RIA Summer School '06
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Nucleon alignment and shape competition at high spin in ^{180}Hf

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In light even-N Hf isotopes (N = 96-106), the first $i_{13/2}$ neutron alignment occurs at a rotational frequency $\hbar\omega < 0.3$ MeV, whereas, no alignment was observed up to ~ 0.4 MeV in ^{180,182}Hf (N = 108,110) [1]. Theoretical calculations predict that oblate collective rotation becomes yrast at high spins in ^{180}Hf [2, 3]. In the present work, the yrast band of ^{180}Hf has been extended to high angular momentum, via inelastic excitation, using a 1300 MeV ^{180}Hf beam incident on a thin ^{232}Th target. The gamma rays were detected by Gammasphere, with event by event Doppler correction and Q-value selectivity provided by the auxiliary heavy-ion detector CHICO. The data reveal onset of the first nucleon alignment in ^{180}Hf at $\hbar\omega \sim 0.43$ MeV, which is much higher than that predicted from calculations. The gamma-vibrational band is crossed by a band with apparent high moment-of-inertia at $\hbar\omega \sim 0.25$ MeV. This structure, which becomes near yrast at the highest observed frequencies will be discussed in the context of nucleon alignment and shape competition at high spin in ^{180}Hf.

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[2] R.R. Hilton and H.J. Mang, Phys. Rev. Lett. 43, 1979 (1979).
[3] F.R. Xu et al., Phys. Rev. C62, 014301 (2000)

Cryogenic Gas Cell Development for Transfer Reactions using Radioactive Ion Beams

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R. Kozub (TN Tech.), C. Nesaraja, D. Bardayan, J. Blackmon, M.S. Smith (ORNL), K. Jones, S. Pain, J. Thomas, J. Cizewski (Rutgers)

Abstract:
Using a gas target with radioactive ion beams (RIBs) for transfer reactions allows for high target uniformity, good energy resolution and a wide range of available target elements or compounds. A cryogenic gas cell can be used with rare or difficult gases to contribute an increase in target density for any desired pressure and obviate any need to flow the gas. This cell was specifically designed for the (3He,p) transfer reaction.

Diffusion and Transport of ^{120}Xe: Towards Rn Electric Dipole Moment Measurements at ISAC*

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The existence of permanent electric dipole moments (EDMs) would reveal time reversal violation and that the Standard Model is incomplete. An atomic EDM search is beginning at TRIUMF involving odd-A Rn isotopes predicted to have enhanced EDMs from collective octupole deformations. In anticipation of Rn beams in 2006-2007, techniques to transport radioactive gas from a collection foil to a measurement cell were developed using ^{120}Xe.

The ^{120}Xe half life was measured to be 46.0 ± 0.6 min. Diffusion coefficients were calculated for Ta, Pt, and Zr foils. Zr had the highest diffusion rate, but Ta may be more reliable due to Zr reactivity. ^{120}Xe gas was transferred from the target chamber to the cell using cryopumping and gas-pushing techniques. The pushing efficiency was determined to be 44% with an upper limit on the overall transfer efficiency of 26% depending on the foil release and cryopumping efficiencies under different conditions.

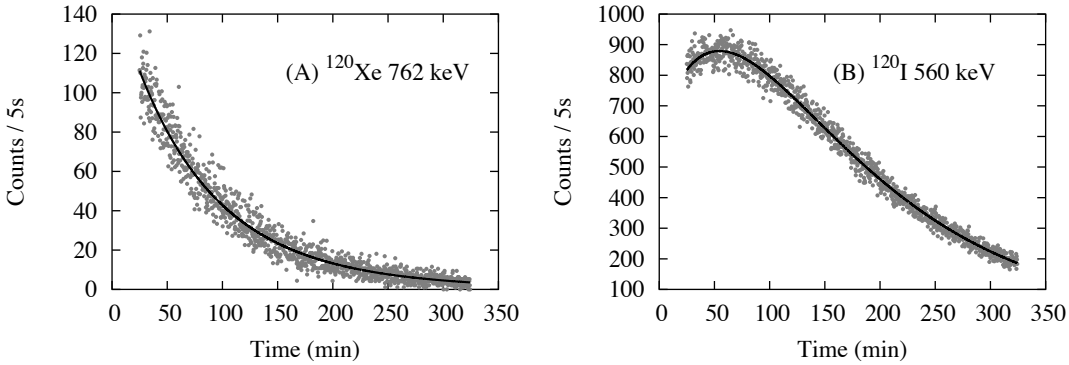

FIG. 1: Fits of activity decay data generated from (A) ^{120}Xe 762 keV and (B) ^{120}I 560 keV γ-ray peaks. The points represent the rate-corrected counts as a function of time in 5 s bins. The solid line represents the region over which the data were fit. For display purposes, only every third data point is shown. The best fit half lives are 46.0 ± 0.6 min and 82.1 ± 0.6 min for ^{120}Xe and ^{120}I respectively.

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P-P Correlation Functions as a Probe to the Nuclear Equation of State

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Abstract

While the equation of state has been determined for symmetric nuclear matter, the density dependence for asymmetric matter is not known. Proton-Proton correlations are a sensitive probe to this asymmetry term. Correlation functions are used to reconstruct an image of the collision at the time a correlated pair of particles is emitted. The BUU model predicts that a stiff asymmetry term gives rise to a larger peak in the p-p correlation function than a soft asymmetry term. The stiff term corresponds to a smaller source size. That is, the protons are emitted in a short time, closer together in time and space, and subject to stronger final state interactions. The soft term corresponds to protons being emitted over a longer time scale, thus they're father apart spatially at the time of emission and have weaker final state interactions. We will help constrain the asymmetry term by measuring p-p correlations from two reactions, ^{40}Ca on ^{40}Ca and ^{48}Ca on ^{48}Ca in an upcoming experiment at the NSCL using the 4π Array and HiRA.

Benchmarking the Surrogate Ratio Method Using $^{234}U(\alpha,\alpha'f)/^{236}U(\alpha,\alpha'f)$

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The Surrogate Ratio Method is a new technique that can be used to obtain neutron-induced reaction cross sections on unstable nuclei. This "external" ratio method promises to be less sensitive than the absolute surrogate method to differences in spin between the neutron-induced and surrogate reactions [1,2]. The first experiment using the ratio method demonstrated that the fission probabilities for ^{237}U vs. ^{239}U was the same over a wide range of equivalent neutron energy regardless of whether the nuclei were formed using neutron-capture or the (d,p) reaction [1]. However, this result had significant (>20%) uncertainty. In order to benchmark the ratio method with greater precision a new experiment was performed at the 88-Inch Cyclotron at LBNL using the Silicon Telescope Array for Reaction Studies (STARS). In this experiment excited ^{234}U and ^{236}U nuclei were formed via inelastic α-particle scattering and the ratio of their fission probabilities was compared to the known $^{233}U(n,f)/^{235}U(n,f)$ cross section ratio. In this experiment, ^{234}U and ^{236}U targets were bombarded with a 55 MeV α-beam and the fission fragments in coincidence with outgoing α-particles were measured. The STARS array consisted of a particle telescope comprised of two Micron S2 detectors, a 140 μm ΔE and a 1000 μm thick E detector, located downstream from the target coupled to a third 140 μm fission fragment detector located upstream from the target. This talk will discuss the surrogate ratio method and the preliminary results of our measurement.

This work is a University of Richmond, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory and Yale University collaboration and was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05NA25929, DE-FG52-06NA26206, and DE-FG02-05ER41379.

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Determination of the astrophysical S factor for the $^{12}N(p,\gamma)^{13}O$ reaction from the proton transfer reaction $^{14}N(^{12}N,^{13}O)^{13}C$

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The reaction rate for the radiative proton capture on the drip line nucleus ^{12}N is currently under investigation at the Cyclotron Institute/ Texas A&M University using an indirect method. This reaction is important in the hot pp mode nuclear burning in hydrogen-rich massive objects [1]. A ^{12}C primary beam from the K500 superconducting cyclotron is used to produce in-flight secondary radioactive ^{12}N beam separated with the recoil spectrometer MARS [2].
We are using the $^{14}N(^{12}N,^{13}O)^{13}C$ proton transfer reaction to extract the asymptotic normalization coefficient (ANC) for the virtual decay $^{13}O \rightarrow ^{12}N+p$, and calculate from it the direct component of the astrophysical S-factor. Preliminary results of the investigation are presented.

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Study of unbound ^{19}Ne states via the proton transfer reaction ^{2}H (^{18}F, α+^{15}O) n[1]

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The nuclear structure of ^{19}Ne near the proton threshold is of interest for understanding the rates of proton-induced reactions on ^{18}F in novae. The proton transfer reaction ^{18}F (d, n) ^{19}Ne has been measured by bombarding a 720-μg/cm^2 CD_2 target with a 150-MeV $^{18}F^{9+}$ beam at ORNL's Holifield Radioactive Ion Beam Facility. The ^{19}Ne states of interest near the proton threshold decay by breakup into α+^{15}O which were detected in coincidence with position-sensitive E-ΔE Si telescopes. The reconstruction of the relative energy reveals the excited states of ^{19}Ne which are populated. In addition the direction of the undetected neutron can be determined. The mirror reaction ^{2}H (^{18}F, α+^{15}N) p has been measured simultaneously. The implications for the ^{18}F (p,α) ^{15}O reaction and ^{19}Ne-^{19}F mirror symmetry will be discussed.

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