

# Exploring the mode conversion of a vector vortex beam in second-harmonic generation using a periodically poled nonlinear photonic $\text{KTiOPO}_4$ crystal

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The nonlinear interactions between structured beams with spatially varying polarization and matter extend the boundaries of fundamental nonlinear optics, opening new avenues for applications across various fields. In this work, the second-harmonic generation (SHG) of vector beams with two orthogonal polarization components of vortices in a periodically poled crystal (PPC) is demonstrated both theoretically and experimentally. Potassium titanyl phosphate  $\text{KTiOPO}_4$  (KTP) is chosen as the PPC for its excellent nonlinear-optical properties. Notably, for a given vector light field, adjusting the initial phase of the vector beam allows for the varying outputs of SHG. In addition, SHG outputs with one, two, or three vortices are achieved by rotating a polarizer to modulate the fundamental light, and the proportion weights of the three vortex terms within the SHG are dependent on the rotating angles of the polarizer. Our findings provide a foundational understanding and offer new insights into the study of full-field selection rules in specific nonlinear processes within superlattices. © 2025 Optica Publishing Group. All rights, including for text and data mining (TDM), Artificial Intelligence (AI) training, and similar technologies, are reserved.

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## 1. INTRODUCTION

Light-matter interaction has triggered numerous novel phenomena and concepts since the invention of the laser. As a fundamental nonlinear optical effect, second-harmonic generation (SHG) has been extensively studied and applied in various research areas. Structured light fields with spatially variant polarization distributions have given rise to many new physical phenomena [1–3]. Due to their customizable spatial polarization distributions, phase, and amplitude, structured light fields have revealed novel characteristics and applications, leading to significant advancements in emerging fields such as particle micromanipulation [4], chiral microstructures [5], optical information transmission [6], remote sensing [7], free space polarization conversion [8], super-resolution imaging [9], quantum information [10], and nonlinear frequency conversion [11–15]. Remarkably, in the realm of nonlinear optics, a material system's electric dipole moment (or nonlinear polarization) is highly dependent on the spatial distribution profiles of the strength, phase, and state of polarization (SoP) of an applied optical field. Consequently, structured light fields interacting with matter offer additional degrees of freedom to

manipulate nonlinear optical processes. Nonlinear polarization driven by a structured light field with spatially varying SoP is particularly sensitive to the vectorial structure of an applied field. Thus, light-matter interaction with structured light fields not only deepens our understanding but also enhances the fundamental capabilities of nonlinear optics. Moreover, the structured light field could be flexibly manipulated across multiple dimensions through nonlinear optical processes in both the spatial and the frequency domains [14–18]. In particular, the second-order nonlinear optical interaction requires a material to exhibit birefringence to satisfy phase-matching conditions. During these nonlinear interactions, light waves exchange energy, linear momentum, and angular momentum [19]. The direction of energy flow between frequency components is typically governed by conventional phase-matching conditions associated with linear momentum [19]. In nonlinear optics, phase-matching conditions or linear momentum conservation facilitate a net positive energy flow from the fundamental to harmonic frequencies [20,21]. Therefore, structured light fields with customized SoP vector structures and unique spatial phase

# Nonlinear Optics volume 43

**Jeffrey H. Hunt**



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**Optical Properties of Metals and Intermolecular Interactions / Opticheskie Svoistva Metallov / Mezhmolekulyarnoe Vzaimodeistvie** D. V. Skobel'tsyn, 2012-12-06 The first part of this collection sets out the results of some experimental and theoretical investigations into the optical properties of nontransition metals The extensive future prospects of metal optics are indicated the use of metal optics enables a whole series of important electron properties of metals to be determined Results obtained by studying intermolecular forces the hydrogen bond and van der Waals forces using spectroscopic methods Raman effect and infrared absorption are presented in the second part A method of studying the true absorption of the drop phase of a water cloud is described Methods of increasing the dispersion of manufactured spectral instruments and constructing various infrared spectrometers are indicated The publication is intended for scientific workers graduates and students concerned with problems of metal optics the electron properties of metals and molecular spectroscopy v CONTENTS OPTICAL PROPERTIES OF NONTRANSITION METALS G P Motulevich Introduction 1 Chapter I Method of the Kinetic Equation in Metal Optics 5 1 Kinetic equation for the infrared part of the spectrum 5 2 Anomalous skin effect 9 3 Normal skin effect 11 4 Weakly anomalous skin effect 13 *Advances in Optics, Vol. 3* Sergey Yurish, 2018-04-26 Advances in Optics Reviews Book Series is a comprehensive study of the field of optics which provides readers with the most up to date coverage of optics photonics and lasers with a good balance of practical and theoretical aspects Directed towards both physicists and engineers this Book Series is also suitable for audiences focusing on applications of optics The Vol 3 is devoted to various topics of applied optics and contains 17 chapters written by 49 experts in the field from 14 countries Australia China India Israel Italy Japan Malaysia Mexico The Netherlands Poland Taiwan UK USA Vietnam A clear comprehensive presentation makes these books work well as both a teaching resources and a reference books The book is intended for researchers and scientists in physics and optics in academia and industry as well as postgraduate students **Introduction to non-Kerr Law Optical Solitons** Anjan Biswas, Swapan Konar, 2006-11-10 Despite remarkable developments in the field a detailed treatment of non Kerr law media has not been published Introduction to non Kerr Law Optical Solitons is the first book devoted exclusively to optical soliton propagation in media that possesses non Kerr law nonlinearities After an introduction to the basic features of fiber optic com *Progress in Optics* Emil Wolf, 2006-10-03 In the thirty seven years that have gone by since the first volume of Progress in Optics was published optics has become one of the most dynamic fields of science At the time of inception of this series the first lasers were only just becoming operational holography was in its infancy subjects such as fiber optics integrated optics and optoelectronics did not exist and quantum optics was the domain of only a few physicists The term photonics had not yet been coined Today these fields are flourishing and have become areas of specialisation for many science and engineering students and numerous research workers and engineers throughout the world Some of the advances

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