^{7}Be(p,γ)^{8}B and the high-energy solar neutrino flux

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The flux of high-energy neutrinos generated in the solar core is directly proportional to the ^{7}Be$(p,\gamma)^8$B reaction rate. Many present (Homestake, Superkamiokande) and future (SNO) solar neutrino detectors are sensitive mainly or exclusively to the ^{8}B neutrinos. Thus, knowledge of S_{17}, the ^{7}Be$(p,\gamma)^8$B astrophysical S factor at solar energies, is crucial for the deciphering of the solar neutrino puzzle [1]. In order to set tighter theoretical limits on the value of S_{17}, the nonresonant part of the ^{7}Be$(p,\gamma)^8$B reaction has been studied in a microscopic eight-body model [2] and in a ^{7}Be+p potential model [3], respectively.

The eight-body three-cluster model [2] is variationally converged and virtually complete in the ^{4}He+^{3}He+p cluster model space. We find that the low-energy astrophysical S factor is linearly correlated with the quadrupole moment of ^{7}Be (Fig. 1). A range of parameters is found where the most important ^{8}B, ^{7}Be and ^{7}Li properties are reproduced simultaneously; the corresponding S factor at zero energy is $25-26.5$ eVb.

In the potential model [3] the relationship between the Coulomb displacement energy for the A=8, J=2^+, T=1 state and the low-energy astrophysical S factor for the ^{7}Be$(p,\gamma)^8$B reaction is discussed. The displacement energy is interpreted in a particle-hole model. The dependence of the particle displacement energy on the potential well geometry is investigated and is used to relate the particle displacement energy to the rms radius and the asymptotic normalization of the valence proton wave function in ^{8}B. The asymptotic normalization is used to calculate S_{17}. The model predicts S_{17} to be 24.5 ± 2.9 eVb at zero energy.

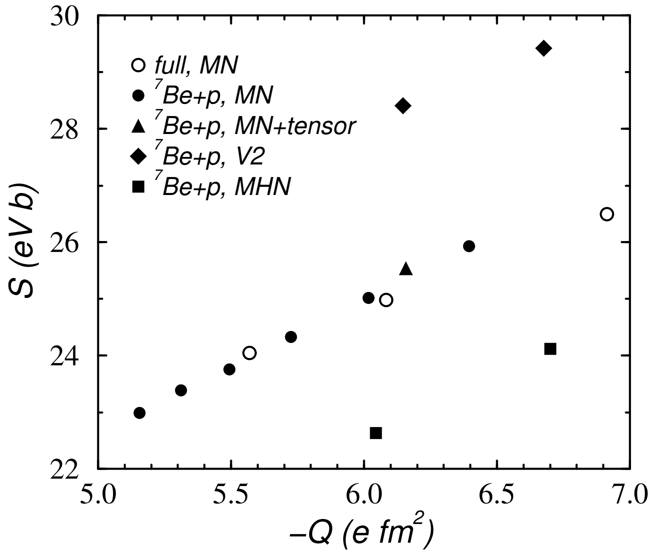

Figure 1: *Zero-energy astrophysical S factor of the $^7Be(p,\gamma)^8B$ reaction as a function of the negative of the ^7Be quadrupole moment, using various $N-N$ interactions and model spaces. (From Ref. [2].)*

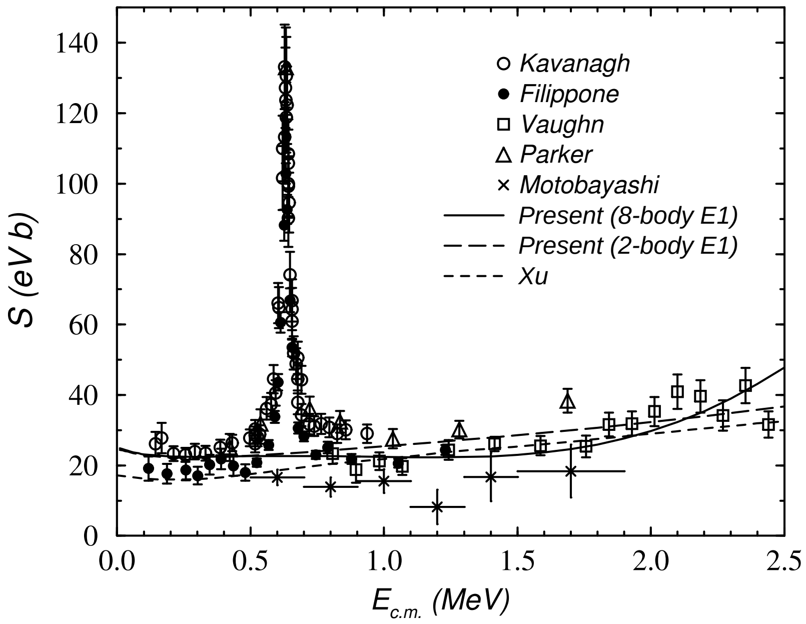

Figure 2: *Astrophysical S factor for the $^7Be(p,\gamma)^8B$ reaction. The symbols show the various experimental data. The solid and long-dashed lines are the $E1$ components of the S factors in the eight-body model of Ref. [4] with and without antisymmetrization in the electromagnetic transition matrix, respectively. The short-dashed line is the result of the potential model [5]. (From Ref. [4].)*

The energy dependence of the S factor is also studied [4] with the aim to understand the apparent disagreement between the predictions of the microscopic eight-body model [2] and potential models, e.g. [5]. It is found that off-shell effects, like antisymmetrization and core-excitation and deformation, significantly influence the energy dependence of the S factor. The proper treatment of these effects results in a virtually flat E1 component of the S factor at $E_{cm} = 0.3 - 1.5$ MeV (Fig. 2). Off-shell effects can cause 15–20% changes in the value of $S_{17}(0)$ extrapolated from high-energy ($E_{cm} > 0.7$ MeV) data.

The zero-energy S factors, predicted by our models, are slightly higher than but compatible with $S_{17}(0) = 22.4 \pm 2.1$ eVb, the value used in standard solar models [6].

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