those seeking information about specific results or techniques Polynomial Operator Equations in Abstract Spaces and Applications an outgrowth of fifteen years of the author s research work presents new and traditional results about polynomial equations as well as analyzes current iterative methods for their numerical solution in various general space settings Topics include Special cases of nonlinear operator equations Solution of polynomial operator equations of positive integer degree  $n$  Results on global existence theorems not related with contractions Galois theory Polynomial integral and polynomial differential equations appearing in radiative transfer heat transfer neutron transport electromechanical networks elasticity and other areas Results on the various Chandrasekhar equations Weierstrass theorem Matrix representations Lagrange and Hermite interpolation Bounds of polynomial equations in Banach space Banach algebra and Hilbert space The materials discussed can be used for the following studies Advanced numerical analysis Numerical functional analysis Functional analysis Approximation theory Integral and differential equation      Nonlinear

Operators and Differential Equations in Abstract Spaces Yuqing Chen,2000      **Nonlinear differentia equations in**

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**Nonlinear Functional Evolutions in Banach Spaces** Ki Sik

Ha,2013-04-17 There are many problems in nonlinear partial differential equations with delay which arise from for example physical models biochemical models and social models Some of them can be formulated as nonlinear functional evolutions in infinite dimensional abstract spaces Since Webb 1976 considered autonomous nonlinear functional evo lutions in infinite dimensional real Hilbert spaces many nonlinear an alysts have studied for the last nearly three decades autonomous non linear functional evolutions non autonomous nonlinear functional evo lutions and quasi nonlinear functional evolutions in infinite dimensional real Banach spaces The techniques developed for nonlinear evolutions in infinite dimensional real Banach spaces are applied This book gives a detailed account of the recent state of theory of nonlinear functional evolutions associated with accretive operators in infinite dimensional real Banach spaces Existence uniqueness and stability for solutions of nonlinear func tional evolutions are considered Solutions are presented by nonlinear semigroups or evolution operators or methods of lines or inequalities by Benilan This book is divided into four chapters Chapter 1 contains some basic concepts and results in the theory of nonlinear operators and nonlinear evolutions in real Banach spaces that play very important roles in the following three chapters Chapter 2 deals with autonomous nonlinear functional evolutions in infinite

dimensional real Banach spaces Chapter 3 is devoted to non autonomous nonlinear functional evolu tions in infinite dimensional real Banach spaces Finally in Chapter 4 quasi nonlinear functional evolutions are con sidered in infinite dimensional real Banach spaces

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石川清三 (Japan),1900 *Nonlinear Differential Equations in Ordered Spaces* S. Carl,Seppo Heikkilä,2000-06-14 Extremality results proved in this Monograph for an abstract operator equation provide the theoretical framework for developing new methods that allow the treatment of a variety of discontinuous initial and boundary value problems for both ordinary and partial differential equations in explicit and implicit forms By means of these extremality results the authors prove the existence of extremal solutions between appropriate upper and lower solutions of first and second order discontinuous implicit and explicit ordinary and functional differential equations They then study the dependence of these extremal solutions on the data The authors begin by developing an existence theory for an abstract operator equation in ordered spaces and offer new tools for dealing with different kinds of discontinuous implicit and explicit differential equation problems They present a unified approach to the existence of extremal solutions of quasilinear elliptic and parabolic problems and extend the upper and lower solution method to elliptic and parabolic inclusion of hemivariation type using variational and nonvariational methods *Nonlinear Differential Equations in Ordered Spaces* includes research that appears for the first time in book form and is designed as a source book for pure and applied mathematicians Its self contained presentation along with numerous worked examples and complete detailed proofs also make it accessible to researchers in engineering as well as advanced students in these fields

**Stochastic Stability of Differential Equations in Abstract Spaces** Kai Liu,2019-05-02 Presents a unified treatment of stochastic differential equations in abstract mainly Hilbert spaces *On the Existence of Solutions of Nonlinear Volterra Equations in Abstract Spaces* Gustaf Gripenberg,1978 *Theory of Set Differential Equations in Metric Spaces* V. Lakshmikantham,Tenali Gnana Bhaskar,J. Vasundhara Devi,2006 The aim of this volume is to describe the theory of set differential equations SDEs as an independent discipline It incorporates the recent general theory of set differential equations discusses the interconnections between set differential equations and fuzzy differential equations and uses both smooth and nonsmooth analysis for

investigation The study of SDEs is a rapidly growing area of mathematics and this volume provides a timely introduction to a subject that follows the present trend of studying analysis and differential equations in metric spaces It is a useful reference text for postgraduates and researchers nonlinear analysts engineering and computational scientists working in fuzzy systems

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