Negative Ion Beam Production by Sequential Charge Transfer in Tandem Mg and Cs Vapor Cells

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Ion beams produced at an ISOL facility are usually positively charged. However the HRIBF at Oak Ridge National Laboratory requires negative radioactive ion beams for injection in the tandem accelerator. A general way applicable to many elements is to change the positive ion beam into a negative ion beam by charge exchange in a suitably chosen gaseous medium. In this case, the charge exchange is a two step process where the electron transfers first produce neutral atoms and then negative ions. An experimental challenge in this connection is to produce a negative ion beam with a small emittance by optimizing the selection and the thickness of the charge exchange medium. For the example of producing a low emittance negative As beam, experiments were carried out at UNISOR with either Mg or Cs vapors as the charge exchange medium. The corresponding charge exchange rates were measured for different As beam energies and the resulting beam divergences were estimated via the intensity decrease of the transmitted beams. While both vapor targets produced negative ions, Mg was shown to be an excellent medium for making the first step namely neutral beams, and Cs for making the second step namely negative ion beams from neutral beams. This is due to their difference in ionization potentials and electron affinities. The results of the measurements suggested the application of two charge exchange cells placed one after the other, with Mg vapor in the first cell and Cs vapor in the second. This arrangement was implemented and the tandem arrangement resulted in the minimum target beam divergence for producing negative As beams. Experimental results and rate equations describing the two step charge exchange processes are discussed. The experiment demonstrated the advantage of properly choosing projectile-target combinations with minimum energy defects .