Reply to "Comment on 'Triton model calculation test of the Bonn W-matrix rank-one approximation'"

B. F. Gibson and B. C. Pearce*
Theoretical Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545

G. L. Payne
Department of Physics and Astronomy, University of Iowa, Iowa City, Iowa 52242
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We reply to the preceding comment.

We thank H. Haberzettl for pointing out that the conclusion drawn from the calculations reported in Ref. 1 was incorrect. Although the potentials and calculations were properly reported, the potential modifications used in the local potential calculation and in the W-matrix calculation were not identical. The rank-one W-matrix approximation does, in fact, provide a bound (as was the conjecture made in Ref. 2) for the modified Reid-soft-core (RSC)[3] singlet-potential three-boson problem which we used to test the W-matrix prescription in the case of strong short-range repulsion.

Our initial purpose in the Ref. 1 study was to test the rank-one W-matrix approximation for a model with stronger short-range repulsion than is exhibited by the Malfliet-Tjon (MT)[4] I-III and V models. If quantitatively successful, we planned to utilize the rank-one W-matrix approximation in calculations for the $A=4$ system. We chose a simple three-boson model (exactly equivalent to the three-fermion problem when $V_{\text{singlet}}=V_{\text{triplet}}$ so that the S' state vanishes identically) deliberately to avoid the complexities of a tensor force. Furthermore, the W-matrix approximation for the MT V model—again a three-boson case—appeared to do as well quantitatively as that for the MT I-III model.[1]

We list results in Table I for the three-body binding energy utilizing the RSC singlet model

$$V(r)=(-10.463e^{-0.7r}-X\times 1650.5e^{-2.8r}+6484.2e^{-4.9r})/(0.7r)$$

as a function of the factor X multiplying the midrange attractive term. The difference between the local potential binding energy results and the rank-one W-matrix approximation is only some 3% for a model binding energy approximating that of the triton. This increases to about 3.5% for a binding energy similar to that of the alpha particle. (We note that the local potential result of 7.1 quoted in Ref. 1 was rounded from the 7.05 results obtained by a calculation in which higher precision was not required.) One would have preferred to see the same quantitative agreement for such a model with strong short-range repulsion as was found for the less repulsive MT I-III and MT V models, or for the momentum-dependent one-boson-exchange-type models.[5] However, for scattering calculations, where experimental uncertainties are often 5%, the rank-one W-matrix approximation may be well suited.

TABLE I. Comparison of three-body binding energies for the RSC $^1S_0$ potential as a function of the midrange strength parameter X for the optimum W-matrix parameter k.

X	$-V_2$ (MeV)	$-E_{\text{local}}$ (MeV)	$-E_3(W$ matrix) (MeV)	$k_{\min}$ (fm^{-1})
1.08	1782.65	7.04	6.83	0.80
1.10	1815.66	9.40	9.12	0.85
1.12	1848.67	12.13	11.76	0.91
1.14	1881.68	15.25	14.77	0.96
1.16	1914.70	18.77	18.15	1.02
1.18	1947.71	22.71	21.93	1.06
1.19	1964.22	24.84	23.98	1.09
1.20	1980.72	27.08	26.12	1.12

*Present address: TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., Canada V6T 2A3.

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