EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Status Report to the ISOLDE and Neutron Time-of-Flight Committee

IS521: Simultaneous spectroscopy of γ-rays and conversion electrons: Systematic study of E0 transitions and intruder states in close vicinity of mid-shell point in odd-Au isotopes

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Abstract

The goal of approved experiment is to study beta decay of ^{179,181,183,185}Hg. Acquired data will be of great relevance for understanding of the shape coexistence phenomenon in odd-Au isotopes and as well for understanding of evolution of Nilsson states as a function of neutron number. Dedicated setup was developed at Institute of Physics, SASc, equipped with 5 mm thick Si(Li) detector, metallic transporting tape, γ ray detectors and fully digital data acquisition system.

Remaining shifts: 12

Motivation, experimental setup/technique

Motivation for the IS521 experiment is to study the shape coexistence phenomenon in odd-Au isotopes in a great detail. Odd-Au isotopes herald very suitable system for such studies, since many different coexisting configurations occur at low excitation energy. States due to proton-intruder ($h_{9/2}$, $f_{7/2}$ and $i_{13/2}$) and proton-hole ($s_{1/2}$, $d_{3/2}$ and $d_{5/2}$) orbitals couple to different coexisting structures in corresponding Pt and Hg cores. This leads to enormous complexity of decay schemes of odd-Au isotopes. However, systematic and unambiguous quantification of energies, spins and parities of these states along whole isotopic chain is highly demanding, since it allows for testing and subsequent further modifying of particle-plus-triaxial-rotor approach.

Complementary to proposed IS521 experiment series of in-beam studies of ^{173,175,177,179}Au with unusually long running-times (typically 2 weeks for each isotope) were performed by our collaboration at the University of Jyväskylä. Preliminary analysis indicates totally unexpected significant change in nuclear structure of low spin states. This issue is probably far beyond model description based only on quadrupole degree of freedom. However, to address these issues, the high quality data for isotopes in vicinity of N = 104 are crucial. In-beam studies of these nuclei cannot answer these questions, due to limited population of non-yrast configurations in complete fusion reactions. Therefore beta decay study is an ideal technique, since it would populate dominantly low-spin states in daughter nuclei (due to presence of only low-spin beta decay state in Hg precursors).

Such experiments have to involve simultaneous measurements of both γ rays and conversion electrons, since only in such way internal conversion coefficients can be extracted with sufficient precision. Moreover, $E0$ transitions that are model-independent fingerprint of the shape coexistence can be identified. Only in such way can we have reliable information on spins and parities of nuclear states of interest.

Due to large density of states, complex spectra of both conversion electrons and γ rays are expected. Therefore, LN_2 cooled 5 mm thick Si(Li) windowless detector needs to be employed in order to reach the best resolution and efficiency even for conversion electrons above 1.5 MeV. The detector needs to be placed in a retractable cryostat with gate valve, which allows to vent the vacuum inside of the chamber without necessity of warming up and subsequent cooling of the Si(Li) crystal.

Status report

The delay of development of dedicated beta decay setup needed for proposed experiment was caused mainly by the complete funding cut for ISOLDE activities in Slovakia in years 2011 and 2012. Massive media campaign conducted by the Institute of Physics, Slovak Academy of Sciences (IP SASc), was successful and funding from the Ministry of Education of Slovak Republic was returned. Presently, our activities are covered by the Collaboration Agreement signed between IP SASc, CERN and the ISOLDE collaboration.

A versatile and easily transportable tape system was developed and tested at the Institute of Physics. Its design is based on the idea of past 8-track tapes used mainly in the United States from the mid-1960s through to the early 1980s. These cartridges contained only single reel, carrying endless loop of magnetic tape. The tape was pulled from the center of the reel, passed across the opening at one end of the cartridge and wound back onto the outside of the same reel. In the past, tape systems based on these cartridges were used during beta decay experiments at UNISOR at HFRIBS. These designs used original 8-track reels and tapes. However, this approach could not be used, since the production of tapes was ceased in late 1970s. Although it is still possible to purchase them, e.g., via Ebay.com, usually, as a result of long time in a store, the tape is too deteriorated and does not operate satisfactorily. Therefore, new amorphous metallic tape of similar properties was manufactured at the Department of Metal Physics of IP SASc using rapid quenching of melt. The alloy of the tape was specifically chosen to reach easy slipping of layers of the tape, similar to original graphite coated plastic tape. Such metallic tape is very robust against braking (however can tear easily from sides), is high-vacuum ready and has stable properties during operation. Therefore it is an ideal material for application in beta decay setup.

A new data acquisition system based on Pixie-16 digitizers and Agilent Acquiris TDCs is under construction (all the components are funded and ordered). Suitable conversion electron detector, according to above description (designed by Canberra) and γ ray detectors (standard Ortec coaxial detectors) were ordered and delivery is expected in February 2014. **We expect that the system will be ready for experiment in August 2014 the latest.**

Accepted isotopes: ^{179,181,183,185}Hg

Performed studies: series of in-beam runs, complementary to IS521 proposal were performed at the University of Jyväskylä

Future plans

Future plans with <u>available</u> shifts:

(i) Envisaged measurements and requested isotopes

Study of beta decay of ^{179,181,183,185}Hg isotopes, see table below.

(ii) Have these studies been performed in the meantime by another group?

To our knowledge, no one has performed such study.

ISOLDE remains to be the best facility where such experiment can be performed.

(iii) Number of shifts (based on newest yields) required for each isotope

isotope	yield (/uC)	target – ion source	Shifts (8h)
^{185}Hg	2.5E+08	Pb – plasma ion source	3
^{183}Hg	4.5E+07	Pb – plasma ion source	1
^{181}Hg	7.1E+05	Pb – plasma ion source	1
^{179}Hg	1.6E+03	Pb – plasma ion source	7

Total shifts: 12

Appendix

Student of Slovak Technical University Mr. Matúš Sedlák is working on development of the tape station within his project of diploma thesis, which is going to be defended in school year 2014/2015.