Resonant laser ionization of ^{211}At

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The feasibility study for the medical radioisotope astatine-211 (^{211}At) production by the gas cell-based laser ionization technique is ongoing.[1] Our aim is to develop a new separation method to extract ^{211}At from the target, where ^{211}At is produced by the ^{209}Bi$(\alpha, 2n)^{211}$At nuclear reaction. This approach is based on the element-selective isotope separation by resonant laser ionization without chemical separation.

We developed a new experimental apparatus,[2] comprising a laser system and a vacuum chamber called "reference cell." The reference cell comprises an ionization chamber and a quadrupole mass separator. The construction of the gas cell and a collection system for ^{211}At is underway.

At the preliminary test, we dedicated the resonant laser ionization for ^{211}At in vacuum, using the reference cell. ^{211}At was produced by the nuclear reaction. We prepared a metallic bismuth target[3] (diameter: 6 mm, thickness: 13.9 mg/cm^2), which was vapor-deposited onto a 25.4 μm-thick niobium foil. The target was irradiated by a 28.1 MeV α beam for 10 min, which would yield ∼100 kBq of ^{211}At, and installed inside the reference cell. Then, the electric current was applied directly onto the foil to evaporate ^{211}At, and the evaporated atoms are ionized by laser beams.

Figure 1 shows the ionization scheme for astatine we adopted, based on previous research.[4] Three laser beams with the wavelength of 216.2 nm, 795.2 nm, and 532 nm for the first, second, and third steps, respectively, were prepared. The timing and position of the three laser beams were carefully synchronized and adjusted, and the beams were delivered into the reference cell. Photo-ionized ions were mass-separated by the quadrupole mass separator by setting the ion transport condition to ion's mass of around 211 (a.m.u). The transported ions were detected by a channel electron multiplier.

Figure 2 shows the preliminary result of the ionization spectrum of ^{211}At, where the wavelength of the first step laser was scanned while those of the second- and third-step laser were fixed. Because the centroid of the observed spectrum and the peak width were in agreement with the values expected from the past experimental data,[4,5] we concluded that this result indicated the ionization of ^{211}At.

The preliminary ionization test for ^{211}At was successfully completed. Next, we will investigate the ionization efficiency in terms of the laser power for individual wavelength and perform laser ionization in the gas cell for the efficient collection of ^{211}At.

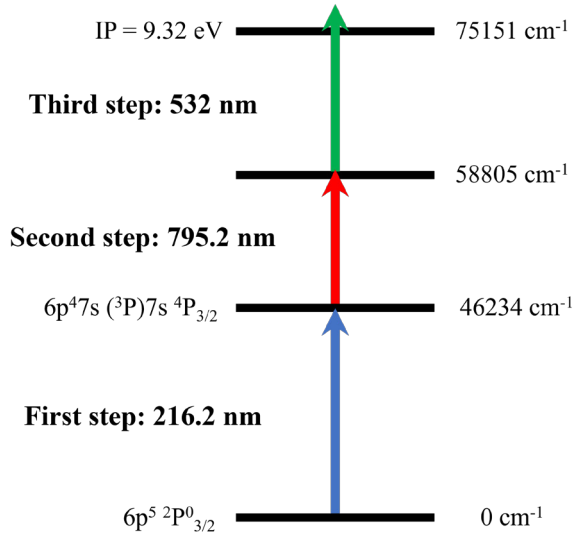

Fig. 1. Three-step laser-ionization scheme for astatine.[4]

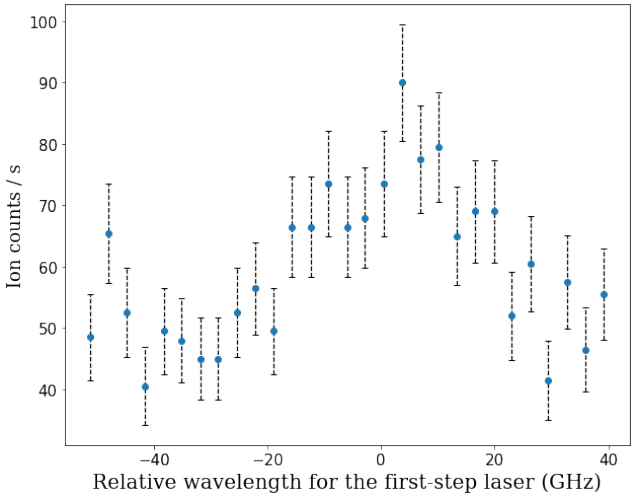

Fig. 2. Ionization spectrum of ^{211}At obtained by scanning the wavelength of the first-step laser.

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DOI:10.34448/RIKEN.APR.57-035