Letter of Intent for the ISOLDE and neutron time-of-flight experiments committee

Experiments with Accelerated Beams of Ne at REX-ISOLDE

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Abstract

Interesting questions in nuclear structure and astrophysics can be answered by studying accelerated beams of radioactive Ne isotopes. ISOLDE produces a variety of Ne isotopes for study. However, Ne beams cannot be efficiently accelerated due to loss of intensity from resonant charge-exchange with the Neon buffer gas in the Penning trap. We request 2 shifts of time during the offline period in order to test whether the use of Argon gas as a buffer gas in the Penning trap will allow Ne beams to be collected and extracted from the trap with high efficiency.

Physics Case

Beams of Ne ions at energies of 2.9 MeV/A and higher, as available with REX_ISOLDE now and with planned upgrades, offer exciting opportunities to investigate reactions of interest in nuclear structure and astrophysics.

Neutron-rich Ne isotopes produced at ISOLDE approach and enter the "island of inversion"[1] where the nuclear shell structure can be broken or quenched at N=20 [2,3]. Studies of the Mg nuclei using intermediate energy Coulomb excitation [4-6] have experimentally verified the existence of such collective states. ISOLDE has performed two experiments in the neutron-rich Mg region using low-energy Coulomb excitation to safely populate the first excited state and measure the reduced transition matrix element [7,8]. This low energy Coulomb excitation of neutron-rich Mg, combined with the high-efficiency γ-ray array Miniball and the CD particle detector, provides an efficient and selective method for measuring nuclear observables, particularly reduced transition matrix elements. The availability of neutron-rich Ne beams at ISOLDE would enable the lower-Z limits of the "island of inversion" to be reached and allow for the study of the evolution of nuclear structure along this isotopic chain. The structure of the proton-rich ^{19}Ne isotope can also be studied via Coulomb excitation at Miniball.

Looking toward the future, with the increasing energy available at REX-ISOLDE, reactions of astrophysics interest with proton-rich Ne isotopes would become accessible at Miniball. These include studies of ^{18,19}Ne with inelastic reactions (p,p') as well as the ^{18}Ne(α,p) reaction.

The availability of Ne beams of appreciable intensity would enable a programme of study to commence. We intend to pursue these opportunities, starting with the Coulomb excitation of neutron-rich Ne isotopes, if Ne can be efficiently trapped and extracted for REXTRAP.

Request

At ISOLDE, the REX-ISOLDE instrument [9-12] routinely accelerates radioactive ions for masses with A less than or equal to 140. An original combination of a Penning trap (REXTRAP), for ion cooling, bunching and emittance reduction, and of an EBIS (REXEBIS), for the charge-state breeding, constitutes the beam preparation stage of the post-accelerator.

The challenge in obtaining beams of Ne is that the Penning trap usually uses stable Ne gas as a buffer gas. The charge exchange process that occurs between the radioactive beam of interest and the buffer gas is in this case resonant so that it will effectively remove the 1+ radioactive Ne isotope from the trap.

Two possibilities exist to reduce the charge exchange process in REXTRAP: using He or Ar as the buffer gas in the Penning trap.

The He option requires an improvement of the current differential pumping scheme. It would therefore constitute a major investment to the trap. Ar gas does not require such a development and can be tested very quickly. It can also be tested during the offline period.

For this reason, we request 2 shifts equivalent during the offline period in order to investigate the possibility of using Ar as a buffer gas to prepare Ne beams for experiments at Miniball with REX-ISOLDE.

Summary

We intend to pursue a programme of study of radioactive Ne beams produced at ISOLDE, starting with the Coulomb excitation of neutron-rich Ne. The first step is to determine if Ne can be efficiently trapped and extracted from REXTRAP. We require 2 shifts of time to test REXTRAP with Argon as a buffer gas in order to determine if proposals for this programme with Ne should be pursued.

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