A New Measurement of $s-$wave strength in ^{12}Be via (d,p) transfer reaction

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A remarkable phenomenon for the light unstable nuclei is the disappearance of the conventional magic numbers. Around neutron number $N = 8$, intruder of $sd-$shell neutrons into $p-$shell for ^{11}Be ground state has been well understood [1]. In ^{12}Be, the relatively low energies of the three bound excited states imply the breakdown of the $N = 8$ magic number and the strong intruder from the upper $sd-$shell [2, 3, 4, 5], leading to the growing of other non-shell like structure in this nucleus [6, 7]. To date most studies agree on the large probability (60%) of intruder from the $sd-$shell, but the relative importance of the $s-$ and $d-$components remains a subject of active investigation [8], where controversial results exist in the literature, both experimentally and theoretically [9, 10, 11, 12, 13, 14]. Especially, the spectroscopic factors extracted from the previous transfer reactions are in conflict with many theoretical and experimental works and have been questioned from various sides [9].

In order to study the configurations of ^{12}Be, an experiment was designed, aiming at investigating the intruder $s-$wave strength in the ground state and low-lying excited states of ^{12}Be, via the highly selective $^{11}\mathrm{Be}(d,p)^{12}\mathrm{Be}$ transfer reaction. The experiment was performed in inverse kinematics, in which the projectile like fragments emitting at forward angles were measured in coincidence with the recoil protons or deuterons to have a better discrimination of various reaction channels. Special cares were taken in determining the deuteron target thickness and separating the 0_2^+ isomeric state from the mixed excitation-energy peak. Elastic scattering of $^{11}\mathrm{Be}{+}p$ was simultaneously measured, serving to estimate the hydrogen contamination in the CD_2 target and to obtain the reliable OPs to be used in the analysis of the transfer reaction.

$^{11}\mathrm{Be}(d,p)^{12}\mathrm{Be}$ transfer reaction, elastic and inelastic proton(deuteron) scattering on ^{11}Be were measured in inverse kinematics at RCNP (Reacher Center for Nuclear Physics) [16] using a radioactive beam produced at 26.9A MeV. The ^{11}Be beam was produced from a primary beam of ^{13}C at 60A MeV impinging on a 456-mg/cm^2 Be target and purified by the electromagnetic separator with a 650-mg/cm^2 aluminium degrader. The secondary beam intensity was approximately 10^4 particles per second (pps) with a purity of about 95% for ^{11}Be, and a contamination of about 5% for ^{9}Li. The momentum spread was limited, by a slit, down to 1% to reduce the energy uncertainty of the beam.The elastic scattering data of $^{11}\mathrm{Be}{+}p$ together with the earlier elastic scattering data were analyzed with the Chapel Hill 89 and Koning−Delaroche phenomenological optical potential. The angular distribution was found to be reproduced by reducing the real part and increasing the imaginary part of the well depth, which attributes to the coupling effects to continuum states [19]. With normalized optical potentials of ^{10}Be elastic scattering on proton, breakup effects were analyzed using the continuum-discretized coupled-channels (CDCC) method at the four incident energies, and results shows relatively satisfying agreement [21]. Finally, core excitation of ^{10}Be core in ^{11}Be was included by an extended version of the CDCC method (XCDCC) calculation [17], and breakup cross section is consistently reproduced. For the $^{11}Be + d$ breakup reaction, the DCX effect is particularly noticeable for the higher excitation energy interval ($Ex = 3C5.5$ MeV), for which the calculation ignoring the DCX mechanism clearly underestimates the data. These results confirm the relevance of the DCX effects in the scattering of weakly bound deformed systems on light targets. Finally, with the obtain optical potential, we report the $s-$wave spectroscopic factors abstracted from $^{11}\mathrm{Be}(d,p)^{12}\mathrm{Be}$ transfer reaction.

FR-ADWA calculations were employed to three sets of transfer reaction data, and consistent $s-$wave SFs are obtained for the low−lying 0^+ states. Presently determined small $s-$wave SF of 0.20(0.04), together with previously reported $p-$wave strength, leads to a dominating $d-$wave intruder in the g.s. of ^{12}Be. Comprehensive shell-model calculations were performed with the latest YSOX interaction [18], indicating a possible strong pairing correlation for valence neutrons in light neutron-rich nuclei. This work demonstrates the importance of

measuring the individual SFs in the low−lying states in order to fix the major ingredients in the shell−model.

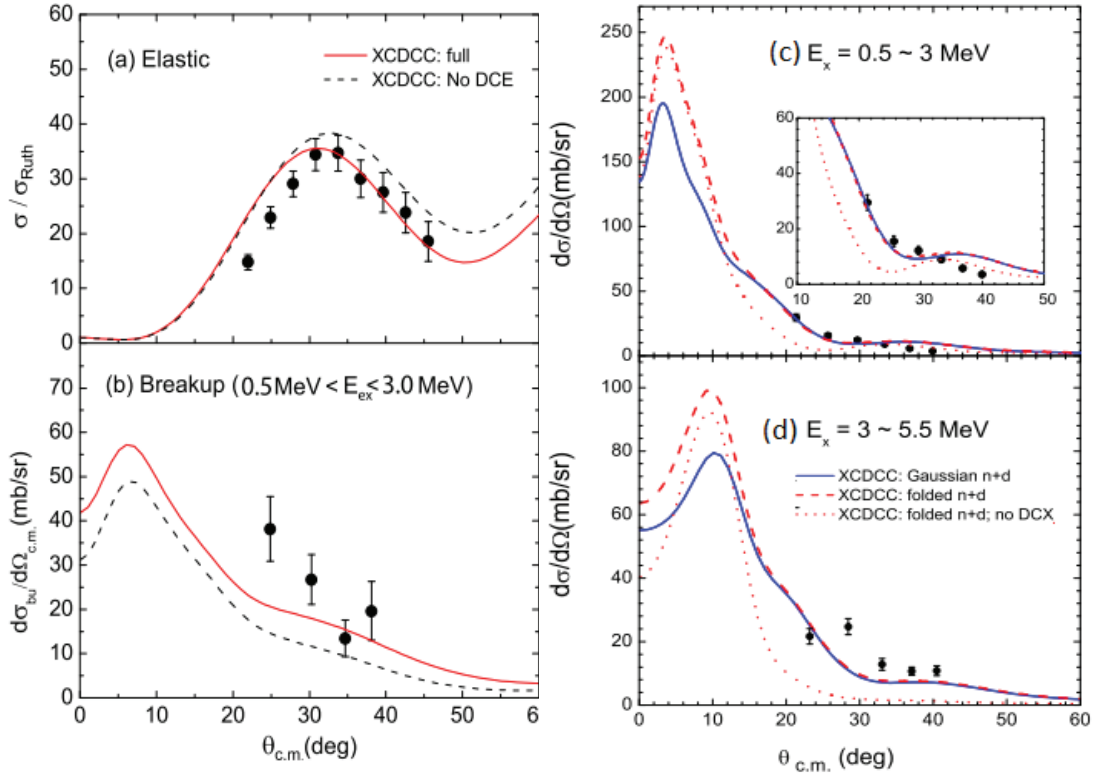

Figure 1: Experimental and calculated elastic (a) and breakup (b) cross sections as a function of the c.m. scattering angles, for the reaction ^{11}Be+p at 26.9A MeV. Experimental and calculated breakup cross sections (c,d), as a function of the c.m. scattering angles, for the reaction ^{11}Be+d at 26.9A MeV. The meaning of the lines is shown in the figure. See details in Ref. [19, 20].

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