DEVELOPMENT OF THE LASER ION SOURCE TECHNIQUE FOR UNSTABLE NUCLIDE ATOMIC SPECTROSCOPY

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Measurements of hyperfine structure and isotope shifts in optical transitions by the method of laser resonance photoionization have been carried out successfully for a long time at the on - line mass separator IRIS with the purpose of obtaining nuclear spins, electromagnetic moments and isotopic changes of nuclear charge radii for unstable nuclides [1]. The application of the above method in the hot capillary – a main part of a laser ion source (LIS) of a mass separator – increased the sensitivity of the measurements compared with that of resonance ionization spectroscopy in atomic beam formed at the mass separator output [2].

However that approach leads to a full Doppler broadening of optical lines. To achieve a high resolution and sensitivity, which are absolutely essential for such intricate experiments as the isotope shift measurement planned at IRIS for ^{11}Li aimed at determination of the charge radius of this nucleus [3], the use of resonance photoionization spectroscopy of saturation in LIS was proposed [4]. For this aim a special type of LIS was designed and manufactured [5] in which the capillary is arranged at a right angle to the field created by the mass separator extraction electrod unlike the standart type with the capillary situated along the field. The new LIS makes it possible for laser radiation, that passes through the capillary, to come through it again in the opposite derection after reflecting from a mirror (the requirement of saturation spectroscopy). The investigations of the new LIS was fulfilled at the mass separator IRIS using photoionization of Yb. The efficiency of photoionization and the selectivity (the ratio of the photoions to the ions of the surface ionization in LIS) turned out to be not worse then those of the standard LIS. The new type of LIS seems to be quite suitable for saturation spectroscopy.

Installing and comming into operation the off-line mass separator LARISA gave us a good chance to do thorough studies of LIS. A number LIS with various constructive parameters were tested. Rather satisfactory values of photoionization efficiency (20 – 30 per cent) and selectivity (200 – 400) at different temperatures (up to 2000 centigrade) were obtained.

A pulsed character (due to a pulsed laser radiation with the repetition rate of 10 kHz) of the mass separator photoion current allows a fivefold supression of the background contribution by using a time gate in the detection electronics (see Fig.). For a radical reduction of background caused by surface ionization, capillaries for LIS were prepared with a low work function inner layers from yttrium-carbon and strontium-carbon. The test of their properties is in progress.

An optical fibre system was designed and tested, intended for three laser beams to merge into a single beam, to transmit it to the laser ion source situated in a high-radioactivity zone, and to form inside the source the radiation beam of the required geometrical parameters.

To make an approach to a problem of the isotope shift investigation for Li, two-colorous photoionization of natural lithium was successfully performed with dye lasers. Employment additionally of a powerful copper-vapor laser (10 W) for ionization of the excited atoms by dye lasers raised ionization by 20 times. The fibre system and the new disign of LIS are ready to carry out experiments with unstable nuclides at IRIS.

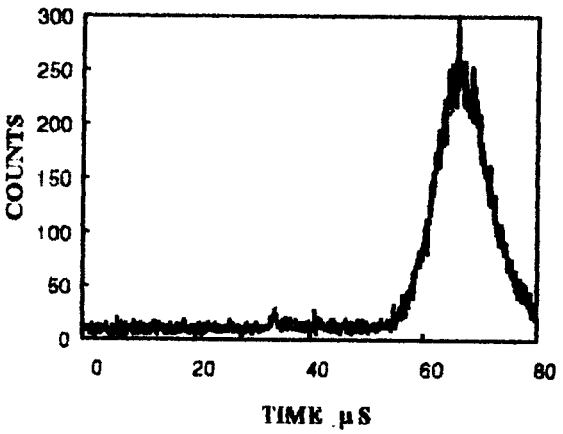

Fig. Time structure of the photoion current from LIS

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MASS SURFACE OF THE "MAGIC CROSS" AT ^{132}Sn

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The idea of possible universality in description of the shell model properties of heavy nuclei throughout the nuclidic chart was put forward by various authors(see ref.[1-3]). The conclusion was made that the properties of the magic nuclides of different mass regions can be described by the same theoretical approach but slightly varying parameters of theory. The subject of interest is whether the similarities in ordering and even in energy spacing of single particle states extend to nucleon residual interaction energies as well.
To examine this postulation [1] the masses for the nuclides of the "magic crosses" besides the lead region must be measured precisely. The "magic cross" is formed by the nuclides having two or less nucleons (holes) outside the double shell closure. Only the nuclides from the tin "magic cross" are available for mass determination nowadays. They are shown in Figure.