2 - 14 Measurement of $^{12}C+^{13}C$ Fusion Cross Section around Coulomb Barrier Energies and Estimation of the Systematic Error of the Statistical Model

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The $^{12}C+^{13}C$ system has been studied extensively, because of the similarity of the entrance channel to the astrophysically important $^{12}C+^{12}C$ reaction[1−3]. Until now, three different methods have been exploited to perform the fusion cross section measurements for $^{12}C+^{13}C$ under the Coulomb barrier: (1) measuring the yield of characteristic γ rays, (2) the total γ-ray yields using NaI summing detectors and (3) the activity of the reaction residue ^{24}Na ($T_{1/2}$=15.0 h). Recently, the fusion cross section of $^{12}C+^{13}C$ has been measured down to 0.9 nb through the activity measurement by our group[4]. Although the statistical model calculations in all these three methods have been routinely used to convert the observed partial cross sections into the total fusion cross sections[5], the systematic uncertainty induced by the statistical corrections has not been studied very well.

We have studied the fusion cross section of $^{12}C+^{13}C$ by measuring the $^{12}C(^{13}C, p)^{24}Na$ reaction cross section in the range of $E_{c.m.}$=4.4 to 5.7 MeV. The ^{13}C beam was delivered by the 6 MV Tandem of Peking University and impinged on a thin carbon target with a thickness of 20 μg/cm^2. The cross sections for the $^{12}C(^{13}C, p)^{24}Na$ reaction were determined through the measurement of the yield of ^{24}Na using the $\beta-\gamma$ coincidence method to suppress the ambient background γ rays emitted from natural radioactive isotopes. The total fusion cross section of $^{12}C+^{13}C$ was deduced from the sub-channel cross section of ^{24}Na, using the theoretical branching ratio given by Hauser-Feshbach model.

The total fusion cross sections of Dayras[6], Dasmahapatra[7] and our measurement are determined using method (1), (2) and (3), respectively. Comparing the ratios among the three sets of fusion cross sections offers the opportunity of estimating the systematic error of statistical model calculation. The preliminary results are shown in Fig. 1. The statistical distributions of the two ratios are fitted by Gaussian function. The results are 1.11(mean)±0.7(1σ) for the ratios of Dasmahapatra's data to Dayras's data and 1.06(mean)±0.08(1σ) for the ratios of our data to Dayras's data. Assuming no problem in the normalization of different experiments, the 0.11 or 0.06 deviation is considered to be the systematic differences among the statistical models being used in the correction. The σ reflects the effect of Ericson fluctuation in the total fusion cross sections. The systematic error of the statistical model is deduced to be $\sqrt{0.11^2+0.06^2}=0.13$.

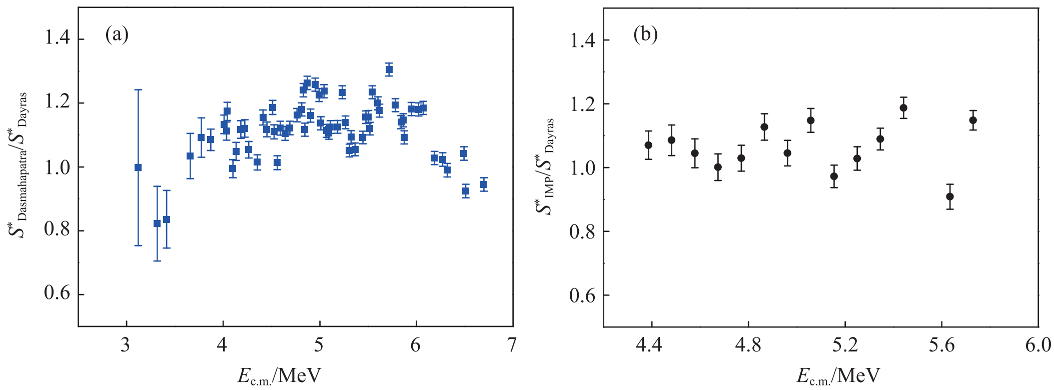

Fig. 1 (color online) (Left) Ratios of Dasmahapatra's data to Dayras's data and (Right) ratios of this work to Dayras's data.

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