Mutipole Decomposition Analysis of the SDR and GDR excited by the $^{12}C(\vec{p},\vec{n})^{12}N$ reaction at 197 MeV

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Giant Dipole Resonances (GDR) and Spin Dipole Resonances (SDR) excited by charge exchange reactions on ^{12}C at intermediate energies are observed as two prominent peaks at $E_x \sim 4$ MeV and $\sim$7 MeV for both (p,n) and (n,p) type reactions. While the peak at $\sim$4 MeV is known to be a complex of 2^- spin-dipole states and a 4^- state, J^π assignment of the peak at $\sim$7 MeV is still controversial. The $^{12}C(p,n)$ reaction measurements [1, 3] obtained results that the main component of the 7 MeV peak is GDR 1^-, while the measurements of the ^{12}C(^{12}C, ^{12}N) reaction [4] and tensor analyzing powers of the $^{12}C(\vec{d}, {}^2He)$ reaction [5] have shown that the state is better described with 2^- spin-parity assignment. Moreover, Measurements of residual nuclei's decays of the $^{12}C(d, {}^3He)$ and $^{12}C({}^3He, t)$ reactions [6] have shown that the main component of the state is 1^-.

Thus, in order to investigate the distributions of $J^\pi = 0^-, 1^-$, and 2^- components in the GDR and SDR region, we performed a Mutipole Decomposition Analysis (MDA) of the $^{12}C(\vec{p}, \vec{n})^{12}N$ reaction at 197 MeV. Differential cross sections and spin observables A_y, P, and D_{NN} were taken from the experiment at RCNP [7, 8]. Cross sections and A_y were measured at nine points ($\theta_{CM} = 0° \sim 32.6°$), while P and D_{NN} were at $\theta_{CM} = 5.5°$ only. The shapes of the angular distributions of the cross sections and spin observables are characterized by the transferred J^π values. The data were fitted with a weighted summation of DWIA outputs with different ΔJ^π transfers at each excitation energy bin. Normaly, only cross section spectra are used for this procedure. In our case, however, spin observables were also used, because of the difficuly of the separation of 1^- and 2^- states which have similar shapes of cross sections. The strength of each J^π was determined by the χ^2 mimization. In the region $E_x = 2.7 \sim 11.7$ MeV, we have calculated the angular distribution of six J^π transitions: $1^+, 0^-, 1^-, 2^-, 2^+$, and 4^-. For each J^π transition we performed DWIA calculations by choosing a 1p1h configuration which minimizes the χ^2. For the DWIA calculations, we used nucleon-nucleon interaction parameters at $E = 210$ MeV [9] and optical potential parameters obtained by the proton elastic scattering from ^{12}C at 183 MeV [10]. Harmonic oscillator wave functions were assumed for the single particle states. It is known that DWIA calculations for $\Delta J^\pi = 2^-$ transitions underestimate the cross section at forward angle [2]. To prevent this effect we calculated all the 2^- states by adding an extra Q value. This additional Q value (-10 MeV) and the harmonic oscillator's size parameter ($b = 1.80$ fm) were determined so that the MDA results reproduce the complex of 2^- and 4^- states of the 4 MeV peak.

Obtained MDA results for differential cross section and spin observable spectra are presented in Figure.1 and Figure.2, respectively. The 4 MeV peak is well decomposed as the complex of 2^- and 4^- states. The structure of the spin observables is also reproduced. These results indecate that the 7 MeV peak consists of 1^- and a little 2^- states. The results imply the existence of a continuous distribution of the 0^- component in the region $E_x = 4 \sim 10$ MeV, while successful extraction of the 0^- component has not been reported so far. Scince the main component is 1^-, positive D_{NN} values are expected at the 7 MeV peak. The negative D_{NN} values at $\sim$7 MeV mainly stem from the existence of the small 0^- component.

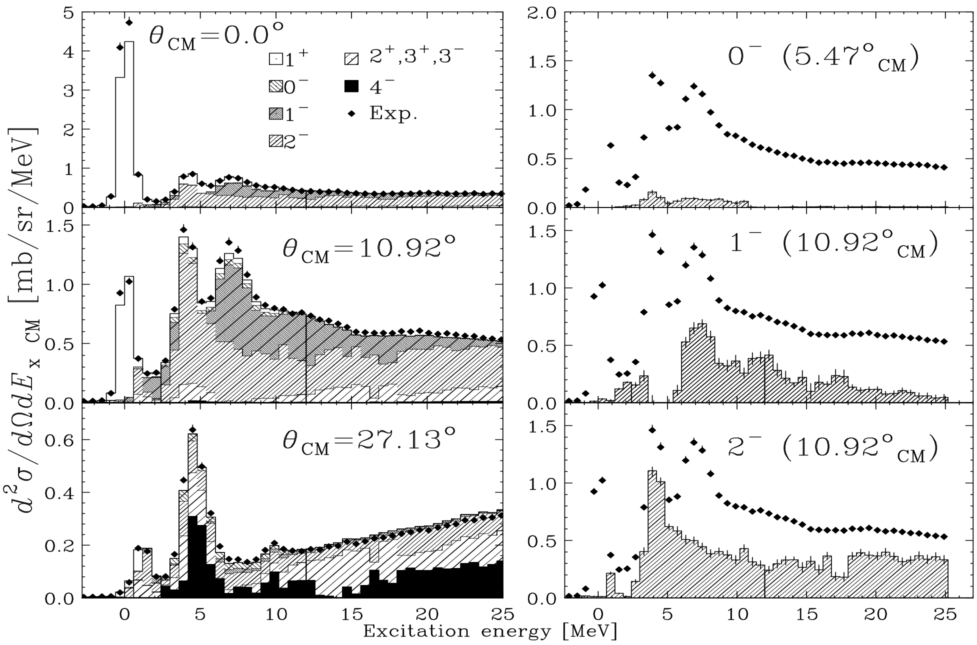

Figure 1: Obtained MDA results for the double differential cross section of the $^{12}C(\vec{p},\vec{n})\,^{12}N$ reaction at 197 MeV. The left panel shows the decomposed J^π strengths. The right panel shows separately the components of the 0^-,1^-, and 2^- at the angles where the strenghs of these components are most prominent. Diamonds are the experimental results from Ref [7].

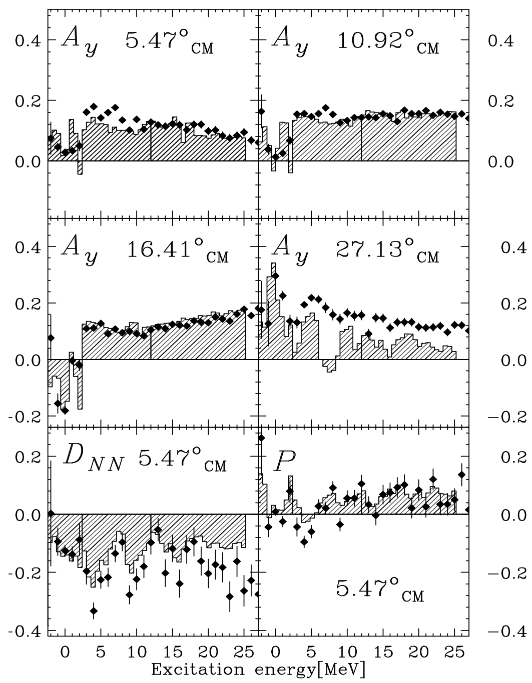

Figure 2: Obtained MDA results for spin observable spectra. Hatched regions are the weighted mean of all the decomposed J^π strenghs. Diamonds are the experimental results from Ref [7].

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