Introduction
April 1, 2018 – March 31, 2019

Progress in research and operations at the Texas A&M Cyclotron Institute is summarized in this report for the period April 1, 2018 through March 31, 2019. The format follows that of previous years. Sections I through III contain reports from individual research projects. Operation and technical developments are given in Section IV. Section V lists the publications with Cyclotron Institute authors and outside users 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.*

The goal of accelerating radioactive beams by the K500 was achieved recently using beams produced by K150 proton beams impinging on targets in the light-ion guide and then charge-bred by the charge-breeding electron-cyclotron-resonance ion source, CB-ECRIS. In November of 2018, the production of the radioactive ^{112}In (14.4 minute half-life) from a ^{114}Cd target and subsequent charge breeding and re-acceleration with K500 were investigated. Using the CB-ECR ion source the charge bred $^{112}In^{21+}$ ions, along with $^{16}O^{3+}$ which was used as a pilot beam, were accelerated to 14 AMeV from the K500 cyclotron and were then sent to the MARS spectrometer for analysis. The beam switch from $^{16}O^{3+}$ to $^{112}In^{21+}$ was accomplished by shifting the K500 RF frequency by +6.5 kHz. The MARS analysis identified the beam as ^{112}In along with two other contaminants (from the ion source) of similar intensities to the ^{112}In; it was verified that the ^{112}In was indeed produced from the LIG gas cell. Thus this 14 AMeV $^{112}In^{21+}$ became our first accelerated radioactive beam.

The K500 provided an impressive 6,414 hours of beam for both science and radiation effects testing. The K150 cyclotron provided, 3859 hours of beam on target and continues to be used by external users for radiation effects testing with its proton beams. Additionally, efforts to meet the increasing radiation testing demand are underway by developing heavy-ion beams from the K150. Significant effort was devoted to improving the K150 cyclotron vacuum leading to new intensity records for H-minus (24 μA) and heavy-ions such as ^{40}Ar.

As in previous reports, I include here some scientific highlights.

- Explained the large enhancement of Λ production recently observed in proton-proton collisions at the LHC within the statistical hadronization model using a largely augmented set of "missing" charm-baryon resonances (compared to the listings of the particle data group), as predicted by lattice QCD and the relativistic quark model.

- Established tight constraints on the incompressibility coefficient, nucleon effective mass and the enhancement coefficient of the energy weighted sum rule of the isovector giant dipole resonance

by calculating the energies of wide ranges of giant resonances and nuclei with 33 energy density functionals.

- Found a possible new resonance in the middle of the Gamow window for ^{34g,m}Cl(p,γ)^{35}Ar with the AstroBox2 detector through the beta-delayed proton decay of ^{35}K.

- Measured Coulomb dissociation and nuclear breakup of ^{9}C → ^{8}B+p and ^{9}C → ^{7}Be+2p at RIKEN to study the rate of the ^{7}Be+p → ^{8}B+p → ^{9}C reaction chain as a possible bypass of the 3α process in stellar environments. This was the commissioning experiment of the SAMURAI Si-tracker built and instrumented in collaboration with TAMU, WUSTL, and LSU.

- Measured nuclear breakup of ^{66}Se → ^{65}As+p and ^{66}Se → ^{64}Ge+2p at RIKEN to study the destruction of the waiting point nucleus ^{64}Ge in X-ray burst environments.

- Commissioned the TIARA for Texas detector system and measured four transfer reactions of astrophysical interest using the device.

- Measured the n/γ branching ratio for the $E_{c.m.}$ = 705 keV resonance in ^{22}Ne(α,n)^{25}Mg and established partial α width for the four resonances in ^{26}Mg within Gamow window for the ^{22}Ne(α,n) and ^{22}Ne(α,γ) reactions. As a result of these two experiments, the stellar s-process rate for ^{22}Ne(α,n) is reduced by a factor of ~3 for temperatures above 0.3 GK.

- Commissioned the TAMUTRAP facility by measuring the masses of ^{23}Na, ^{85,87}Rb and ^{133}Cs to better than 50 ppb.

- Commissioned TexAT and studied structure of ^{9}C ^{8}B+p resonance elastic scattering. The s-wave p+8B interaction strength was established, providing the location of the 2s1/2 shell in this A=9 T=3/2 nuclear system.

- Populated cluster states in ^{14}O and ^{18}Ne via ^{10}C + α, ^{14}O + α.

- Performed direct measurement of ^{8}B + ^{40}Ar fusion reaction.

- Measured β-delayed charged particle emission targeting the decay of the Hoyle state.

- A strong heavy-quark potential in the quark-gluon plasma has been extracted in a statistical analysis of bottomonium production in heavy-ion collisions at RHIC and the LHC utilizing our previously developed quarkonium transport approach. Substantial remnants of the confining force are found to persist, playing a critical in understanding the strongly coupled properties of the QGP.

- Identified alpha condensate states that could be analogous to Hoyle state in heavier nuclei.

- The redistribution of axial charges in the transverse plane of non-central heavy ion collisions due to produced vorticity field is shown in the chiral kinetic approach to result in an azimuthal angle dependence of the quark and antiquark longitudinal polarization along the beam direction that is similar to that of Lambda hyperons observed in experiments by the STAR Collaboration at the Relativistic Heavy Ion Collider.

- Production of deuteron and helium-3 via the coalescence of nucleons, which includes the effect of their internal structure, is found to provide a natural explanation for the observed suppression of their production in p+p collisions by the ALICE Collaboration at the LHC.

Institute scientists remain active in a number of collaborative research efforts around the world. Major programs include: measurements of beta decays with the TRINAT collaboration at TRIUMF; nuclear structure measurements with TexAT at TRIUMF; continued work with the STAR collaboration at RHIC; fusion studies at MSU; and participation in the SAMURAI collaboration at RIBF in Tokyo, Japan.

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