

# Asymmetric stationary points, frequencies, and transformation to normal modes for helium potentials

$\lambda$	$\begin{pmatrix} r_1 \\ r_2 \\ r_3 \end{pmatrix}$	$\begin{pmatrix} \omega_1^2 \\ \omega_2^2 \\ \omega_3^2 \end{pmatrix}$	$\begin{pmatrix}  T_{11}  &  T_{12}  &  T_{13}  \\  T_{21}  &  T_{22}  &  T_{23}  \\  T_{31}  &  T_{32}  &  T_{33}  \end{pmatrix}$ and $V_0$		
0.05	-0.04670-0.22421*I 0.11101-0.04909*I 0.00001-0.06754*I	1939.1+1223.2*I -1351.8+106.4*I -374.23-177.62*I	0.465 0.681 1.168	0.395 0.637 0.588	0.365 0.472 0.2531
			V=-3.32214-3.43299*I		
0.10	-0.03348-0.24337*I 0.12182-0.04474*I 0.00689-0.09313*I	1366.8+576.3*I -741.6+395.4*I -271.28-99.05*I	0.531 0.755 1.061	0.425 0.700 0.497	0.417 0.539 0.2893
			V=-3.299714-2.810513*I		
0.15	-0.01964-0.26021*I 0.13128-0.04012*I 0.01608-0.11474*I	1044.9+268.3*I -428.3+442.1*I -200.68-45.96*I	0.577 0.776 0.980	0.440 0.714 0.429	0.453 0.579 0.2982
			V=-3.249128-2.334184*I		
0.20	-0.00477-0.27577*I 0.14000-0.03522*I 0.02740-0.13461*I	820.6+94.2*I -234.1+419.8*I -149.49-12.48*I	0.612 0.790 0.928	0.448 0.721 0.379	0.481 0.615 0.3012
			V=-3.182428-1.944173*I		
0.25	0.01139-0.29047*I 0.14822-0.03003*I 0.04088-0.15351*I	651.1-9.5*I -106.30+373.72*I -110.52+7.56*I	0.642 0.805 0.893	0.454 0.726 0.342	0.504 0.649 0.3016
			V=-3.105358-1.614906*I		
0.30	0.02911-0.30448*I 0.15609-0.02459*I 0.05671-0.17179*I	517.8-71.0*I -20.90+320.60*I -80.17+18.57*I	0.667 0.819 0.870	0.457 0.731 0.3104	0.523 0.683 0.2998
			V=-3.021355-1.332326*I		
0.35	0.04868-0.31788*I 0.16373-0.01893*I 0.07515-0.18960*I	410.99-105.51*I 35.73+267.72*I -56.41+23.51*I	0.688 0.834 0.857	0.461 0.736 0.2835	0.540 0.717 0.2957
			V=-2.932731-1.087632*I		
0.40	0.07048-0.33065*I 0.17123-0.01308*I 0.09662-0.20699*I	324.58-122.14*I 72.17+218.41*I -37.91+24.42*I	0.705 0.848 0.851	0.465 0.742 0.2593	0.553 0.751 0.2890
			V=-2.841166-0.874860*I		
0.45	0.09505-0.34268*I 0.17869-0.00707*I 0.12171-0.22391*I	254.45-126.63*I 94.22+174.18*I -23.757+22.704*I	0.718 0.862 0.854	0.471 0.748 0.2369	0.563 0.785 0.2794
			V=-2.747943-0.689762*I		
<b>0.50</b>	<b>0.12315-0.35368*I</b>	<b>197.59-122.86*I</b>	<b>0.727</b>	<b>0.480</b>	<b>0.569</b>

	<b>0.18625-0.00096*I</b>	<b>106.01+135.56*I</b>	<b>0.875</b>	<b>0.755</b>	<b>0.820</b>
	<b>0.15123-0.24014*I</b>	<b>-13.233+19.392*I</b>	<b>0.864</b>	<b>0.2156</b>	<b>0.2665</b>
			<b>V=-2.654084-0.529224*I</b>		
0.55	0.15587-0.36306*I	151.71-113.45*I	0.731	0.495	0.572
	0.19408+0.00522*I	110.56+102.58*I	0.886	0.762	0.856
	0.18644-0.25522*I	-5.782+15.231*I	0.883	0.1949	0.2497
			<b>V=-2.560424-0.390949*I</b>		
0.60	0.19486-0.36964*I	114.99-100.24*I	0.728	0.518	0.568
	0.20242+0.01140*I	110.16+74.97*I	0.895	0.769	0.891
	0.22918-0.26814*I	-0.942+10.797*I	0.912	0.1745	0.2287
			<b>V=-2.467667-0.273287*I</b>		
0.65	0.24269-0.37089*I	85.93-84.40*I	0.714	0.554	0.556
	0.21170+0.01746*I	106.51+52.27*I	0.902	0.777	0.926
	0.28241-0.27673*I	1.680+6.557*I	0.950	0.1544	0.2032
			<b>V=-2.376414-0.175190*I</b>		
0.70	0.3036-0.3609*I	100.92+33.89*I	0.905	0.783	0.960
	0.22271+0.02314*I	63.30-66.52*I	0.683	0.607	0.530
	0.35107-0.27588*I	2.4386+2.9332*I	0.999	0.1351	0.1728
			<b>V=-2.287190-0.096291*I</b>		
0.75	0.3844-0.3229*I	94.36+19.04*I	0.905	0.790	0.992
	0.23741+0.02760*I	45.98-46.19*I	0.609	0.689	0.474
	0.4441-0.2509*I	1.7037+0.3928*I	1.054	0.1187	0.1368
			<b>V=-2.200460-0.037328*I</b>		
0.80	0.4934-0.1694*I	87.54+5.61*I	0.898	0.799	1.021
	0.26567+0.02310*I	32.738-17.529*I	0.351	0.812	0.318
	0.5793-0.1290*I	0.15402-0.27477*I	1.083	0.1189	0.0872
			<b>V=-2.116640-0.002331*I</b>		
0.85	1.1223	72.92	0.870	0.678	0.901
	0.25296	56.04	0.428	0.778	0.453
	1.1597	0.05342	1.014	0.0043	0.01488
			<b>V=-2.055656</b>		
0.90	2.0359	67.30	0.849	0.632	0.858
	0.25049	61.68	0.511	0.787	0.517
	2.0545	0.008943	1.003	0.0003	0.00308
			<b>V=-2.022609</b>		
0.95	4.587	64.73	0.830	0.604	0.831
	0.25004	63.57	0.556	0.799	0.557
	4.594	0.0004689	1.000	0.00001	0.00030
			<b>V=-2.005282</b>		

Footnote. Transformation matrix is defined so that normal coordinates are:  
 $q_i = \sum_j T_{ij} \Delta r_j$ , where  $\Delta r_j$  are displacements of interparticle distances.