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Im Rahmen des Institutsseminars

Besprechung neuerer Arbeiten aus Angewandter Physik (LVA Nr. 374.008)

spricht

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Optical measurement techniques for isotope analysis of chemical elements

Isotopes are types of atoms whose atomic nuclei contain the same number of protons but different numbers of neutrons, giving them slightly different weights. Most chemical elements have multiple isotopes. They can be divided into two categories—radioactive and stable. There are many stable isotopes that are used for research purposes. Stable isotopes have a stable nucleus that does not decay. Their abundance therefore stays the same over time. Radioactive isotopes decay over time, a property which makes them very important for the research of nuclear fusion, for the determination of nuclear forensics, to research archaeological cycles or to improve the atomic bomb. Various enrichment techniques have been developed specifically for the radioactive isotopes. These are gas diffusion and gas centrifugation. An experimental enrichment method of the different radioactive isotopes with a lot of commercial potential is laser separation [1].

The isotope analysis is used in many scientific areas. An example is the study of the climate and the environment in the past. At isotope analysis with the help of a laser, isotopes can be distinguished by measuring the spectral line wavelength shift of the optical emission spectrum. Radioactive isotopes can be identified based on their decay products or the emitted ionizing radiation. The isotope effects, such as mass effect or field isotope effect, can be described with the help of statistical thermodynamics and quantum mechanics [2].

As an example, the isotope ratio of uranium and thorium can be determined with the isotope shift. Therefore, the noninvasive and near-instantaneous laser ablation method commonly called LIBS can be used. There are several advantages of using laser ablation (LA) for nuclear material detection, which includes minimal sample preparation, near-instantaneous detection, and isotope detection. One of the main advantages of optical emission spectroscopy (OES): The detection of special nuclear materials, such as uranium and thorium. Chemometrics analysis coupled with LIBS is a suitable combination for the determination of isotope ratios in the air at atmospheric pressure using poorly resolved lines. Typically, the precision will be in the range from 4 to 10% depending on the enrichment level [3].

Another analysis method is also examined more closely. A direct and fast technique for the isotope analysis is the molecular isotope spectroscopy (LAMIS) with laser ablation. LAMIS uses relatively large isotope shifts in spectra of transient molecular isotopologues formed in laser ablation plasma. LAMIS can be performed without sample preparation at atmospheric pressure in open air or inert buffer gases. The precision of quantitative LAMIS measurements was determined within 9‰ for the $^{10}B/^{11}B$ ratio [4].

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