"He Standard of Japan" (HESJ)の^{3}He/^{4}He比校正

Determination of absolute ^{3}He/^{4}He ratio of He Standard of Japan

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^{3}He/^{4}He ratios in terrestrial samples vary more than three orders of magnitude, because primordial helium with ^{3}He/^{4}He of (1.4-4.6) x 10^{-4} has been diluted by addition of radiogenic ^{4}He produced by decay of U- and Th-series elements in different degrees depending on ^{3}He/(U+Th) ratio of each reservoir. This feature makes ^{3}He/^{4}He ratio a powerful tracer in geochemistry and cosmochemistry. Though atmospheric helium with ^{3}He/^{4}He ratio of 1.4 x 10^{-6} is used to calibrate ^{3}He/^{4}He measurement with a noble gas mass spectrometer, relatively low concentration and ^{3}He/^{4}He ratio of the atmospheric helium cause many difficulties to use it as a working standard for daily measurements. Thus noble gas laboratories often use their own working standards prepared from a natural gas sample with high ^{3}He/^{4}He ratio or by mixing of isotopically pure ^{3}He and ^{4}He. "He Standard of Japan" (HESJ) is one of the latter originally prepared by four noble gas laboratories in Japan [1] and now distributed worldwide as an interlaboratory standard [1,2]. However, ^{3}He/^{4}He ratio of HESJ was determined by comparison with that of atmospheric helium, i.e., absolute ^{3}He/^{4}He ratio has not been determined yet and the accuracy of the value still rely on the early determinations of absolute ^{3}He/^{4}He ratio of atmospheric helium [3].

As long as ^{3}He/^{4}He ratio is used to compare relative contributions of primordial and radiogenic in each geochemical reservoir, absolute ^{3}He/^{4}He value of atmospheric helium or HESJ is less important. However, it is a critical issue in some applications of helium isotopes, such as tritium-^{3}He dating and an experimental project to measure the neutron lifetime with total uncertainty of 1 sec (0.1%) using pulsed neutron source at J-PARC [4].

A neutron decays into a proton, an electron, and an anti-neutrino with a lifetime of 880.3 ±1.1 sec [5]. The lifetime is an important constant in the Big Bang nucleosynthesis (BBN) that controls amounts of primordial elements in our universe. In this experiment, the incident neutron flux is measured by counting ^{3}He(n,p)^{3}H reaction in a time projection chamber detector filled with ^{3}He, ^{4}He and CO_2. To determine neutron lifetime with uncertainty less than 0.1%, ^{3}He number density in the detector must be accurately known with even smaller uncertainty. As a part of this experiment, we are developing a gas handling system to control ^{3}He number density with uncertainty of 0.1%. The ^{3}He gas is mixed with research grade He in a vessel with measuring pressures of these gases precisely using a calibrated piezoresistive transducer.

We fabricated control samples of known ^{3}He/^{4}He ratio using the gas handling system and measured the ratio using a sector type single focusing noble gas mass spectrometer with double collector system [6] at Dept. of Basic Sci., the Univ. of Tokyo by referring to HESJ. The results will contribute to determine the absolute ^{3}He/^{4}He value of HESJ, and that of atmospheric helium also [6].

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