
STUDY OF DEVICES AND METHODS FOR MEASURING THE MAGNETIC AND MAGNETIC-OPTICAL PROPERTIES OF RARE EARTH IONS

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Abstract

This article analyzes the main equipment and methods used to measure the magnetic and magnetic-optical properties of rare earth ions. Magnetic properties and magnetic-optical effects provide in-depth information about the study of physical properties, electronic and magnetic structure of materials. Detailed information about the devices used in the research - magnetometers, spectroscopy devices and optical measuring devices - is discussed, their advantages and limitations are discussed. These methods are the basis for the widespread application of rare earth-based materials in research and industry.

Introduction

Rare earth ions occupy a special place in the fields of modern materials science and condensed matter physics. Due to their unique circuit configuration and strong magnetic properties, they are widely used in many scientific studies and industrial applications. Magnetic and magnetic-optical properties of ions in the composition of rare earth elements make it possible to study in depth their electronic structure, and is also a key indicator of the creation of new functional materials.

Magnetic properties are the basic physical parameters representing the response of materials to external magnetic fields that contribute to the determination of microscopic mechanisms of magnetism. On the other hand, magnetic - optical effects represent the transformation of electromagnetic radiation under the action of a magnetic field and is widely used in optical devices, sensors and data processing technologies.

This article discusses the main equipment and methods used to measure the magnetic and magnetic-optical properties of rare earth ions. The purpose of the article is to contribute to a deeper understanding of the physical properties of rare earth ions by analyzing the principles, possibilities, and limitations of these devices and methods.

Magnetic properties of rare earth ions

Rare earth ions will have unique magnetic properties, mainly due to electrons in the 4f orbital. Because these electrons are located around the nucleus, they are relatively well protected from external influences and at the same time cause complex magnetic interactions.

Magnetic moment is the main magnetic property of ions, which consists of the sum of orbital and spin moments. In rare earth ions, especially the spin-orbit interaction, the spin-orbit interaction is very strong, complicating their magnetic response. The determination of the magnetic moment is important in the study of the general magnetic properties of matter.

Magnetic interactions in rare earth ions, including phenomena such as ferromagnetism, antiferromagnetism, and ferrimagnetism, determine the macroscopic magnetic state of matter. Various theoretical models, such as the Heisenberg model, the Ising model, and other quantum mechanics approaches, are used to understand these interactions. When measuring magnetic properties, the following parameters are often taken into account: moment, magnetic susceptibility, magnetic field strength, and the dependence of a magnet on temperature. These parameters provide important information about the electronic structure of the materials and serve as the basis for the development of new materials.

Magneto-optical properties of rare earth ions

Magnetic - optical properties - a set of phenomena associated with the change in optical properties of materials under the influence of a magnetic field. The unique electron configuration of rare earth ions enhances their magneto-optical effects, which enables controlling the optical responses of materials.

The most common magnetic-optical effects include the Faraday effect and the Kerr effect. The Faraday effect is a phenomenon of the polarization axis rotation of a lamp under the influence of a magnetic field, and it is used in optical fibers, sensors, and data transmission systems. The Kerr effect, on the other hand, expresses the polarization change of light reflected on the surface of a material under the influence of a magnetic field and plays an important role in the processing of optical data.

Also, the magnetic-optical properties of rare earth ions are studied by spectroscopic methods and provide information about their electron energy levels and magnetic interactions. These effects will help researchers gain a deeper understanding of the microscopic structure of materials and create new optical devices.

The scientific significance of magnetic and optical properties is that they serve not only new knowledge in the field of fundamental physics, but also expands its practical application in optoelectronics, quantum computing and sensor technologies.

Measuring Equipment

Various instruments are used to study the magnetic and magnetic-optical properties of rare earth ions. This equipment allows you to accurately and reliably measure the physical parameters of a substance.

Magnetometers

The most common equipment for measuring magnetic properties is magnetometers. There are several types of them:

Vibrating magnetometer (VSM) - determines the magnetic moment of a substance under the influence of an external magnetic field. The VSM equipment measures the magnetic signals through the vibration of the specimen and has high sensitivity.

SQUID (Superconducting Quantum Interference Device) is a device designed to measure very fine magnetic fields and is used to detect tiny magnetic changes of rare earth ions.

Ferromagnetic Resonance (FMR) - Studies the magnetic dynamics of a material by measuring the resonance state of magnetic moments.

Spectroscopy equipment

Spectroscopic equipment plays an important role in the study of magneto-optical properties:

Optical spectroscopy is a technique that studies the interaction of electromagnetic rays with matter, including used to detect Faraday and Kerr effects.

Raman spectroscopy - used to study the vibrational states and magnetic properties of materials.

Optical measuring devices

Optical measuring devices, e.g. polarimeters, are used to measure the polarization of a lamp under the action of a magnetic field. By means of these devices it is possible to determine the magnetic-optical effects and to evaluate the optical properties of materials.

The total amount of these instruments constitute a necessary set of instruments for the advanced study of the magnetic and magnetic-optical properties of rare earth ions.

Conclusion

This article discusses in detail devices and methods for measuring magnetic and magnetic-optical properties of rare earth ions. The unique electron configuration of rare earth ions leads to their complex magnetic properties, which makes them widely used in fields such as materials science, optoelectronics, and energy.

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