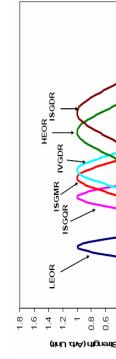
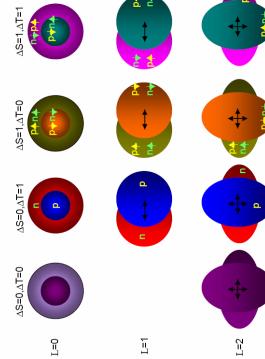


Using ${}^6\text{Li}$ in Measuring Giant Monopole Resonances

Theory

Giant resonances are collective modes of excitation of a nucleus. In a macroscopic liquid drop model the protons and neutrons are treated as separate liquids. The resonances are then shape or density oscillations of the nucleus. These resonances are classified by spin (S) and isospin (I). Spin can be either $S=0$ referring to electric oscillations and $S=1$ referring to magnetic oscillations. Isospin refers to whether the protons and neutrons are moving in phase or out of phase isoscalar ($T=0$) and isovector ($T=1$).



By finding the energies of the Isoscalar Giant Monopole Resonance (ISGMR) also called the breathing mode, we can determine K_A for different nuclei.

$$E_0 = \sqrt{\frac{k_A K_A}{m/r^2_0}}$$

By finding K_A for many nuclei ranging from heavy to light, we can use the semi-empirical mass formula as a macroscopic way to determine K_{nm} .

$$K_A = K_{\text{sym}} + K_{\text{asym}} A^{-\frac{1}{3}} + K_{\text{sym}} \left(\frac{N-Z}{A} \right)^2 + K_{\text{vol}} \frac{Z^2}{A^{\frac{4}{3}}}$$

For lighter nuclei the macroscopic approach does not work as well because the K_{vol} term is hard to interpret. But a microscopic approach using the Hartree-Fock Random Phase Approximation has been used to determine K_{nm} also. We then use the compressibility of nuclear matter (KnM). To determine the nuclear equation of state.

$$K_{\text{nm}} = 9\rho_0^2 \left. \frac{d^2 E/A}{d\rho^2} \right|_{m_0} = k_f^2 \left. \frac{d^2 E/A}{dk_f^2} \right|_{k_f^2}$$

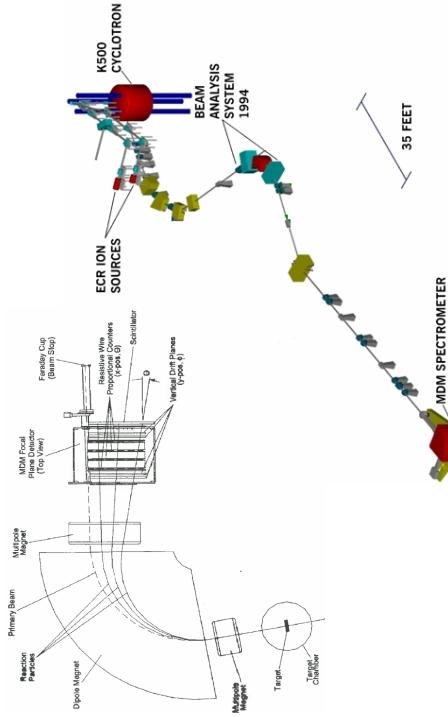
Also K_{nm} is used in the fields of astrophysics in relation to star collapse, black holes, supernova, and neutron stars.

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REU Cyclotron Institute 2008
Mentor: Dr. David Youngblood

Experiment Setup

To measure the ISGMR particles are scattered in inelastic collisions with the target and the products of the reaction are measured with the MDM Spectrometer at small angles.

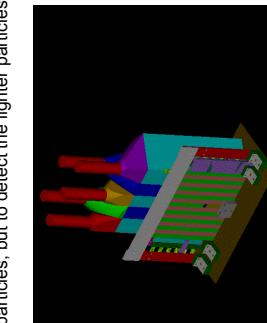


The incident particles come off of the target with different energies related to which interaction they went through. These different particles are separated with the dipole magnet and then measured in the Focal Plane Detector according to energies and mass.

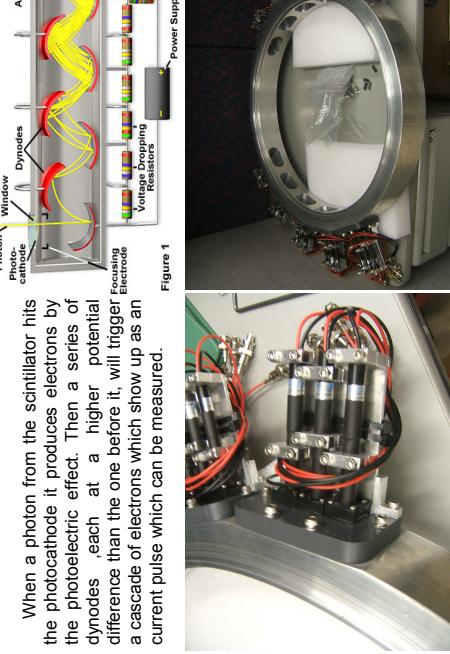
The Decay Detector

In the survey of giant resonances the study has moved from stable isotopes to unstable isotopes. In these reactions the heavier particle cannot be used as a target because it would decay before the experiment could be done. The inverse reaction can be looked at where the incoming particle is radioactive and the target is ${}^4\text{He}$ gas. But getting ${}^4\text{He}$ gas to a high enough density is problematic. So instead Lithium (${}^6\text{Li}$) is used as a target. But in studying the inverse reaction all particles of the decay need to be studied. The MDM spectrometer can detect the larger particles, but to detect the lighter particles the decay detector needs to be built.

The decay detector consist of two layers of 1mm thick scintillators one vertical and one horizontal to determine position and then larger scintillators to detect the total energy of the particles. Each of the strip scintillators will be connected via optical fiber to a photomultiplier tube which converts the light output of the scintillators to an electrical signal. The larger scintillators have light guides which will be connected to photomultiplier tubes.



Photomultiplier Tubes



This is the current progress on the decay detector and target chamber. The above pictures display the ring of photomultiplier tubes (PMT). Each of the 1mm scintillators is connected via fiber optics to a PMT. These PMTs are located in a ring that goes around the target chamber and then each PMT is run from the cave to the counting room.



Using a Strontium 90 beta source we setup an experiment with two test scintillators placed horizontally in the rack pictured to the left. The scintillators were hooked up as close to experiment type conditions with the scintillators connected to fiber optics and PMTs. The output of the PMTs was counted with the source placed at different positions. Also different wrappings of the scintillators were tried to see if any noticeable difference in count was present.

Also using a program called SRIM, which calculates range and energy lost for ions in material, a graph for the light output of the scintillators can be made using $\text{Log}(1+\text{adE}/\text{dx})$ as approximately the dL/dx and integrating to find $L(x)$ we can find the relative light output of the 1mm scintillators for different particles.

