Physics opportunities with the SPIRAL upgrade

Monday 08 February 2016 - Wednesday 10 February 2016

Book of Abstracts

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Role of nuclear structure in fission around neutron-deficient Pt

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The expected production of heavy ions after the Spiral1 upgrade opens a small window for the study of new fission modes recently found in 180Hg [PRL 105, 252502 (2010)]. These reveal a new role for structure effects, not observed in fission of actinides.

The competition between the Coulomb barrier and the foreseen energies of the new beams would allow the study of fusion-fission around neutron-deficient Pt, just two protons away from Hg. From an experimental point of view, observables such as the neutron-proton partition of the fission fragments are a useful tool to tag the presence and influence of structure effects. These observables can be obtained with the use of the spectrometer VAMOS, providing a complete characterisation of the fission fragments and the scission point.

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Performances of the SPIRAL1 charge breeder

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In the framework of the SPIRAL1 upgrade under progress at the GANIL lab, the charge breeder based on a LPSC Phoenix ECRIS, first tested at ISOLDE [1] has been modified as to benefit of the last enhancements of this device from the 1+ / n+ community [2].

Prior to its installation in the midst of the low energy beam line of the SPIRAL1 facility, it has been tested at the 1+/n+ LPSC test bench to evaluate its performances and investigate the future operational modes.

This contribution shall sum up the results obtained at LPSC concerning the 1+ to n+ conversion efficiencies for noble gazes as well as for alkali elements and the corresponding transformation times.

[1] P. Delahaye et al, Review of Scientific Instruments. 77, 03B105 (2006)
[2] R. Vondrasek et al, Review of Scientific Instruments 83 113303 (2012)

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Fusion-evaporation reaction at SPIRAL1

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Heavy ion beams from CSS1 allow to produce proton-rich ions via fusion-evaporation reactions. Different heat resistant targets would be bombarded with beams of about 6 MeV/A. This would allow to send these proton-rich nuclei to DESIR and to CIME for acceleration. In the talk, calculated production rate will be presented.

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Lifetime plunger measurement of low-lying states in 133Ce

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We propose a plunger measurement to determine the lifetimes of low-lying states in 133Ce using the 116Cd(22Ne,5n)133Ce reaction and the AGATA+OUPS setup. The 133Ce nucleus has been recently studied with Gammaspehre. Several chiral bands and multiple triaxial rotational bands have been identified at high spins. From the same Gammasphere experiment a new, well populated band has been identified at low spins, which is a good candidate for transverse wobbling motion. We recall that very recently a transverse wobbling band has been identified in the oddproton nucleus 135Pr, in which a proton particle is coupled to a triaxial core. This opened new horizons for the understanding of the low-spin rotational excitations in nuclei, revealing that the wobbling motion also exists in normal-deformed lanthanides. The new band of 133Ce can be the first example of transverse wobbling in an odd-neutron nucleus in which a neutron hole is coupled to a triaxial core. However, to support such an interpretation precise lifetime measurements are necessary, to allow to disentangle between alternative interpretations. The deduced B(E2; I ->I-2)out and B(M1; I -> I-1)out will be compared with realistic QRPA calculations including the newly introduced additional interaction which couples the wobbling mode to the scissors mode. Lifetimes will be also obtained for low-lying states in 133La, an odd-proton isotone of 135Pr which is candidate for transverse wobbling, and for the even-even neighboring nuclei 132;134Ce.

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Precision measurements in mirror beta decays

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In this contribution, we propose to measure the beta-neutrino angular correlation parameters in mirror beta decays using an upgraded LPCTrap setup at LIRAT. The main interest lies in the determination of Vud which can be deduced from this set of transitions if the GT/F mixing ratios are precisely known. This is precisely the purpose of the proposed measurements. The setup also provides the charge state distributions of the recoiling ions, enabling to study the atomic processes involved in these ions when the electron cloud is disturbed. The most interesting nuclei will be highlighted, among the new beams produced at SPIRAL1.

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Beta-delayed two-proton emission

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Beta-delayed 2p emission is an exotic decay mode close to the limits of stability.Like in other cases of 2p emission, the decay may go through intermediate levels, if energetically available, or be a direct 2p process by the simultaneous emission of two protons. In this last case, the two protons may reveal angular and energy correlations which could be compared to nuclear structure and dynamics models to study effects like pairing, barrier penetration etc.
Possible experiments with SPIRAL1 beams will be presented.

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Studies of Superallowed Fermi Beta Emitters Using the IBE Decay Station

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The study of superallowed Fermi β transitions between nuclear isobaric analog states of spin Jπ = 0+ provides demanding, and fundamental, tests of the properties of the electroweak interaction. In particular, high-precision measurements of the β-decay ft values for superallowed Fermi β emitters with isospin T = 1 have been used to validate the conserved vector current (CVC) hypothesis to better than 12 parts in 10^5 and provide the most precise determination of Vud, by far the most precisely determined element of the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix.

Much current interest lies in the set of superallowed decays with Tz =−1 parents, as the isospin symmetry breaking corrections are, in general, larger than those for the Tz = 0 parents of the same mass due to an increased radial-overlap mismatch between the proton and neutron wave functions in the parent and daughter nuclei. However, high-precision measurements of the ft values for these decays are, in general, more challenging than for the Tz = 0 parents, due both to the fact that they are further from stability, and their daughter nuclei are in general also β unstable and give rise to unwanted but unavoidable time-dependent β-decay backgrounds. Recent experimental efforts, in combination with extensive simulation work, have, however, demonstrated that these challenges can be overcome.

At the IBE low-energy decay station, a program to investigation Tz=−1 superallowed Fermi β emitters has been previously established. The setup uses a moving tape collection system and couples a plastic scintillator with a precisely calibrated HPGe to perform both half-life and branching ratio experiments simultaneously. Possible experiments for those superallowed emitters that are, or are expected to be, available at SPIRAL1 with sufficient intensity and purity will be discussed. This talk will highlight the complementarity of this program with similar studies performed at LISE, ISOLDE, and TRIUMF as well as the decays of T=1/2 mirror nuclei at LPCTrap.

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Mass measurements of light neutron-rich nuclei with SPIRAL1 beams

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Mass spectrometry of short-lived neutron-rich nuclei give access to observables like 2n separation energies, which are sensitive to nuclear structure (shell effects, deformations, ...) and therefore allows to probe the nuclear force far from stability. The SPIRAL1 upgrade offers the possibility to access masses of exotic nuclei which are currently either unknown or measured with large uncertainties. Different physics cases will be presented.

Penning traps and MR-TOFs are nowadays the instruments of choice to measure atomic masses with high precision. Performances of these two different systems will be described. The possibility of installing PILGRIM at LIRAT for the commissioning would allow to measure masses in the near future. On a longer term, such measurements are foreseen at DESIR with MLLTRAP or an MR-TOF with more possibilities thanks to the high-quality and high-purity beams delivered to DESIR.

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ACTAR TPC: First experiments with SPIRAL1 beams

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The active target and time projection chamber (ACTAR TPC) is a novel high-luminosity gas-filled detection system that features a highly pixelated pad plane of more than 16K fully digitized electronic channels for studies of reactions and decays of nuclei furthest from stability. Design of the first (cubic) chamber is essentially complete and construction is ready to begin. Commissioning and the first experimental campaign with ACTAR TPC and SPIRAL1 beams are foreseen in 2017 in the G3 experimental hall. These experiments represent the first scientific deliverables of the ERC project.

In this presentation, the timeline of the project and experiments being considered for the first ACTAR TPC campaign with SPIRAL1 beams will be discussed along with our requirements in terms of beam intensity, energy, and purity.

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Structure of proton-rich Tz=-5/2 nuclei

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Study of explosive hydrogen burning in classical novae using 30P and 25Al radioactive ion beams

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Classical novae outbursts are very special events since they are the 3rd most energetically ones after gamma-ray bursts and supernovae. The nucleosynthesis network involved in such events is now mainly known experimentally with a few exceptions such as the ^{25}Al(p,γ)^{26}Si and ^{30}P(p,γ)^{31}S reactions. In this contribution we would like to emphasize the importance to develop ^{25}Al and ^{30}P radioactive ion beams with intensities of the order of 10^5 pps.

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Study of 9He through isobaric analog states in 9Li

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Mass measurements of light neutron-rich nuclei with SPIRAL1 beams

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Role of nuclear structure in fission around neutron-deficient Pt

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Direct reactions in the N=Z region

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Near and sub-barrier fusion of neutron-rich light nuclei

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Structure of proton-rich Tz=-5/2 nuclei

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Study of 9He through isobaric analog states in 9Li

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Detailed spectroscopy 112Cd and 240Pu isotopes using fusionevaporation reactions with 6He beam from SPIRAL1

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Probing the H–buring rate through the CNO–cycle via the Coulomb–excitation of 15O

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Population of the N=Z region around the 100Sn via cluster emission.

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Direct isospin mixing measurement in Coulomb excitation of an 38mK isomeric beam

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To be announced (Astro)

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Study of light nuclei with A=25 via multi-nucleon transfer reactions induced by radioactive beams

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Lifetime measurements in the A~70 region using the relativistic Coulomb excitation and three-foil plunger techniques

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Mirror symmetry in the sd shell close to the proton drip line

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29Mg: Tracking shell evolution toward the island of inversion

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Study of n-p pairing in fp-shell through two-nucleon transfer reactions

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Mapping of neutron orbitals around N=28 using 56Ni(d,p)57Ni

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Oblate driving force in n-deficient nuclei above 56Ni: occupation in 68Se

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Structure of low-lying states in 43,45Ar studied using Coulomb excitation of SPIRAL beams

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Shape transition along and across N=28: 0+ 2 in 46,48Ar

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Spectroscopy of light nuclei at the drip lines

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