

Gamma Ray Spectroscopy Using Deep-Inelastic Reactions

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Currently, nuclear high spin states are produced almost exclusively by heavy-ion induced fusion reactions and in a few cases by Coulomb excitation. However, with a stable beam and target, only neutron-deficient nuclei can be produced in fusion reactions. So far, high spin states in neutron-rich nuclei and in most of the odd-even and odd-odd nuclei near the stability line have not been studied due to the lack of suitable nuclear reactions. However, deep inelastic reactions have been shown to produce a high multiplicity of gamma-rays [1] and attempts have been made to use them and quasi-elastic reactions to populate and study high spin states[2,3]. Since these reactions produce many final nuclei, a high efficiency gamma-ray detector array, such as Gammasphere, is needed to resolve and study the gamma rays from such reactions.

To test the feasibility of using deep-inelastic reactions to populate high spin states in neutron-rich products, we have carried out the reaction $^{48}\text{Ca} + ^{176}\text{Yb}$ at beam energies of 250 and 275 MeV. The Ca-like products were detected at 66° in a counter telescope consisting of a gas ΔE and a position-sensitive silicon-strip E-detector with a solid angle of 130 msr. The early implementation of Gammasphere with 32 detectors was used to detect the gamma-rays. Particle-gamma coincidence data were taken at a rate of 1 k/sec. The velocity vector of the target-like product was calculated from the measured energy and angle of the projectile-like product and the Doppler-shift correction of the gamma rays was based on this vector and the direction of the gamma ray. Gamma-rays of Er, Tm, Yb, and Hf nuclei were identified from particle-gamma-gamma coincidence data. We observed several new high spin states in ^{173}Tm , ^{175}Yb and ^{178}Yb . The nucleus ^{173}Tm which has one less proton and two less neutrons than the target is four neutrons richer than the stable ^{169}Tm , whereas ^{178}Yb has two more neutrons than the most neutron rich Yb. From this 10-hour run, we were able to observe gamma rays from nuclei produced with a cross section $d\sigma(66^\circ)/d\Omega$ down to approximately 0.1 mb/sr. The population of the yrast states of the Yb nuclei are shown in the figure. States with spin up to 16 were populated, and the nuclei further away from the target are produced at higher spin. A follow up experiment is scheduled which will provide a 100-fold increase in data. These data will be discussed. We expect to observe new high spin states in many neutron-rich nuclei such as ^{178}Yb .

- [1] P. Glassel et. al. Phys. Rev. Lett. **38** (1977) 331.
- [2] H. Takai et. al. Phys. Rev C**38** (1988) 1247.
- [3] R. Broda et. al. Phys. Rev. Lett. **68**(1992) 1671.

