Mughabghab Responds: In the previous Comment, Raman and Lynn[1] question the applicability of the channel-capture formula[2] and hence the resulting conclusion of a spin-spin interaction term in the $^{9}Be(n,\gamma)^{10}Be$ study.[3] Instead, they advocate another approach[4] in which the Lane and Lynn (LL) formula was retained but was normalized by a factor C_{opt}. This factor is estimated from the ratio of the potential-capture cross section as predicted by the optical model (OM) (with its many parameters) to the corresponding value computed from the channel-capture (LL) formula. It is crucially important to note here that (1) the contribution of the internal region was included in Ref. 4 and (2) C_{opt} is extremely sensitive to the diffuseness parameter d as well as the imaginary part of the OM potential and its form factors. By contrast, in the R-matrix approach[2] (square-well potential) only a single adjustable parameter R, which gives a measure of the range of the nuclear force and simultaneously represents a lower limit of the dipole integral I_{if}, is introduced, i.e., direct radiative capture is confined to the exterior region. The basic overriding question is which approach gives better description of the experimental data. On phenomenological grounds and with support from recent calculations,[5,6] I maintain that (1) the channel-capture formula accounts[7] remarkably well for the direct-capture component of a large body of data and (2) the two approaches would converge if the internal contribution of the nucleus is ignored, i.e., $C_{opt} \simeq 1$ for reasonable values of d. The fundamental reasons for the validity of the LL approach rests on two physical conditions: (1) the low energy of the incident neutron and (2) the neglect of the internal nuclear contribution (which is associated with statistical processes) to the matrix element, I_{if}. The details of the nuclear surface, such as its diffuseness, cannot be discerned by a slow neutron whose associated wavelength is considerably larger than the nuclear size. Therefore, a square-well description of the potential is quite sufficient for modeling of the physical process. Because of the neglect of the internal region, the behavior of the wave functions and the possible presence of oscillations in the interior region become immaterial. Such a phenomenon is supported by experimental evidence derived from (d,p), (p,γ), and (n,γ) measurements.[5] Its theoretical justification can be made on the grounds of the finite range and nonlocal effects of the nuclear force[8] as well as the exclusion principle.

It is asserted that the LL expression gives at best accuracies to within 40%. Such an estimate is based not on a comparison between the LL predictions and measurements but on an assessment of two theoretical approaches which can be rendered similar if the internal nuclear contribution is excluded as was done in the $^{12}C(n,\gamma)^{13}C$ study.[6] When the single-particle initial s state is located close to the neutron threshold as in ^{9}Be, 99% of the contribution to I_{if} arises from the external region.[9] By contrast, the internal contribution[10] can amount to as much as $\pm 50\%$ of the total for nuclei located away from the single-particle giant resonance as in the S isotopes.

The $^{12}C(n,\gamma)^{13}C$ and $^{58}Ni(n,\gamma)^{59}Ni$ investigations[5,6] provided further tests of the validity of the LL formula for cases of destructive interference. In Ref. 6, it is reported that $\sigma_\gamma = 2.1$ mb for $R = 2.86$ fm and $d = 0.72$ fm. The equivalent radius for a standard value of the diffuseness (0.69 fm) predicts[11] a channel capture cross section of 1.94 mb. In $^{58}Ni(n,\gamma)^{59}Ni$, the channel-capture cross sections feeding the ground and excited states at 466.5, 877.9, and 1303 keV are 2.88, 1.18, 0.27, and 0.39 b, to be compared with measured values of 2.42 ± 0.42, 1.18 ± 0.10, 0.21 ± 0.02, and 0.060 ± 0.08 b.

It is not surprising that the OM channel-capture cross section in Ref. 6 is insensitive to the radius parameter since simultaneous changes in V_0 for a constant d value have been effected in order to retain the position of the single-particle final state, E_f, unaltered. This procedure results in nearly constant capture cross section as a function of (V_0, r_0), a situation well known in other neutron cross-section calculations. However, it is important to point out here that variations in r_0 and d are not independent.[12]

The previous comparisons provide further demonstrations of the validity of the LL formula and hence justification for the procedure[3] of extracting physically meaningful spin-dependent radii and hence spin-spin potential for $^{9}Be(n,\gamma)^{10}Be$, which is in excellent agreement with other measurements.[13]

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