A BRIEF DISCUSSION ON APPLICATIONS OF ACCELERATOR MASS SPECTROMETRY

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ABSTRACT

In the present work the various applications of Accelerator Mass Spectrometry have been enumerated and discussed. It has developed into a powerful tool with wide ranging applications. The ultra-sensitive detection of long lived radio-nuclides and their applications has been discussed. Application of radiocarbon in archaeology and other fields have been discussed.

Keywords: *cosmogenic, Spectrometry, radiocarbon, atmosphere*

1. INTRODUCTION

Accelerator Mass Spectrometry (AMS) is an ultra-sensitive technique for isotopic analysis, in which atoms extracted from a sample are ionized, accelerated to high energies separated according to their momentum, charge and energy and then individually counted after identification as having correct atomic number and mass. AMS has now evolved into a powerful and sophisticated analytical tool with wide ranging applications described in review articles [1] [5] [7] [8]. More than 40 laboratories have developed AMS systems using existing or dedicated (some purpose designed) accelerators.

2. APPLICATIONS

It has developed into a powerful tool with wide ranging applications. The ultra-sensitive detection of long lived radio-nuclides and their applications has been discussed. Application of radiocarbon in archaeology and other fields have also been discussed. Also applications in atmosphere, biosphere, hydrosphere, and lithosphere have been discussed.

The AMS of long lived cosmogenic radio-nuclides (produced by cosmic rays) is independent of half life and decay mode of a radio-isotope and thus excels in the determination of cosmogenic radio-nuclides with half lives typically in the range of 10^3 to 10^7 years. AMS is mainly used to measure very low concentration of long lived radioisotopes and stable isotopes with high sensitivities. AMS has the potential for a number of fundamental nuclear physics applications like half-life measurement and nuclear reaction cross section measurements. In the past, half lives of isotopes were measured by Low Energy Mass Spectrometry using the famous Rutherford Soddy relation;

$$\frac{dN}{dt} = -\lambda N$$

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Where, N is the absolute number of radioactive atoms and $\frac{dN}{dt}$ is the decay rate. This process was carried out when a sufficiently large number of atoms were present to get rid of eventual interference from stable isobar background and N was calculated from the production cross sections of the radioisotopes with larger uncertainty. However AMS measures the ratio of absolute radioisotope to stable isotope with high precision and better accuracy. So far, half lives of five radio isotopes have been re-determined with AMS among them are 32Si, 44Ti, 60Fe, 10Be and 41Ca.

A new half life of 60 Fe [4] was measured by AMS with Argonne FN type tandem super-conducting Linear Accelerator. A value of (1.49±0.27) x10^5 was obtained over the previous measurement of 3 x10^5 years. Similarly, for ^{10} Be the previously reported value ranged from 1.48x10^6 years to 1.9x10^6 years, however, Hoffmann et. al. presented a more accurate value of 1.51x10^6 with a smaller uncertainty of 4%. Finally a new accurate half life 1.04±0.05x10^5 years has been calculated for ^{41}Ca [6] by AMS method over the previous value 1.03±0.04x10^5 by specific activity measurement.

Further, many production cross sections of radio-nuclides can be measured by radiochemical techniques. However when the half lives become too long for decay measurements it becomes easier to count the atoms by Accelerator Mass Spectrometry directly. Also, AMS has also found application in detecting exotic or hypothetical particles. In AMS method a fractionally charged particle [3] has a unique behavior in the accelerator which is reflected in the beam analyzing process. However, no positive evidence for free quarks has been found.

Applications as tracers and chronometers in geo-science, cosmic ray physics, archeology and environmental studies are well established and are the main theme of AMS studies.

In Hydrological applications, ^{36} Cl since its first determination by AMS in 1978 has proved to be a versatile tracer. ^{129} I produced naturally also seems to be very useful in studying hydrological processes. Elmore et. al. [5] has postulated that ^{129}I can be used to trace slow movement of sea water through sediments in response to hydro thermal convection process in the oceanic crust.

According to Colin Renfrew, "Archaeology has the ability to open unimaginable vistas of thousands, even millions of years of past human experience." In 1949, American Chemist Willard Libby [9] while working on atom bomb published the first set of radiocarbon dating techniques. In archaeology, it is still the main tool for dating the past 50,000 years. As every living organism has certain amount of radiocarbon [11] within it by way of consuming plants, this radiocarbon decreases through a regular pattern of decay after an organism dies. The half life of radiocarbon is 5730 years [10]. The application of radiocarbon dating is immense as it excited scientists to shed light on human evolution, timing of development of different species, climatic changes etc. The results were often compared with traditional time sequences and also the measurements were correlated with materials of known dates e.g., a well documented mummy or a log from the roof of an old building. Further in bio-medicine, nuclear medicine, cosmology AMS has immense application in bringing about new changes.

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