Introduction
April 1, 2009 – March 31, 2010

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April, 1, 2009 through March 31, 2010. The format follows that of previous years. Sections I through IV contain reports from individual research projects. Operation and technical developments are given in Section V. Section VI lists the publications with Cyclotron Institute authors and the Appendix gives additional information including talks presented by members of the Institute during the past year. Once again, the full volume of this year's Progress in Research is available only on our web site (http://cyclotron.tamu.edu). *Since most of the contributions presented here are truly reports on progress in research, results and conclusions should not be quoted from the report without the consent of the authors.*

We have now completed 5 1/2 years of the Upgrade Project which ultimately will give us accelerated radioactive beams at intermediate energies. The progress on the project continues to be good. The K150 cyclotron is operational for both positive-ion and negative-ion beams. As of mid June, the new radiation monitoring system has been installed and is waiting on a short schedule break to be implemented. We expect to have limited operation of the machine to experiments before the end of the summer.

During the past year, two decisions made by the TAMU administration will impact the Cyclotron Institute in the near future. A request to develop a new multi-disciplinary research effort involving basic and applied nuclear science and nuclear non-proliferation policy issues was approved. A new institute—the Nuclear Solutions Institute—will be established as an umbrella institute to coordinate the activities of several departments and institutes that will form this program. The Cyclotron Institute will be one of the principle components of the NSI. In September, 2009, TAMU approved our plan to add a second floor of offices onto the existing building. In June, an architect firm will be awarded the contract to develop a final design for the addition. Construction should begin before the end of the current calendar year.

As in previous reports, I have pulled out some highlights of work over the past year. Those that are noteworthy are given below.

Research highlights:

(1) A review article on the evaluation of V_{ud} and its impact on the unitarity of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix was published this past year. The value for V_{ud} can be obtained from four different classes of beta-decay measurement: superallowed $0^+ \rightarrow 0^+$ nuclear transitions, neutron decay, mirror nuclear transitions and pion decay. All four results are consistent with one another, but the nuclear superallowed value has an uncertainty that is at least a factor of six smaller than the others, and it thus dominates the average. Currently V_{ud} is the most precisely known element of the CKM matrix (by a factor of nearly 20). The sum of squares of the top row elements of the CKM matrix now equals 0.9999(6), confirming the matrix's unitarity to unprecedented precision.

(2) A new proton resonance has been found for ^{22}Na+p by measuring the beta-delayed proton decay of ^{23}Al. The new resonance is the lowest energy one observed and it dominates the reaction rate for $^{22}Na(p,\gamma)^{23}Mg$.

(3) A unified description of heavy-quarkonium spectral functions and heavy-quark transport properties in the quark-gluon plasma (QGP) has been established using a thermodynamic T-matrix approach based on model independent input potentials including relativistic corrections, paving the way for quantitative analysis of the QGP as produce in high-energy heavy-ion collisions.

(4) Recent work at TAMU has demonstrated that a quantum statistical model of nuclear matter that includes formation of clusters at densities below nuclear saturation describes quite well the low-density symmetry energy, which was extracted from the analysis of heavy-ion collisions. Within such a theoretical approach the composition and the thermodynamic quantities of nuclear matter can be modeled in a large region of densities, temperatures, and asymmetries that are required in models such as supernova simulations.

(5) The beta asymmetry parameter measurement using ultra-cold neutrons has been improved, using data obtained by the UCNA collaboration in 2008 and 2009, to 1.3% of its value. The result is in good agreement with the most recent result for the asymmetry parameter.

(6) The heavy element group completed its characterization of the MARS velocity filter for low-velocity ions using a ^{241}Am source. With this information, the excitation function of the ^{40}Ar + ^{165}Ho reaction for the production of At isotopes was determined.

(7) The transverse collective flow of isotopically identified particles was observed to depend on both the neutron concentration of the particle of interest as well as the reacting system. The first experimental evidence isolating the dependence of the transverse flow on the charge of the system, and thus the Coulomb force, was found. In comparison to theory, the data favors a stiff form of the symmetry energy.

(8) Using an empirically constrained isospin- and momentum-dependent nuclear interaction, a better understanding of the properties of neutron stars, such as the relation between their masses and radii as well as the transition density and pressure at the boundary between their inner crust and liquid core, has been obtained.

(9) Two Institute theorists (Fries and Ko) are founding members and co-PI's of the newly established JET collaboration. The multi-institutional 'Collaboration on Jet and Electromagnetic Tomography of Extreme Phases of Matter in Heavy-Ion Collisions' will systematically study various probes of the quark-gluon plasma and hot hadronic matter. The JET collaboration is one of the topical collaborations being supported by DOE.

(10) The theory of reactions leading to resonance excitation in the Trojan Horse Method (THM) has been completed and is now the main tool for analysis of important astrophysical processes that are studied by the THM.

(11) The STAR collaboration has observed charge-dependent azimuthal correlations in ultra-relativistic Au+Au and Cu+Cu collisions that may arise from local strong parity violation.

(12) By including the effect of the medium on the binding energies of light clusters, the symmetry energy of low-density nuclear matter at low temperature is significantly larger than that obtained from the commonly used mean-field approximation.

As in the past, Institute scientists remain active in a number of collaborative research efforts around the world. Major programs include: a measurement of Michel parameters in normal μ^+ decay at TRIUMF in Vancouver, B.C.; mass measurements using the Penning Traps at Argonne National Laboratory and the University of Jyväskylä; continued work with the STAR collaboration at RHIC; and the measurement of neutron beta decay with the UCNA collaboration.

Once again, I am indebted to Dr. Y.-W. Lui for assembling this report.

R.E. Tribble
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