s-wave scattering lengths for the ^{7}Be+p system from an R-matrix analysis

S. N. Paneru[1],* C. R. Brune[1], R. Giri[1], R. J. Livesay[2], U. Greife[2], J. C. Blackmon[3], D. W. Bardayan[4], K. A. Chipps[5], B. Davids[6,7], C. Ruiz[7], and D. S. Connolly[7]

[1] *Department of Physics & Astronomy, Ohio University, Athens, Ohio 45701, USA*
[2] *Colorado School of Mines, Golden, CO, USA*
[3] *Louisiana State University, LA, USA*
[4] *University of Notre Dame, IN, USA*
[5] *Oak Ridge National Laboratory, TN, USA*
[6] *Physics Department, Simon Fraser University, Burnaby, BC, Canada and*
[7] *TRIUMF, Vancouver, BC, Canada*

Introduction

The low-energy astrophysical S-factor for the ^{7}Be(p,γ)^{8}B radiative capture reaction, $S_{17}(E)$, is the most uncertain nuclear input needed to predict the ^{8}B solar neutrino flux [1, 2]. It must be known at or near the Gamow peak of $\sim$ 18 keV, which is experimentally inaccessible due to the Coulomb barrier. The cross sections are unmeasurably small at these energies, so available data starting around 100 keV above the Gamow peak must be extrapolated to solar energies with the aid of theoretical models.

The theoretical models [3, 4] found that the uncertainty in extrapolating S_{17} to zero energy is dominated by the uncertainty due to the s-wave scattering lengths for the ^{7}Be + p system. On account of the radioactivity of the ^{7}Be nuclei required for these measurements, the scattering lengths have only been measured once, by Angulo *et al.* [6], and they have large uncertainties. Better constraints on the scattering lengths may lead to a significant reduction in the uncertainty of $S_{17}(0)$, thereby reducing the overall uncertainty in the ^{8}B neutrino flux prediction. This talk will describe a new measurement of the elastic and inelastic scattering cross sections of ^{7}Be+p and a determination of the s-wave scattering lengths using R-matrix analysis. We used R-matrix code AZURE2 for our analysis [5]. The level structure of ^{8}B based on this analysis and the prospects for a new ^{7}Be+p elastic scattering measurement at DRAGON facility of TRIUMF using a gas target will be discussed.

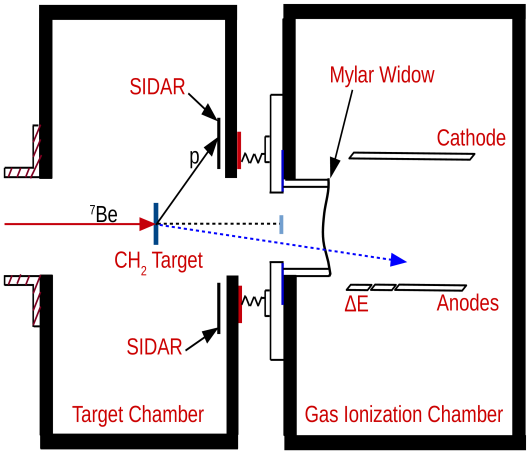

FIG. 1: The experimental setup.

Experiment

The elastic and inelastic ^{7}Be+p scattering cross sections were measured in inverse kinematics in the center-of-mass energy range of 0.474-2.740 MeV at Holifield Radioactive Ion Beam Facility (HRIBF) of ORNL. The ^{7}Be beam was accelerated and bombarded a CH2 target. The scattered charged particles were detected in a segmented Silicon Detector Ar-

*Electronic address: sp266413@ohio.edu

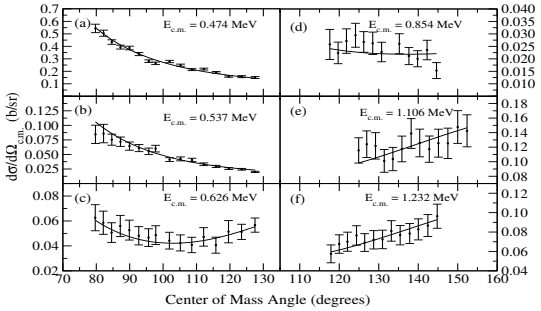

FIG. 2: Fits to the ^{7}Be(p,p)^{7}Be angular distribution data from this work.

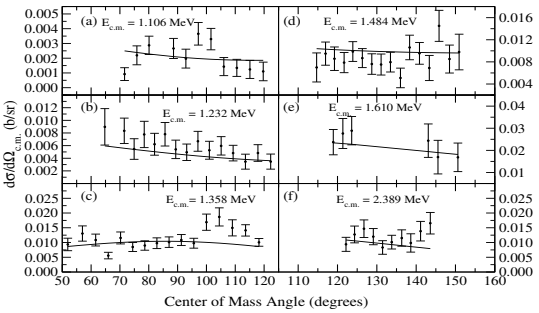

FIG. 3: Fits to the ^{7}Be(p,p')^{7}Be angular distribution data from this work.

ray (SIDAR). The schematic diagram of the target station in shown in Fig. 1.

Methodology and Results

The s-wave scattering length (a_0) can be related to R - matrix parameters using:

$$a_0 = -a\left[\frac{\tilde{\gamma}_c^T \tilde{\mathbf{A}} \tilde{\gamma}_c}{x^2 K_1^2(x)} - \frac{2I_1(x)}{x^2 K_1(x)}\right]. \quad (1)$$

where $I_1(x)$ and $K_1(x)$ are modified Bessel functions and x=$\sqrt{8\alpha a}$ with α= $Z_1 Z_2 e^2 \mu \hbar^{-2}$, $Z_1 e$ and $Z_2 e$ are charges of nuclei, $\hbar$ is Planck's constant, μ is reduced mass and a is the R-matrix channel radius. The quantities $\tilde{\gamma}$ and $\tilde{A}$ are defined in Ref. [7], which can be related to R-matrix parameters. The results of the simultaneous fits to elastic and inelastic scattering data from this work and elastic scattering data from [6] are presented in Fig. 2, and Fig. 3 respectively. The scattering lengths calculated using the best fit parameters from this analysis along with the values published in the literature is presented in the Table I. The analysis from this work provides the evidence for existence of additional 0^+, and 2^+ levels at 1.9 MeV, and 2.21 MeV respectively in ^{8}B. A new precise measurement, spanning a wide energy range seems mandatory to better constrain the s-wave scattering lengths and better understand the structure of ^{8}B.

TABLE I: s-wave scattering lengths for ^{7}Be+p system.

a_{01} (fm)	a_{02} (fm)	Ref.
$17.34^{+1.11}_{-1.33}$	$-3.18^{+0.55}_{-0.50}$	This Work
25±9	-7±3	[6]
-15.3	-5.2	[8]

Acknowledgments

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