

# 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 [11–13]. 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 / Оптические Свойства Металлов / Межмолекулярное Взаимодействие** D. V. Skobeltsyn, 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.

**CONTENTS**  
OPTICAL PROPERTIES OF NONTRANSITION METALS G P Motulevich  
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## **Introduction to non-Kerr Law Optical**

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in these fields have been recognized by awarding Nobel prizes to seven physicists in the last twenty years The volumes in this series which have appeared up to now contain nearly 190 review articles by distinguished research workers which have become permanent records for many important developments They have helped optical scientists and optical engineers to stay abreast of their fields There is no sign that developments in optics are slowing down or becoming less interesting Gaussian apodization and beam propagation Electromagnetically induced transparency Three dimensional electromagnetic fields Quantum cryptography Optical quantum cloning Proceedings (Trudy) of the P.N. Lebedev Physics Institute ,1973

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Академия наук CCCP,1987 **Quantum Electronics in Lasers and Masers** ,1968 *Micro Nano Devices, Structure and Computing Systems II* De Huai Zeng,2013-03-25 Selected peer reviewed papers from the 2013 2nd International Conference on Micro Nano Devices Structure and Computing Systems MNDSCS 2013 January 23 24 2013 Shenzhen China **Nuclear Reactions and Interaction of Neutrons and Matter** Dmitrii Vladimirovich Skobel'tsyn,1975 Contents Theory of Nonstationary thermalization of neutrons Germanium gamma radiation detectors used in investigating the scattering of neutrons Fast neutron collimator for measuring inelastic scattering by nuclei Measurement of spectra of fast neutrons using photoemulsions with high energy resolution Method of determining angular distributions in the scattering of fast neutrons

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