EXTERNAL REPORT
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Topical workshop on low-energy fundamental-interactions physics at ISOL@MYRRHA

Round-up and discussion

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This report summarizes the research opportunities discussed during the "Topical workshop on low-energy fundamental-interactions physics at ISOL@MYRRHA", held in October 2011 at SCK•CEN in Mol, Belgium.

1. Physics cases

ISOL@MYRRHA provides ideal opportunities for low-energy fundamental (weak) interaction physics experiments as long beam times are typically needed to collect the required high statistics and investigate systematic effects. Moreover, improving and tuning the setup so as to reach the optimal sensitivity to the physics observables often requires frequent access to beam time.

The physics cases will mainly be based on experiments involving ion and atom traps, i.e., electro-static, Paul, Penning, and MOT. The high beam purity that can be obtained at ISOL@MYRRHA is of crucial importance. Also the high RIB intensities are of importance, because the upper space-charge limit of 10^6-10^7 ions in ion traps has not been reached yet. At present, traps are loaded at maximum with 2 x 10^5 ions/s. So, there is room for improvement making use of enhanced RIB intensities.

Experimental observables that could typically be addressed in experiments at ISOL@MYRRHA are e.g. the beta-neutrino correlation and the beta-asymmetry parameter, while also for atomic-parity violation measurements and tests of Lorentz violation ISOL@MYRRHA would be highly beneficial. All currently ongoing and planned beta-neutrino correlation measurements (probing the structure of the weak interaction) would benefit from the conditions (long beam times, high beam purity and intensity) that will be available at ISOL@MYRRHA.

Atomic-parity violation measurements, as are currently planned with Ra at the KVI-Groningen, would further benefit from the range of masses that will be available as this will allow studying systematic effects related to the atomic structure.

Measurements of the beta-asymmetry parameter (searching for tensor type weak interactions) and suggested tests of Lorentz violation require polarized nuclear samples. The development of polarized samples in particle traps, which is being pioneered at ISAC-TRIUMF and is now also being considered/started at other laboratories, will thus become a key issue for future experiments in this field. This will, in addition, also allow for measurements of other, more exotic correlations, such as triple correlations (probing time-reversal violation) and the beta polarization-asymmetry correlation (which is sensitive to right-handed currents but also to scalar and tensor type weak interactions). All these would benefit greatly from the conditions offered at ISOL@MYRRHA.

Precision mass measurements with Penning traps would be of interest at ISOL@MYRRHA as well. During long beam times, one has to cope with the drifting conditions, but one can continuously come back to the reference mass marker over the course of the measurements. Further, long beam times permit performing measurements on isotopes with very low yield (e.g. order of 1 count/few hours), as well as alternate measurements of mother and daughter isotopes. Even more important, however, is the possibility of systematically performing precision half-life and beta-branching measurements after each mass measurement with extremely pure sources in the trap. In particular, those measurements would benefit from the long available beam times.

2. Instrumentation

A permanent position of the experimental setup is a prerequisite for high-precision measurements. Therefore, a sufficiently large experimental hall needs to be provided to host the different experimental setups of interest to ISOL@MYRRHA. A team discussion will be initiated on the User's Group workspace, where the future users are invited to indicate their estimate of space needed by each experimental setup to be installed at ISOL@MYRRHA. This information is important in order to evaluate the space requirements for the experimental hall.

A multi-user facility would be desirable, because of the long beam times for each experiment. On the other hand, multi-user schemes have been tried at other facilities but, so far, nobody has managed to apply them efficiently. Below, three reasons are listed why a multi-user scheme could nevertheless be envisaged.

a) The longer beam times would give the operators more time to properly set the desired multi-user scheme.
b) Fundamental-interaction experiments use a limited set of isotopes. Therefore, it seems natural to envisage a scenario where experiments requiring the same isotope can run in parallel. Simultaneously delivering the same RIB to different beam lines is rather straightforward and, in any case, much easier than simultaneously delivering two different beams.
c) Further, trap experiments are ideal for multi-user running as a consequence of their cycle structure, which is typically of the order of one second.

Furthermore, it was noted that MOT traps do not need the high isobaric selectivity of the HRS, as they have an inherent superior selectivity. Ion traps, on the other hand, will certainly benefit from the high isobar selectivity of the HRS. In this case, it is indeed important that no issues with the space-charge limit occur due to contaminant ions. In conclusion, it was agreed that a multi-user facility should be envisaged, but first the needs of the other communities have to be awaited for in the other topical workshops. For nuclear solid-state physics, for example, one might anticipate that the mass-resolving power of the pre-separator will be sufficient for their needs.

3. Beams

Fundamental interaction properties and symmetries are typically probed in (earth-)alkalis and noble gases. In principle, these are the simplest beams, but yet painstaking and tedious efforts need to be taken in order to reach the RIB intensity and purity of currently available beams. Therefore, it is advocated to concentrate on one up to two beams for initial development.

In relation with MOT traps, neon isotopes are of great interest for beyond Standard-Model searches, allowing for the determination of several different observables. Efficient production schemes for masses A=17,18,19 (and A=23 if deuteron beams would be available) exist for primary beams below 40 MeV. An interest is therefore expressed in the primary-beam extraction at a low-energy section.

Finally, the use of irradiated targets off-line in order to study long-lived isotopes was also mentioned as being an interesting option as it e.g. avoids disturbing effects due to varying beam intensities

There seems to be an interest in pion/muon beams, as the currently available facilities (PSI, TRIUMF) cannot provide sufficient beam time for all the pion/muon programmes. Such an option at SCK•CEN would require, however, an additional facility next to MYRRHA and ISOL@MYRRHA.

The question was raised whether a (ultra-)cold neutron facility would be of interest. It seems, however, that the neutron fundamental interaction physics community is not that large and that sufficient neutron facilities matching their needs already exist.

4. Statements of interest

Statements of interest for operating experiments at ISOL@MYRRHA were made by

- the WITCH experiment and several other particle-trap based beta-neutrino correlation experiments (e.g. with Ne isotopes),
- atomic parity violation and electric dipole moment experiments (e.g. with Fr or Ra isotopes),
- experiments aiming at determining the beta-asymmetry parameter, triple correlations and the polarization-asymmetry correlation,
- measurements of recoil terms and searches for second class currents in beta decay,
- precision mass measurements, and
- precision lifetime and branching ratio measurements for super-allowed pure Fermi and mirror transitions.