Proposal for TRIUMF Commitment (5YP 2015-2020)

Date:
September 17, 1012

PROJECT/COMMITMENT TITLE: P138 Laser Spectroscopy

PROPONENT: M.R. Pearson **TRIUMF CONTACT:** M.R. Pearson

PRINCIPAL COLLABORATORS: J. Crawford, F. Buchinger, B. Cheal

PROJECT DESCRIPTION:

The laser spectroscopy group studies ground state properties of short-live, exotic nuclei using several techniques that all exploit the hyperfine interaction. Where yields allow collinear laser spectroscopy is the method of choice, overlapping a fast ion beam with a narrow line-width laser in order to resonantly excite electronic transitions. Over recent years this technique has been greatly enhanced by utilising linear Paul traps to bunch the ion beam. The use of a bunched beam along with suitable data-aquisition systems reduces the background signals by upto four orders of magnitude whilst keeping the original signal strength.

In addition to using the hyperfine interaction to probe the nucleus it is also used in order to manipulate it. By optically pumping within the collinear geometry it is possible to polarise the atomic electrons, and therefore the nucleus. Transporting this polarised beam to suitable spectrometers allows for extreamly high precision Nuclear Magnetic Resonance (NMR) and Nuclear Quadrupole Resonance (NQR) measurements to be made by utilising the angular distribution of emitted particles from the relevant decays.

In order for future development of techniques as well as fully characterising the capabilities of the system a source a clean, stable beams of both the alkali and alkali-earth elements is required.

SCIENTIFIC JUSTIFICATION:

There are few properties of nuclei more fundamental to them than their ground state spins, moments and radii. Without a clear understanding of these basic properties of the atomic nucleus the ability to predict or model the nuclear landscape away from stability is significantly compromised. Collinear laser spectroscopy has long been regarded as a powerful tool in order to answer these problems. It is one of the few methods than can, in general, assign a definite spin as well as ground state moments and in all but the lightest of nuclei changes in the RMS charge radius. In general all of these nuclear properties come from the same measurement allowing broad surveys along long chains of the nuclear chart to be performed. This often gives a very clear picture of the evolution of the nuclear structure from single particle to collective the further away from stability that is probed.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

By its very nature this research crosses many boundaries. Not only are atomic techniques predominantly used in order to extract nuclear properties but the detection techniques also cross into other areas. For example, the NMR/NQR work is carried out in collaboration with material science groups across Canada. Not only do the techniques cross boundaries but the results are also used across many areas of physics. A recent measurement of the charge radius of Rb-74 was carried out in order to assist in reducing the uncertainties on theoretical corrections to CKM matrix calculations carried out by I. Towner. Whereas measurements of the spins, moments and, charge and magnetism radii of Francium isotopes is being used by the Francium PNC collaboration both practically to assist in the trapping of more exotic Francium atoms but also to refine and cross reference theoretical predictions needed for the future extraction of PNC effects, anapole moments and other high order state mixings.

Work is also being carried out at the request and in collaboration with other groups. Measurements of the spins and moments of the heavy Rubidium isotopes was instigated at the request of the 8pi collaboration. The accurate knowledge of the ground state spins of the heavy Rubidium isotopes will greatly assist in the

work that has been carried out looking at the decay of these isotopes to study the low lying nuclear levels within the daughter nuclei.

This work is carried out in collaboration with other groups around the world using similar techniques. The high power primary driver makes many nuclei at the extremes of the nuclear chart accessible here where they are not at other facilities. The use of the ISOL method at TRIUMF it complementary to the IGISOL method employed at Jyvaskyla, there the chemical insensitivity of the ion source lends itself to refractory elements that are at best difficult to extract using the ISOL technique.

BRORDER IMPACTS:

The main impact is in the training of Highly Qualified Personnel (HQP). The work is not only very much "hands on" but also requires almost everyone to have a working knowledge of the entire system from ion beam optics and laser systems through to data analysis. In general there are at least 2 postgraduate students and one postdoctoral reseacher on the project as well as a couple of undergraduates per year.

MAJOR MILESTONES:

Description	Date
First use of the new laser laboratory	September 2012 (Done)
Completion of the lab.	November 2012

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE	TWO	THREE	FOUR	FIVE	TOTAL
TRIUMF	$15,000.00	$15,000.00	$15,000.00	$15,000.00	$15,000.00	$75,000.00
EXTERNAL	$200,000.00	$200,000.00	$200,000.00	$200,000.00	$200,000.00	$1,000,000.00
TOTAL						$1,075,000.00 +/- 15%
TRIUMF NON-CASH RESOURCES						
\YEAR RESOURCE\	ONE	TWO	THREE	FOUR	FIVE	TOTAL
DAQ	0.2FTE	0.2FTE	0.2FTE	0.2FTE	0.2FTE	1FTE
Workshop	0.2FTE	0.2FTE	0.2FTE	0.2FTE	0.2FTE	1FTE
Design office	0.2FTE	0.2FTE	0.2FTE	0.2FTE	0.2FTE	1FTE
B.A.E.	1FTE	1FTE	1FTE	1FTE	1FTE	5FTE

EXTERNAL FUNDING INFORMATION:

Main external funding is from NSERC. Currently the grant is approximately $140,000/year. External funding for students has also been provided by foreign funding agencies (UK and Jordan).

ONGOING OPERATIONAL REQUIREMENTS:

Ongoing support for the polariser beamline, TITAN's RFQ and the upkeep of the laser spectroscopy laser laboratory. Upkeep and gradual upgrading of the data aquisition system.

DECOMMISSIONING REQUIREMENT:

If required all laser equipment will be reallocated to the universities that it either originally came from or those sharing the grant that paid for it. All other equipment is the responsibility of other groups (ISAC for the beamline, TITAN for the RFQ, Material science for the NMR/NQR spectrometers).

Accepted: Date: