Binding Energy and Scattering Observables in the ^{3}He^{4}He$_2$ Atomic System

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There is a great number of experimental and theoretical studies of the ^{4}He three-atomic system. The non-symmetric ^{3}He^{4}He$_2$ system found comparatively little attention. To the best of our knowledge the ^{3}He^{4}He$_2$ trimers were studied numerically only in Refs. [1]–[4]. Except Ref. [4], no scattering calculations were reported for this system. In the present research we employed the approach of Refs. [5] and [6] to investigate the ^{3}He^{4}He$_2$ bound state and the scattering of a ^{3}He atom off a ^{4}He dimer at ultra-low energies on the basis a hard-core version of the Faddeev differential equations.

Table 1: Absolute value of the ^{3}He ^{4}He$_2$ trimer binding energy (in mK).

Potential	$l_{\max}$	This work	[1]	[2]	[3]	[4]
LM2M2	0	7.30	10.22			
	2	13.15				
	4	13.84		13.66		14.4
TTY	0	7.25				
	2	13.09				
	4	13.78			14.165	14.1

Table 2: Estimations for the ^{3}He atom$-^4$He dimer scattering length (in Å).

	TTY		LM2M2	
$l_{\max}$	This work	[4]	This work	[4]
0	38.8		38.5	
2	22.4		22.2	
4	21.2	19.6	21.0	19.3

Several realistic He–He interactions have been used, among them the LM2M2 potential by Aziz and Slaman and the TTY potential by Tang, Toennies and Yiu. Our results for the binding energy of the ^{3}He^{4}He$_2$ trimer compare favorably with alternative results in the literature. Is is found that most of the contribution to the binding energy stems from the $l = 0$ and $1 \leq l \leq 2$ partial components, about 53% and 42%, respectively. The overall contribution from the $l = 3$ and $l = 4$ partial wave components is of the order of 5 %, that is, it is approximately the same as in the case of the symmetric ^{4}He trimer [6]. The binding energy results obtained for a grid with $N_\rho = 600$, $N_\theta = 605$, and $\rho_{\max} = 200$ Å (see Ref. [5] or [6] for explanation of the notation), and the core radius of 1 Å are shown in Table 1.

Our results for the ^{3}He–^{4}He$_2$ scattering length calculated also for a grid with $N_\rho = 600$, $N_\theta = 605$, and $\rho_{\max} = 200$ Å are shown in Table 2. Our phase shift results obtained with the TTY interatomic

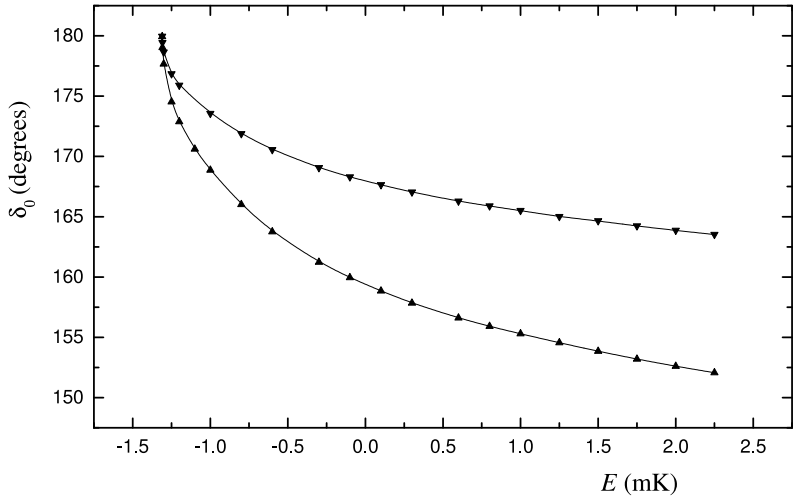

Figure 1: S-wave ^{3}He atom – ^{4}He dimer scattering phase shifts $\delta_0(E)$ in case of the TTY He–He interatomic potential as a function of the c.m. energy. The lower curve corresponds to the case where $l_{\max} = 0$ while for the upper curve $l_{\max} = 2$.

potential for a grid with $N_\rho = 502$, $N_\theta = 500$, and $\rho_{\max} = 460$ Å are plotted in Fig. 1. The ^{3}He–^{4}He$_2$ phase shift results for the LM2M2 potential differ from those for TTY only in about 0.5% and this is a reason why we do not depict them in Fig. 1.

The results presented in this report have been published in Refs. [7]–[9].

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