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Theoretical Thermodynamic Properties of Low Temperature Fluids

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THEORETICAL THERMODYNAMIC PROPERTIES OF LOW TEMPERATURE FLUIDS

by

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The thermodynamic functions for low temperature fluids are computed using parametric integral equations and perturbation theory. Parametric integral equation N is applied to a low temperature Lennard-Jones gas. It is found that there is no significant improvement over the better known parametric integral equation C. The two parameter integral equation T is applied to a low temperature square-well potential and is found to be unsatisfactory at reduced temperatures of $T^* = 1.4$ and 1.6, but quite accurate at $T^* = 2.2$. The equation T results for $T^* = 2.2$ are used as the reference system in perturbation theory computations. Tables of (reduced) pressure, internal energy, entropy, enthalpy, Helmholtz energy, and Gibbs energy are constructed for reduced density $n^* \leq 0.85$, and reduced temperature $0.7 \leq T^* \leq 2.15$. The results of reduced pressure agree very well with the molecular dynamic results but results of reduced internal energy deviate from the accepted values for large perturbations.

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CHAPTER I

INTRODUCTION

A fundamental problem in statistical mechanics is to compute the thermodynamic properties of a material. In this research integral equation methods and perturbation theory are used to compute the thermodynamic functions of simple classical fluids at low temperatures. Results which are presented include the values of pressure, internal energy, entropy, enthalpy, Helmholtz energy, and Gibbs energy.

The System

In a simple classical fluid, it is assumed that the system consists of particles which interact with pairwise radial forces. These forces depend only on the separation distance of the pair of particles for which classical mechanics is good enough to describe the system. The Hamiltonian of a simple classical fluid is given by

$$H = K + \Phi = K + 1/2 \sum_{i} \sum_{j} \phi(r_{ij}), \qquad (1)$$

where K is the kinetic energy of the particles and Φ is the potential energy of the particles which includes the sum of the pair energy of particles $\emptyset(r_{ij})$ where r_{ij} is the distance between particles i and j.

The Lennard-Jones pair potential studied here is of the form[1]

$$\emptyset(r) = 4\epsilon\,[(\sigma/r)^{12} - (\sigma/r)^{6}], \tag{2}$$

where ϵ and σ are parameters characteristic of the molecules which make up the system.

The square-well potential studied here is of the form[2]

$$\begin{aligned} \emptyset(r) &= \infty \quad , r < d, \\ \emptyset(r) &= -\epsilon \quad , d \le r \le 1.5\,d, \\ \emptyset(r) &= 0 \quad , r > 1.5\,d, \end{aligned} \tag{3}$$

where ϵ is the well depth and d is the diameter of the hard-sphere core.

Radial Distribution Function

The radial distribution function is defined by

$$g(r) = \frac{n(r)}{\bar{n}}, \tag{4}$$

where n(r) is the average number of particles per unit volume at a distance r from a central particle and $\bar{n}$ is the average number density which is the total number of particles divided by the volume of the system ($\bar{n} = N/V$). In terms of potential energy, g(r) can be written as[3]

$$g(r) = V^2 Z^{-1} \int \ldots \int \exp\,(-\Phi/kT)\; dr_3 \ldots dr_N\,, \qquad (5)$$
$$Z = \int \ldots \int \exp\,(-\Phi/kT)\; dr_1 \ldots dr_N\,,$$

where k is the Boltzmann's constant and T is the absolute temperature. The integration is over the position coordinates of the particles. Figure 1 shows a typical shape of a radial distribution function.

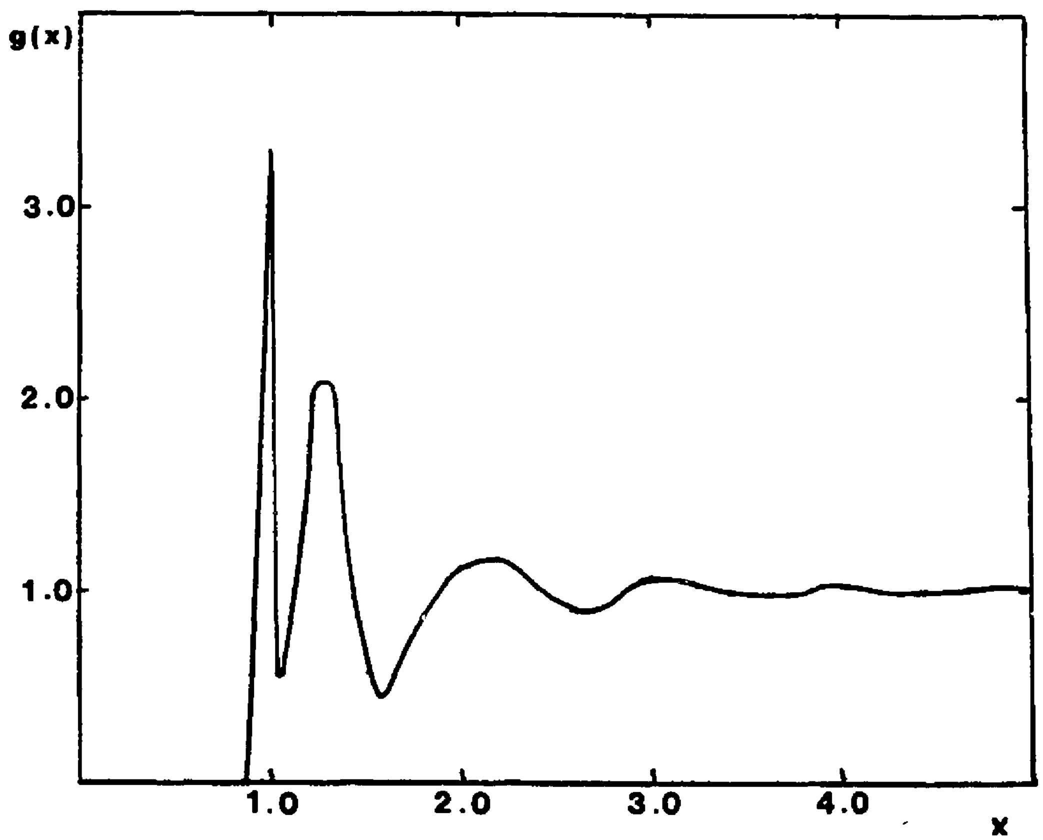

Figure 1. Graph of Radial Distribution Function as a Function of Particle Separation x for n* = 0.80 at T* = 1.6 (For Parametric Integral Equation T with Parameters $b_2 = -1.80$ and $b_3 = 0.55$)

Once g(r) is known, the pressure (P) and internal energy (U) can be computed by the following relationships[4]

$$P^* = \frac{PV}{NkT} = 1 - \frac{2\pi N}{3VkT}\int_0^\infty \frac{d\emptyset}{dr}\, gr^3\, dr \,, \qquad (6)$$

and

$$U^* = \frac{2U}{3NkT} = 1 + \frac{4\pi N}{3VkT}\int_0^\infty \emptyset\, gr^2\, dr \,. \qquad (7)$$

When the pressure and internal energy are computed over a range of temperatures and densities, it is possible to compute other thermodynamic functions. Therefore, g(r) contains a complete thermodynamic description of the system.

CHAPTER II

METHODS FOR COMPUTING THERMODYNAMIC FUNCTIONS

Exact Methods

The most direct way of computing g(r) (thus getting the thermodynamic functions) is by a method called molecular dynamics[5] (MD). Here Newton's equations of motion are solved on a computer to obtain the motions of the particles. Then relevant averages that are related to the thermodynamic properties are computed. Another method is called Monte Carlo[6] (MC). In this method the motions of the particles are governed by probability rules and averages related to the thermodynamic properties can be computed. Both methods are very direct, therefore these results are often called "exact" (however there are approximations involved) and are used as the accepted values. The main disadvantage of these methods are large computer and long computer time requirements. In this research, the molecular dynamics results of Alder, Young, and Mark[7] are used for comparison for the square-well system.

Integral Equations

Integral equations are approximate equations for computing radial distribution function. Most give good results at low densities and high temperatures but produce large errors at high densities and low temperatures. The advantage of integral equations is the shorter computer time requirements compared to the "exact" methods.

Integral equations of interest here are the hypernetted chain[8] (HNC), Percus-Yevick[9] (PY), and parametric integral equations. Three parametric integral equations that have been studied are equation C,[10] equation N,[11] and equation T.[12] These integral equations are given by the Ornstein-Zernike equation,[13]

$$h(12) = c(12) + \bar{n} \int c(13)h(23)d3 \ , \tag{8}$$

where

$$h = g - 1. \tag{9}$$

The function h is the total correlation function and the function c is the direct correlation function. (12) indicates the correlation of particle 1 on particle 2 and the same apply to (13) and (23). In terms of the direct correlation function, the integral equations are given by

(HNC) $$c = g - 1 - \ln (ge^{\beta\phi}) \ , \tag{10}$$

(PY) $$c = g\,(1 - e^{\beta\phi}) \ , \tag{11}$$

(Equation C) $$c = g - 1 - \frac{1}{a} \ln (age^{\beta\phi} - a + 1), \tag{12}$$

$$\text{(Equation N)} \quad c = g - 1 - \frac{1 - ge^{\beta\phi}}{ge^{\beta\phi}(a-1)-a}, \qquad (13)$$

where $\beta = (kT)^{-1}$ and a is an adjustable parameter. There is no simple relationship between c and g for equation T.

A function S is introduced,

$$S = h - c. \qquad (14)$$

Using this and equation (8), the integral equations can be written as

$$\text{(PY)} \quad g = e^{-\beta\phi}(1 + S), \qquad (15)$$

$$\text{(HNC)} \quad g = e^{-\beta\phi} e^{S}$$

$$= e^{-\beta\phi}[1 + S + (1/2)S^2 + (1/6)S^3 + \ldots], \qquad (16)$$

$$\text{(Equation C)} \quad g = e^{-\beta\phi}[1 + 1/a\,(e^{aS} - 1)]$$

$$= e^{-\beta\phi}[1 + S + (1/2)aS^2 + (1/6)a^2S^3 + \ldots), \qquad (17)$$

$$\text{(Equation N)} \quad g = \frac{e^{-\beta\phi}(1 + aS)}{1 + aS - S}$$

$$= e^{-\beta\phi}[1 + S + (1 - a)S^2 + (1 - a)^2S^3 + \ldots], \qquad (18)$$

$$\text{(Equation T)} \quad g = e^{-\beta\phi}(1 + S + b_2S^2 + b_3S^3). \qquad (19)$$

where a, b_2, and b_3 are adjustable parameters.

In this research parametric equation N is studied for a low temperature Lennard-Jones gas and equation T is solved for g for three temperatures and for several densities and sets of parameters.

Perturbation Method

The first order perturbation theory of Zwanzig[14] will be considered. Here the pair potential energy is separated into sum of a reference potential $\emptyset_r$ and perturbing potential $\emptyset_p$,

$$\emptyset = \emptyset_r + \emptyset_p. \tag{20}$$

The system Helmholtz free energy (F) and the reference Helmholtz free energy (F_r) are related by[15]

$$F = F_r + F_p = F_r + \frac{N^2}{2V}\int_0^\infty \emptyset_p \quad g_r \, 4\pi r^2 dr. \tag{21}$$

The thermodynamic functions can then be calculated from the g_r and the correction terms involving the perturbation potential. Results of equation T are used in this research to calculate the thermodynamic functions of the reference system.

CHAPTER III

COMPUTATIONAL METHOD

Solutions of Equation N

The method of solution of equation N is essentially that of Broyles.[16] This involves an iterative procedure where equation N is solved numerically on a computer to obtain the radial distribution function.

The following dimensionless quantities are introduced for the Lennard-Jones pair potential,

$$x = r/\sigma \; , \tag{22}$$

$$T^* = kT/\epsilon = 1/\beta\epsilon \; , \tag{23}$$

$$n^* = \bar{n}\sigma^3 \; . \tag{24}$$

Equations (6) and (7) can then be written as[17]

$$P^* = 1 - \frac{16\pi n^*}{T^*}\int_0^\infty (x^{-10} - 2\,x^{-10})\, g(x)\, dx \; , \tag{25}$$

and

$$U^* = 1 + \frac{16\pi n^*}{3T^*}\int_0^\infty (x^{-10} - x^{-4})\, g(x)\, dx \; . \tag{26}$$

The computer gives solutions for 75 points with an x interval of 0.075 and for 297 points with an x interval of 0.01875. Solutions of 297 points will only be considered. The truncation point is at x = 5.55.

The computational steps are as follows,

1) Equation N is solved for the isotherm $T^* = 1.6$ at reduced densities of $n^* = 0.70$ and $n^* = 0.90$. Several different values of the parameter a are used.

2) Graphs of P^* versus a for both the reduced densities are then drawn. Here, results by D. D. Carley[18] using integral equations combined with perturbation theory are used for comparison.

Solutions of Equation T

The method of solution here is the same as the method of solving equation N. The same dimensionless quantities are introduced except for the square-well,

$$x = r/d \ , \tag{27}$$

$$n^* = Nd^3/V \ . \tag{28}$$

P^* and U^* can then be written as[19]

$$P^* = 1 + (2/3)\pi n^*[g(1.0) - 3.375\ g(1.5)\ (1-e^{-\beta\epsilon})], \tag{29}$$

and

$$U^* = 1 - \frac{4\pi n^*}{3T^*}\int_{1.0}^{1.5} g(x)\ x^2\ dx \ , \tag{30}$$

where g(1.0) is the radial distribution function as x approaches 1.0 from above and g(1.5) is the radial distribution function as x approaches 1.5 from below.

The computer gives solutions for 75 points with an x interval of 0.07142857 and for 297 points with an x interval of 0.01785714. As before, solutions of 297 points will only be considered. The truncation point is at $x = 5.2857$.

The computational steps of equation T are as follows:

1) Equation T is solved for the isotherms $T^* = 1.4$, 1.6, and 2.2 at a high and an intermediate density. Different sets of parameters are used so that a grid can be set up for the parameters (b_2 and b_3).

2) With the above results, a least square-fit computer program is used to determine the c's that give the best least square fit according to the equation

$$P^* = P_o + c_1 b_2 + c_2 b_3 + c_3 b_2^2 + c_4 b_3^2 + c_5 b_2 b_3. \quad (31)$$

3) A computer program is then used to find values of b_2 and b_3 that give results equal to the accepted results. Molecular dynamics results of Alder are used for comparison. A graph of b_3 versus b_2 is then plotted, and the point of interception is taken to be the best choice of parameters for the isotherm. Since equation (31) is approximate, equation T is solved with these "best" values to see if indeed they give agreement with accepted values of P^*.

4) Equation T is solved again at other densities, using the best choice of parameters. With the results, another computer program is then used to obtain the

interpotation coefficients (Pade coefficients) which can then be used to find the values for other densities without going through the long iteration procedure again. The two interpolation formulas for P* and U* are

$$p^* = \frac{1 + a_1 n^* + a_2 n^{*2} + a_3 n^{*3}}{1 + a_4 n^* + a_5 n^{*2} + a_6 n^{*3}} , \qquad (32)$$

and

$$U^* = \frac{1 + a_1 n^* + a_2 n^{*2} + a_3 n^{*3}}{1 + a_4 n^* + a_5 n^{*2} + a_6 n^{*3}} . \qquad (33)$$

The results for pressure only are used in determining the best choice of parameters because results in the internal energy are not as sensitive to changes in the parameters.

Computation of Thermodynamic Functions (Perturbation Method)

The reference potential is taken to be

$$\begin{aligned} \phi_r(r) &= \infty , && r < d , \\ \phi_r(r) &= -\alpha\epsilon , && d \le r \le 1.5\, d , \\ \phi_r(r) &= 0 , && r > 1.5\, d , \end{aligned} \qquad (34)$$

where α is a constant.

The following dimensionless quantities are introduced,

$$T^+ = T^*/\alpha , \qquad (35)$$

$$F^* = 2F/3NkT. \qquad (36)$$

The system and the reference system are then both square-well where in the well

$$\phi/kT = -1/T^* \,, \tag{37}$$

$$\phi_r/kT = -1/T^+ \,. \tag{38}$$

P^* and U^* are related by the following equation[20]

$$dF^* = \left(\frac{2P^*}{3n^*}\right) dn^* - \left(\frac{U^*}{T^*}\right) dT^* \,. \tag{39}$$

Equation 21 can be written as

$$F^* = F_r^* + F_p^* = F_r^* + \frac{4\pi n^* (\alpha - 1)}{3T^*} \int_{1.0}^{1.5} g_r(x) x^2 dx. \tag{40}$$

Comparison of the above equation with equation 30 will show that

$$F_p^* = \left(1 - \frac{T^+}{T^*}\right)\left(1 - U_r^*\right) \,. \tag{41}$$

Equations 39, 40, and 41 are the basic equations that are used to compute the thermodynamic functions.

A computer program by D. D. Carley and modified by Z. Z. Jamal is used to do the computations. The program does computations at reference temperature $T^* = 2.2$ and the thermodynamic functions are constructed for $0.7 \leq T^* \leq 2.15$, and $0.05 \leq n^* \leq 0.85$ for an interval of 0.05. The computational steps in the program are as follows:

1) $T^* = 20.0$, $n^* = 0.001$ is taken to be the standard state and F^* in that state is denoted by F_o^*.

Equation 39 is then integrated at $n^* = 0.001$, using the approximation $g = e^{-\beta\phi}$ at this low density. The result will be [21]

$$F^* - F_0^* = -\int_{20.0}^{T^*} \left(1 - \frac{9.5 \times 10^{-3}\pi}{9T^*}\right) \frac{dT^*}{T^*} . \quad (42)$$

In the proceeding steps $F^* - F_0^*$ will be denoted as F^* $(n^* = 0.001,\ T^*)$.

2) F_r^* $(n^* = 0.001,\ T^*)$ can now be computed using equations 40 and 41, resulting in

$$F_r^*(n^*=0.001,T^*) = F^*(n^*=0.001,T^*) - \left(1-\frac{T^+}{T^*}\right)\left(1-U_r^*\right). \quad (43)$$

3) Equation 39 is integrated again at a constant T^*. F_r^* (n^*,T^*) can then be computed by the following equation,

$$F_r^*\ (n^*,T^*) = F_r^*(n^* = 0.001,T^*) + \int_{.001}^{n^*} \left(\frac{2P^*}{3n^*}\right) dn^* . \quad (44)$$

For low densities ($n^* \leq 0.10$), the values of P^* are interpolated values in the form

$$P^* = 1 + b_1 n^* + b_2 n^{*2} + b_3 n^{*3} . \quad (45)$$

The integral can then be done analytically. At higher densities, interpolated values of P^* are in the form of equation 32. Here numerical integration must be used.

4) F_p^* (n^*,T^*) can be computed directly from equation 41.

5) Finally, with F_r^* and F_p^* known, $F^*(n^*, T^*)$ is obtained from the relationship

$$F^* = F_r^* + F_p^* \ . \tag{46}$$

6) Numerical differentiation is then used to compute P^* and U^* as

$$P^* = \frac{3}{2} n^* \left(\frac{\partial F^*}{\partial n^*} \right) , \tag{47}$$

and

$$U = - T^* \left(\frac{\partial F^*}{\partial T^*} \right) \ . \tag{48}$$

7) Other thermodynamic functions can easily be obtained by the following thermodynamic relationships[22]

$$S^* = 2\ S/3Nk \ = \ U^* - F^* \ , \tag{49}$$

$$H^* = 2\ H/3NkT = \ U^* + (2/3)\ P^* \ , \tag{50}$$

and

$$G^* = 2\ G/3NkT = F^* + (2/3)\ P^* \ , \tag{51}$$

where S is the entropy, H is the enthalpy, and G is the Gibbs energy.

CHAPTER IV

RESULTS AND COMPARISONS

Parametric Integral Equation N and The Lennard-Jones Potential

For the Lennard-Jones potential, equation N was solved for the isotherm $T^* = 1.6$ at reduced densities of $n^* = 0.70$ and $n^* = 0.90$ for several different values of the parameter a. Results of P^* and U^* obtained can be found in the appendix. Graphs of P^* versus a were then drawn. The accepted values for the isotherm $T^* = 1.6$ are $P^* = 1.77$ at $n^* = 0.70$, and $P^* = 4.61$ at $n^* = 0.90$ (Results by Carley using integral equations combined with perturbation theory). The accepted values were also shown on the graphs (see figure 2).

It can be seen clearly that there is no single parameter a that give P^* values equal to the accepted P^* values at both the reduced densities. Thus equation N does not produce good results.

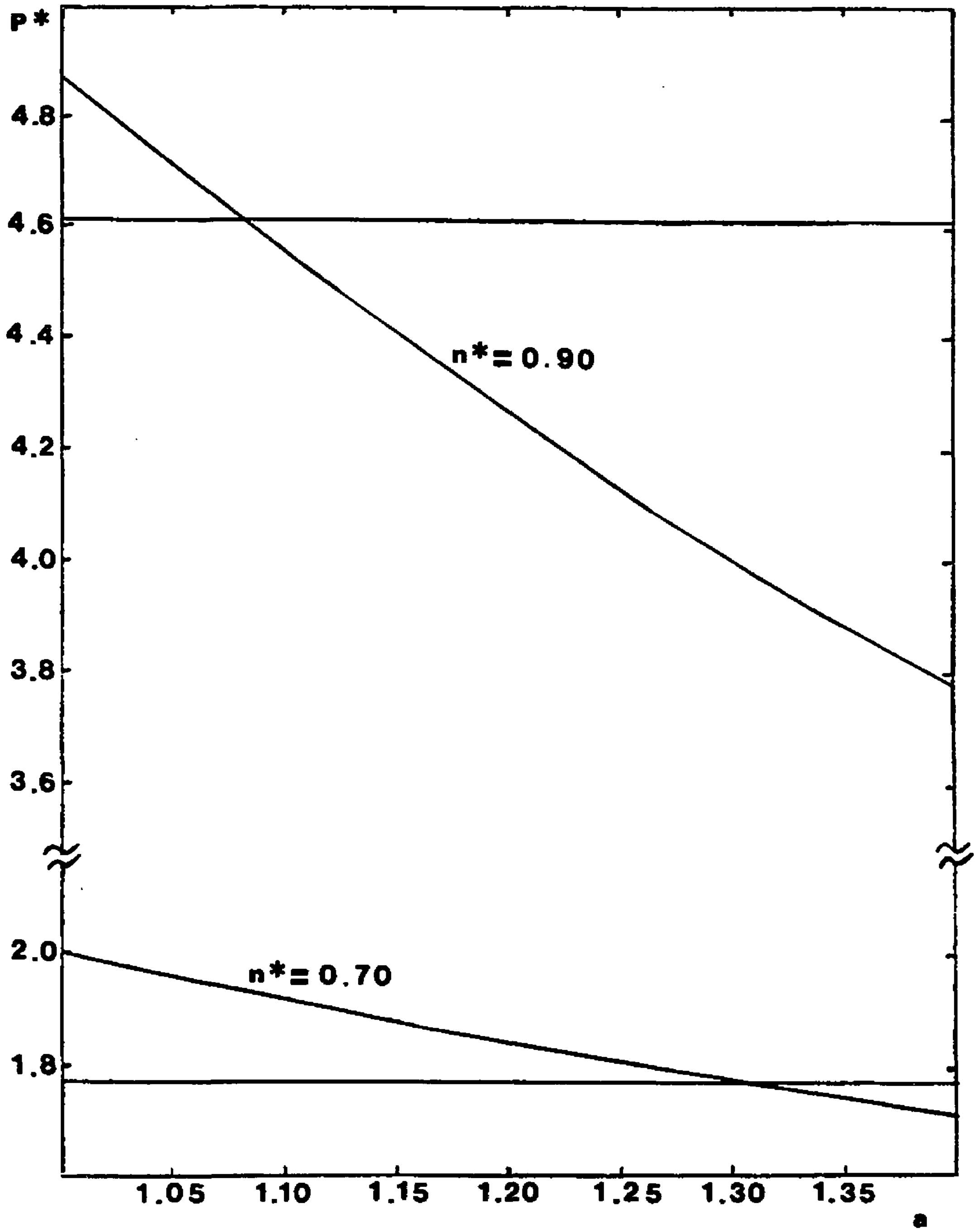

Figure 2. P* Versus a for T* = 1.6 at n* = 0.70 and 0.90 (Equation N)

Parametric Integral Equation T and the Square-Well Potential

For the square-well, equation T was solved at $T^* = 1.4$, 1.6, and 2.2 which were above the critical temperature. These choices of T^* were to keep the perturbation as small as possible while still providing good thermodynamic values for the reference system (for the perturbation theory computations).

The first thing that was done was to solve equation T for $T^* = 1.4$ at $n^* = 0.70$, and $n^* = 0.88$ with different sets of the parameters b_2 and b_3. At $n^* = 0.88$ the results of P^* obtained were unsatisfactory. Computations were done again at $n^* = 0.85$ and the results of P^* obtained were still unsatisfactory. The same problem occurred when equation T was solved at $T^* = 1.6$. Therefore at $T^* = 1.4$ and 1.6, equation T was found to be unsatisfactory. The results of P^* and U^* can be found in the appendix.

Equation T was then solved for the isotherm $T^* = 2.2$ at $n^* = 0.65$, and $n^* = 0.85$ with different sets of the parameters b_2 and b_3. The P^* and U^* results obtained were satisfactory and can be found in the appendix. The results were then used with a least squares program to find the coefficients in equation 31. Table 1 gives the values of these coefficients.

Table 1

Coefficients for Least Square Equation at $T^* = 2.2$

n^*	c_1	c_2	c_3	c_4	c_5
0.65	.819257	.825071	-.573483	-.39785	-1.14248
0.85	5.70092	11.345	.193985	-23.4007	-14.7053

The coefficients were used to compute various values of b_2 and b_3 that give P^* results equal to the accepted P^* results which were taken from the extrapolated and interpolated results of Alder. Graphs of b_3 versus b_2 were then drawn for both the reduced densities. The point of interception ($b_2 = -0.517$, $b_3 = 0.208$) gives the best choice of parameters (see figure 3).

The best choice of parameters was then used to solve equation T again at ten other densities along the isotherm. The results are given in Table 3. Here, values of P^* and U^* are rounded off and only the 297 points are taken. A more complete result can be found in the appendix.

Results in Table 3 were applied to the interpolation formulas for P^* and U^* (equations 32 and 33) to obtain the Pade coefficients. Other interpolated results of P^* and U^* were then easily obtained without going through the long procedure again. The Pade coefficients are given in Table 4 and the other interpolated results of P^*

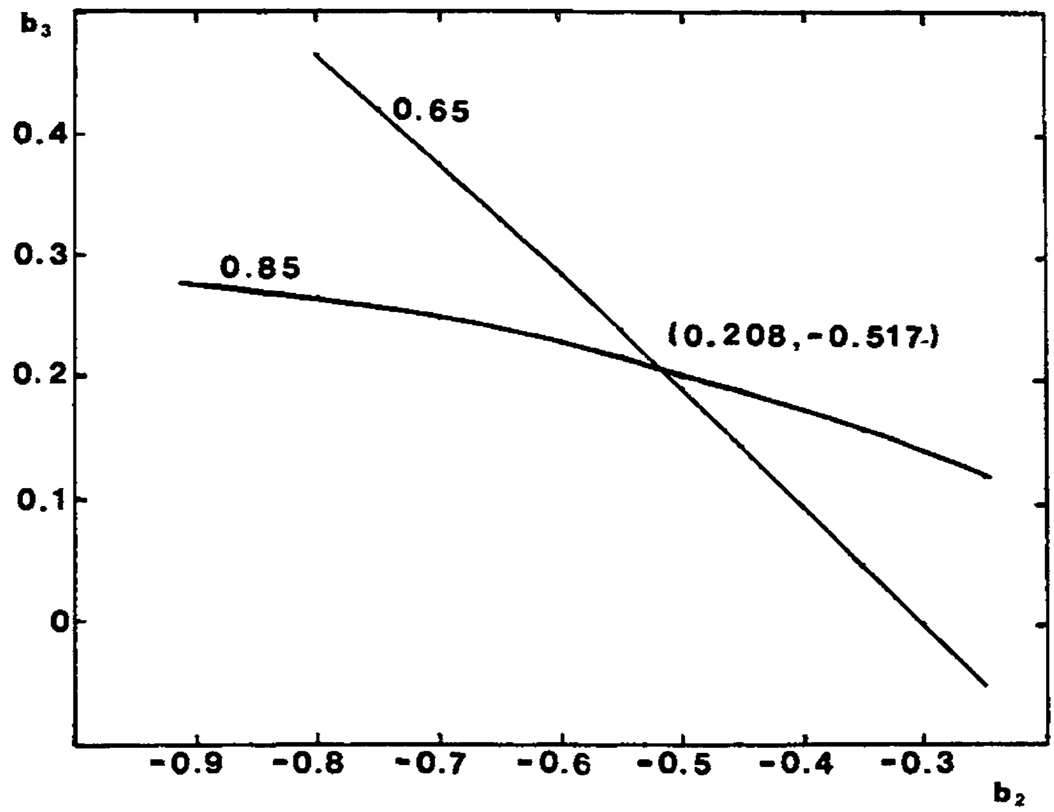

Figure 3. Parameters b_3 and b_2 at $T^* = 2.2$ The Numbers Near the Curves are the Densities (n^*)

and U* are given in Table 5.

The results in Table 5 were used to plot graphs of P* versus n*, and U* versus n*. Interpolated and extrapolated results of Alder were also plotted on the graphs for comparison (see figure 4 and figure 5). The agreement is quite good, thus equation T produces good results.

Table 2

Equation T Results at $T^* = 2.2$
($b_2 = 0.208$, $b_3 = -0.517$)

n*	P*	U*
.001	0.9992342	0.9976260
.01	0.992544	0.976332
.10	0.94806	0.77045
.20	0.9576	0.5539
.30	1.05	0.342
.50	1.67	-0.0959
.60	2.31	-0.322
.65	2.77	-0.434
.80	5.23	-0.734
.85	6.74	-0.811

Table 3

Pade Coefficients for P* and U* for $T^* = 2.2$

Coefficients	P*	U*
a_1	-3.38456	-3.97487
a_2	5.94679	5.45626
a_3	-5.10293	-3.37914
a_4	-2.61652	-1.59996
a_5	1.69642	.733093
a_6	- .175072	.750641

Table 4

Interpotated Results at T* = 2.2

n*	P*	U*
.05	.967498	.883214
.10	.94806	.7702
.15	.94395	.6606
.20	.958	.554
.25	.993	.449
.30	1.05	.345
.35	1.14	.239
.40	1.27	.131
.45	1.44	.0188
.50	1.66	-.0964
.55	1.94	-.212
.60	2.30	-.326
.65	2.77	-.434
.70	3.38	-.537
.75	4.17	-.634
.80	5.25	-.725
.85	6.75	-.812

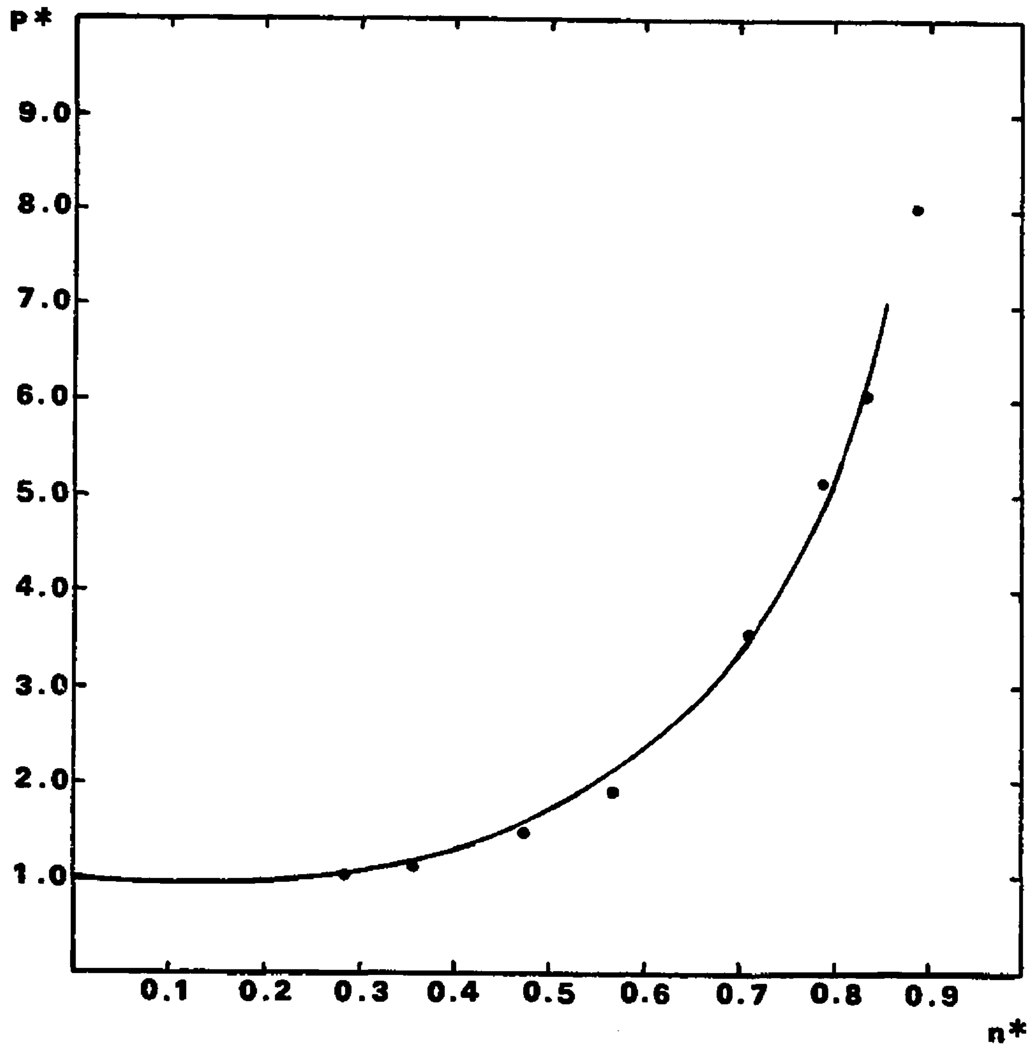

Figure 4. P* versus n* at T* = 2.2 The Points are the Accepted Results of Alder

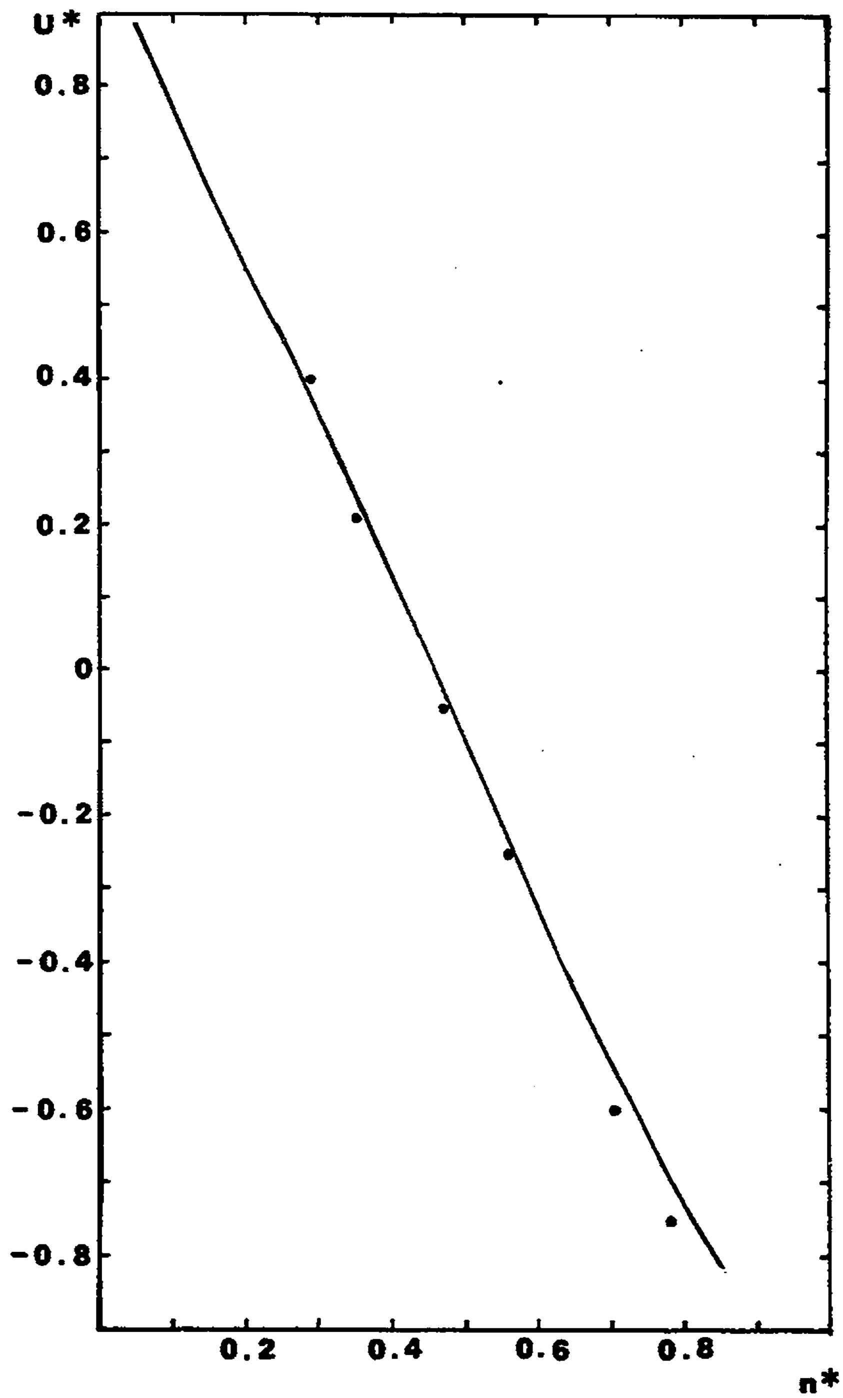

Figure 5. U* versus n* at T* = 2.2. The Points are the Accepted Results of Alder.

Perturbation Theory Applied to the Square-Well Potential

A computer program was used to compute the thermodynamic functions. The program was modified to do computations at a reference temperature of $T^* = 2.2$. Results of the reduced internal energy (Table 5) and the Pade coefficients for the pressure (Table 4) were used in the program for the reference part computations.

The thermodynamic functions obtained were for $0.7 \leq T^* \leq 2.15$ and $0.05 \leq n^* \leq 0.85$ for an interval of 0.05. The results of $T^* = 0.85$, 1.05, 1.35, 1.55, and 2.10 will only be discussed here. A complete result of the thermodynamic functions can be found in the appendix.

Graphs of P^* versus n^* and U^* versus n^* were plotted for the selected T^*. As before, interpolated and extrapolated results of Alder were shown in the graphs for comparisons. Results at $n^* = 0.05$ were dropped from the graphs because of numerical error[23] in the numerical differentiation computations of P^* and U^*. These graphs are shown in figures 6-9. In addition, graphs of F^*, S^*, H^*, and G^* versus n^* were also plotted (figures 10-13).

From these graphs, it can be seen that the P^* results agree quite well with the accepted results. However, the U^* results do not agree with the accepted results at lower temperatures but agree very well at higher temperatures.

For further comparisons, graphs of P* and U* versus n* = 0.85, 0.65, and 0.45 were plotted together with the interpolated and extrapolated results of Alder (figures 14-19).

Again, it can be seen that good agreements with the accepted results are only at higher temperatures.

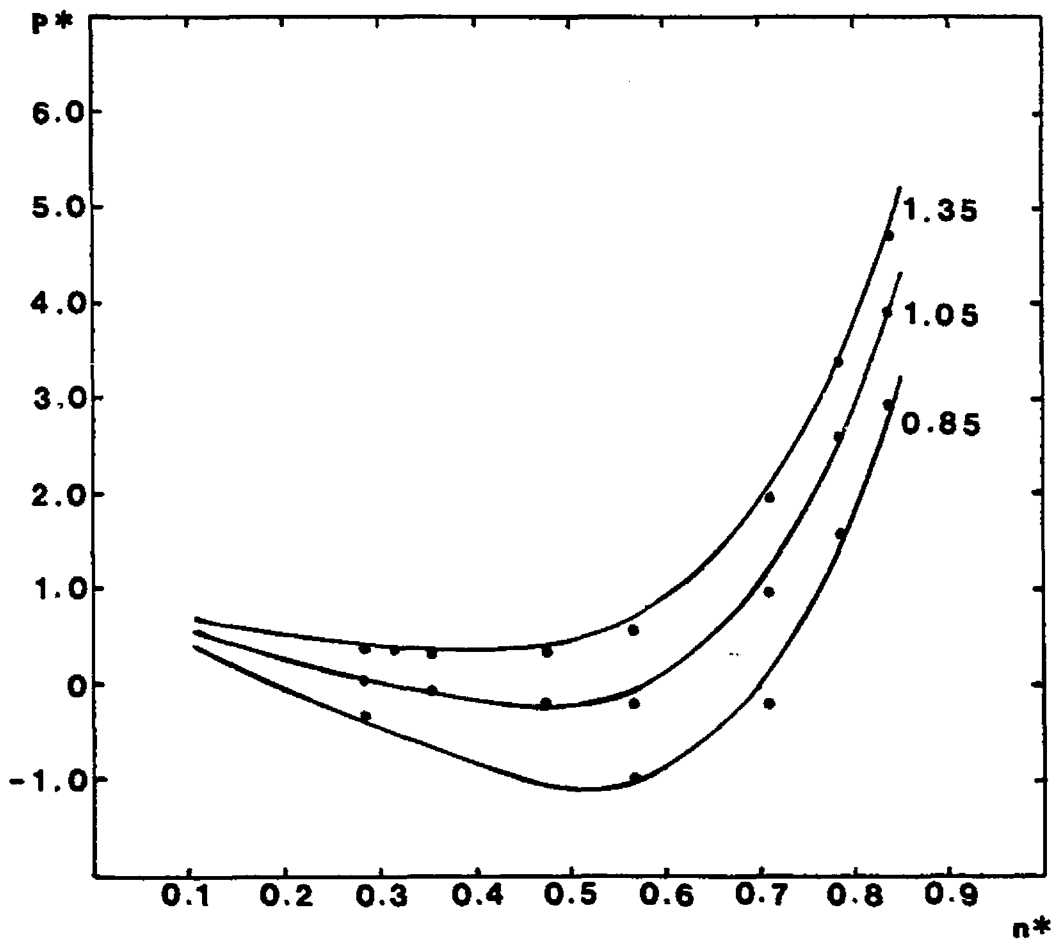

Figure 6. P* versus n* for T* = 0.85, 1.05, and 1.35. The Numbers Near the Curves are the Temperatures (T*) and the Points are the Accepted Results of Alder.

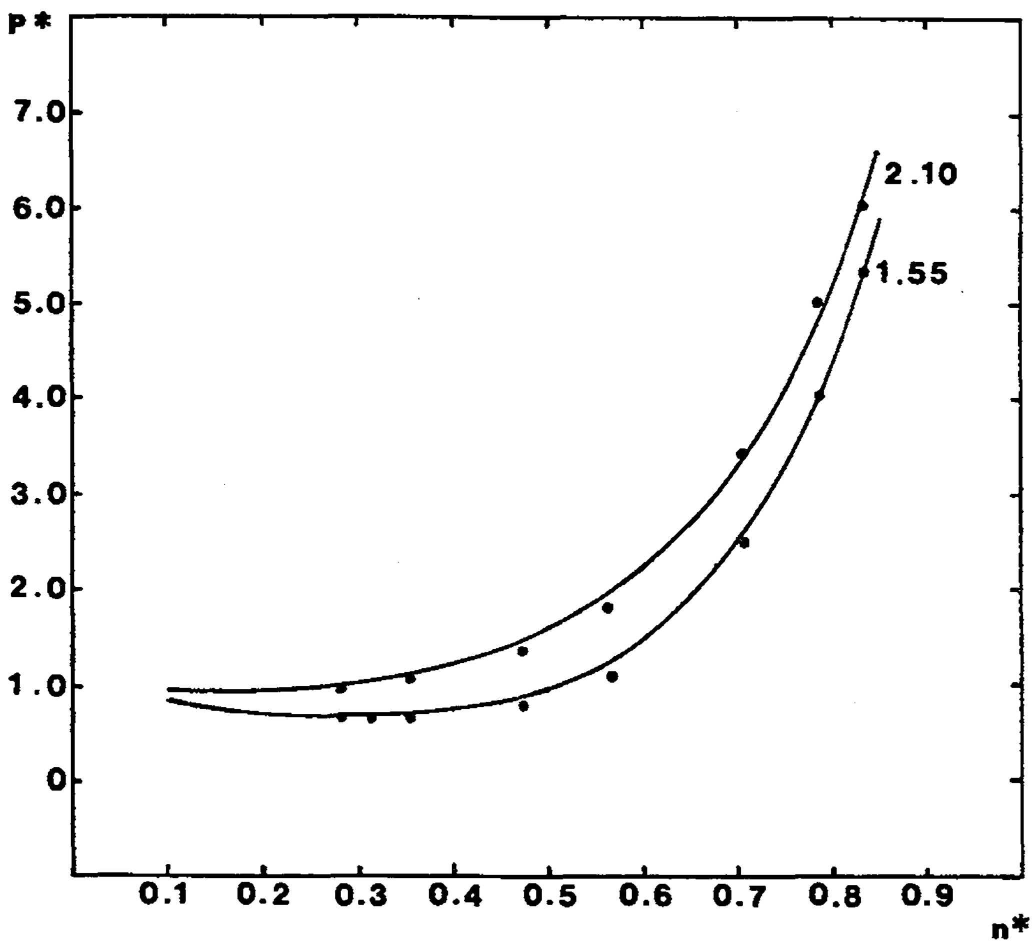

Figure 7. P* versus n* for T* = 1.55 and 2.10. The Numbers Near the Curves are the Temperatures (T*) and the Points are the Accepted Results of Alder.

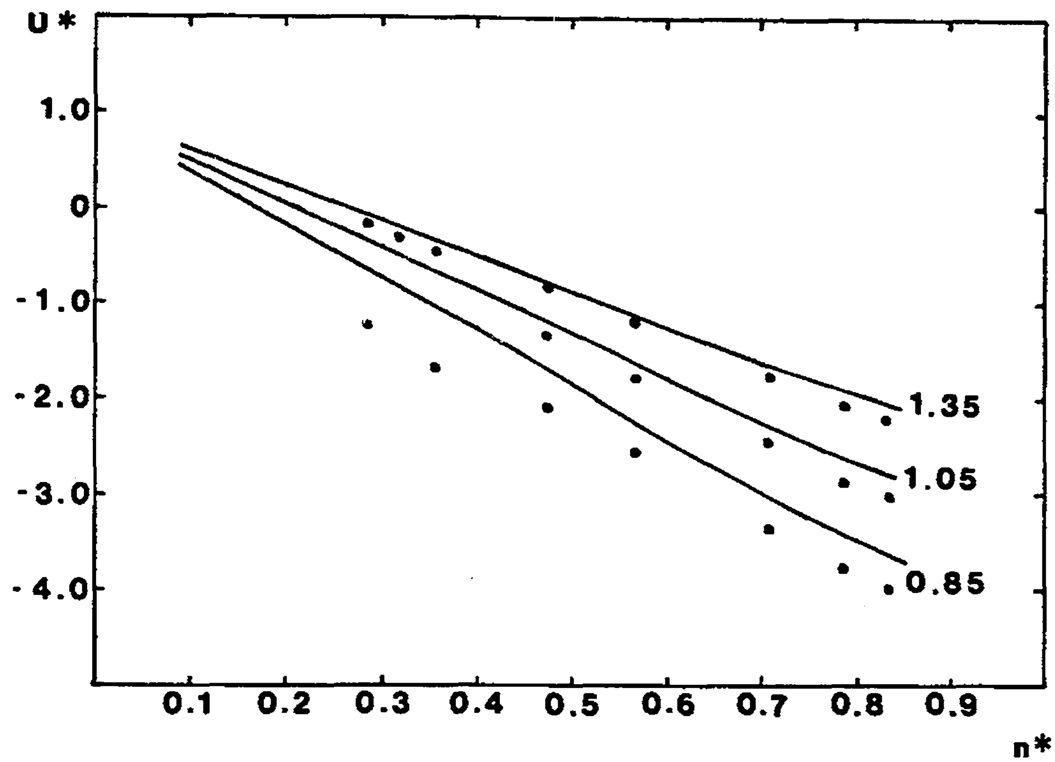

Figure 8. U* versus n* for T* = 0.85, 1.05, and 1.35. The Numbers Near the Curves are the Temperatures (T*) and the Points are the Accepted Results of Alder.

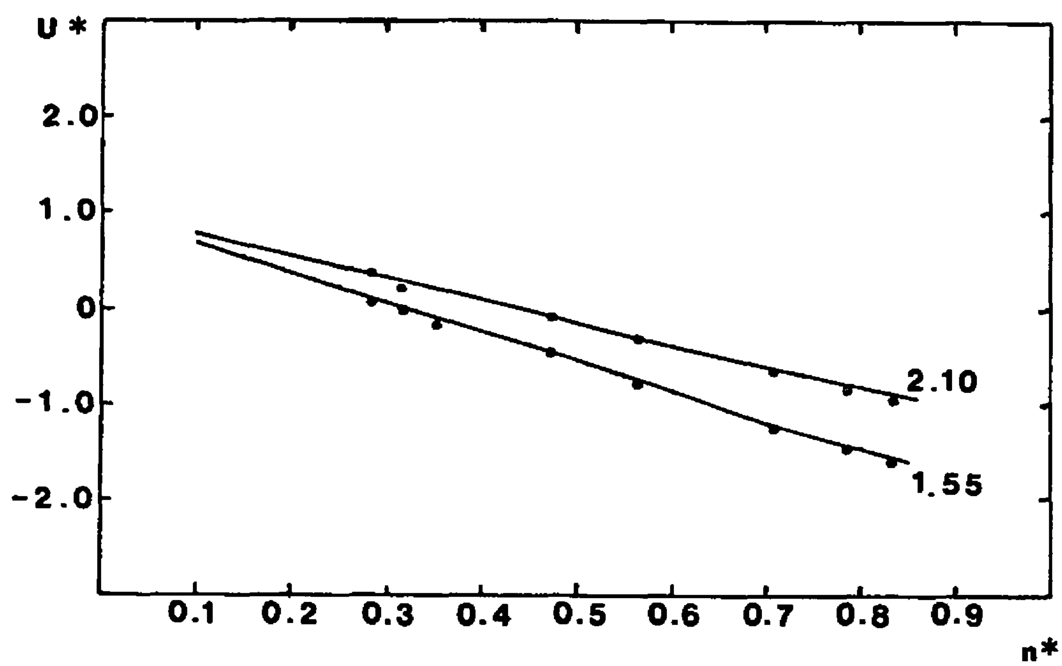

Figure 9. U* versus n* for T* = 1.55 and 2.10. The Numbers Near the Curves are the Temperatures (T*) and the Points are the Accepted Results of Alder

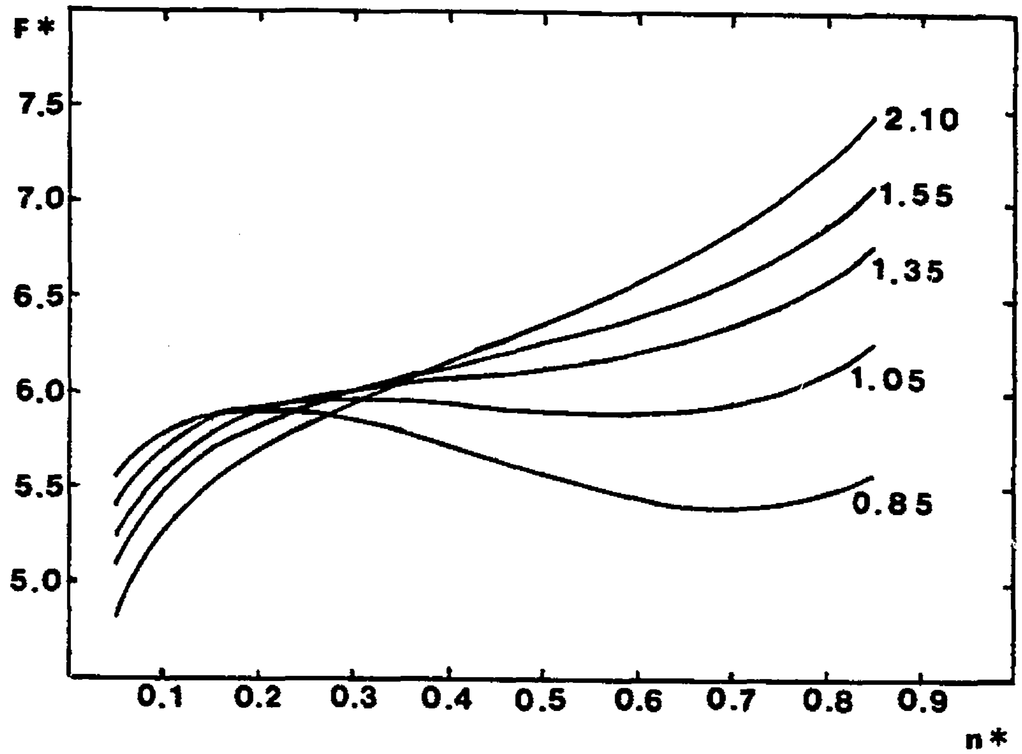

Figure 10. F* versus n* for Constant T*. The Numbers Near the Curves are the Temperatures (T*)

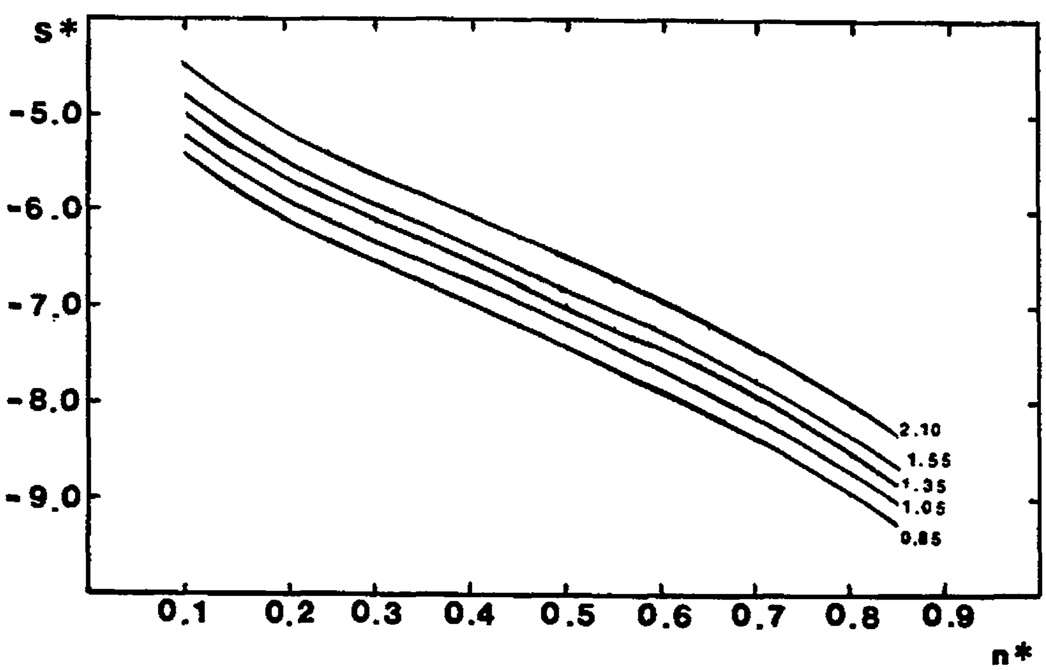

Figure 11. S* versus n* for Constant T*. The Numbers Near the Curves are the Temperatures (T*)

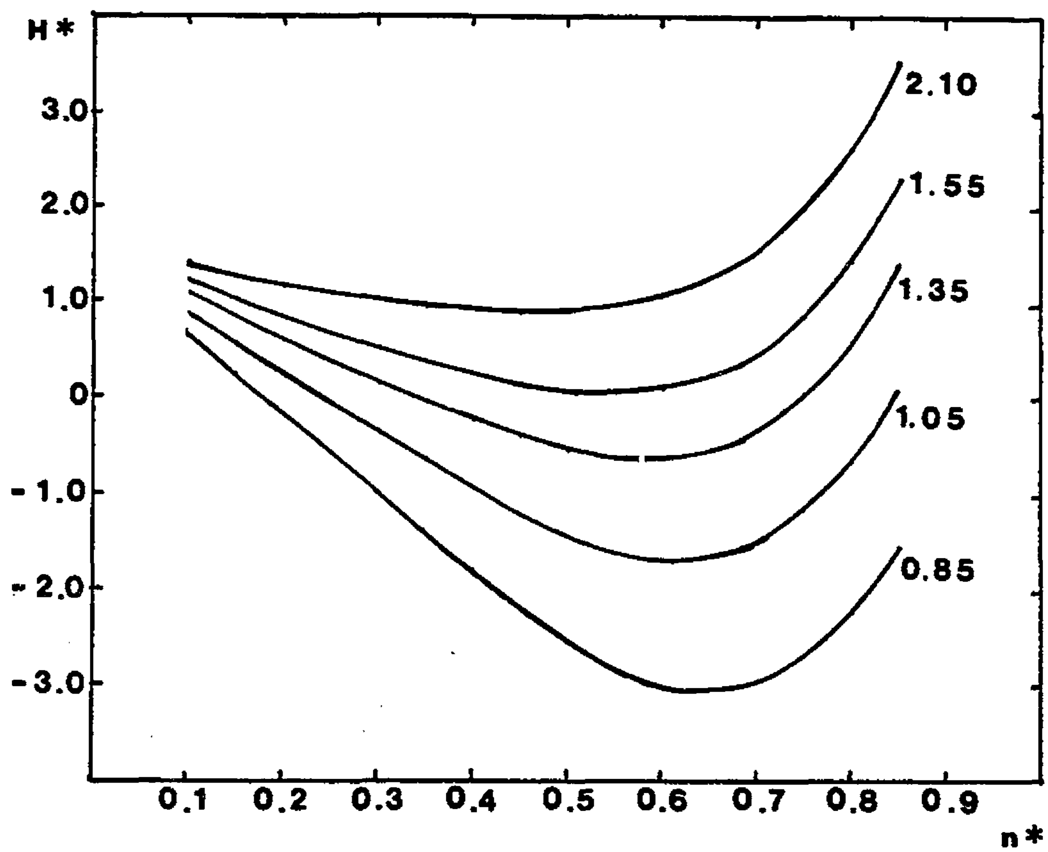

Figure 12. H* versus n* for Constant T*. The Numbers Near the Curves are the Temperatures (T*)

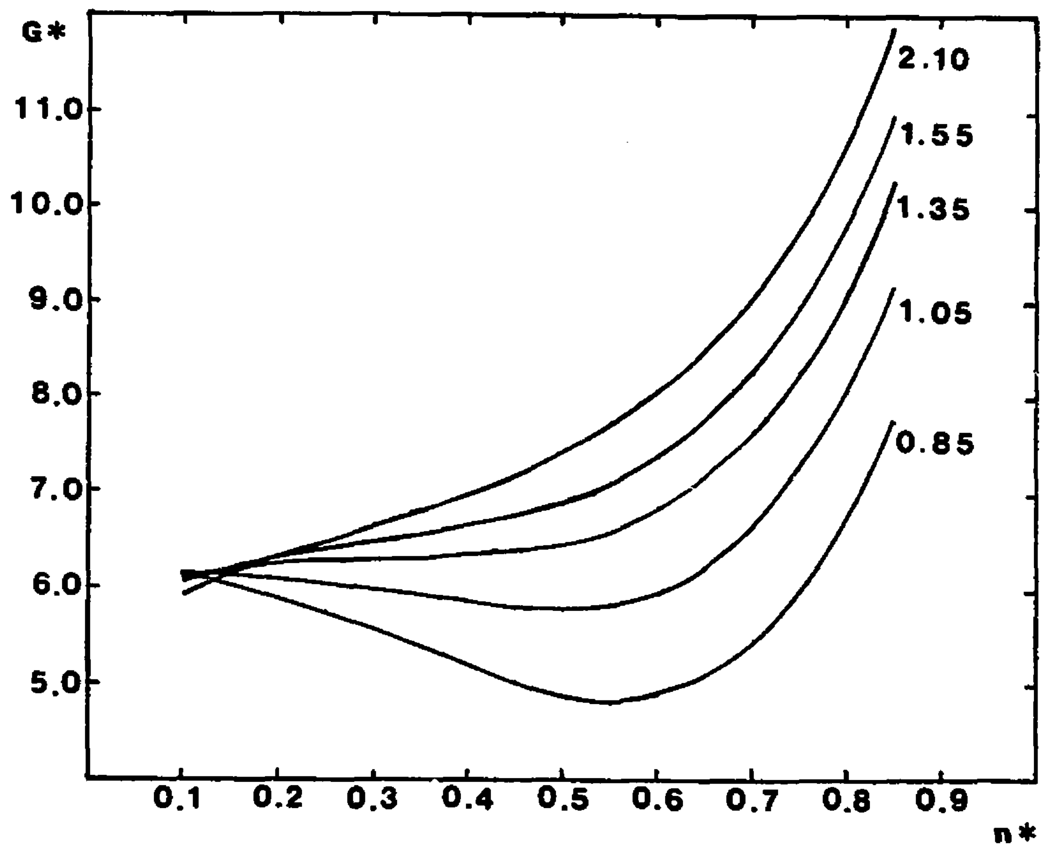

Figure 13. G* versus n* for Constant T*. The Numbers Near the Curves are the Temperatures (T*)

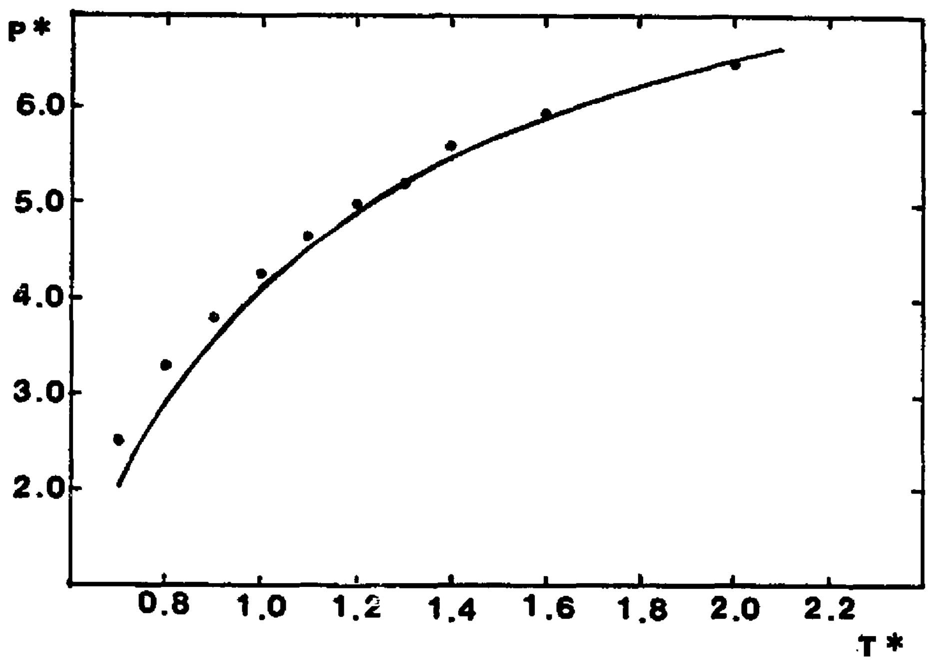

Figure 14. P* versus T* for n* = 0.85. The Points are the Accepted Results of Alder

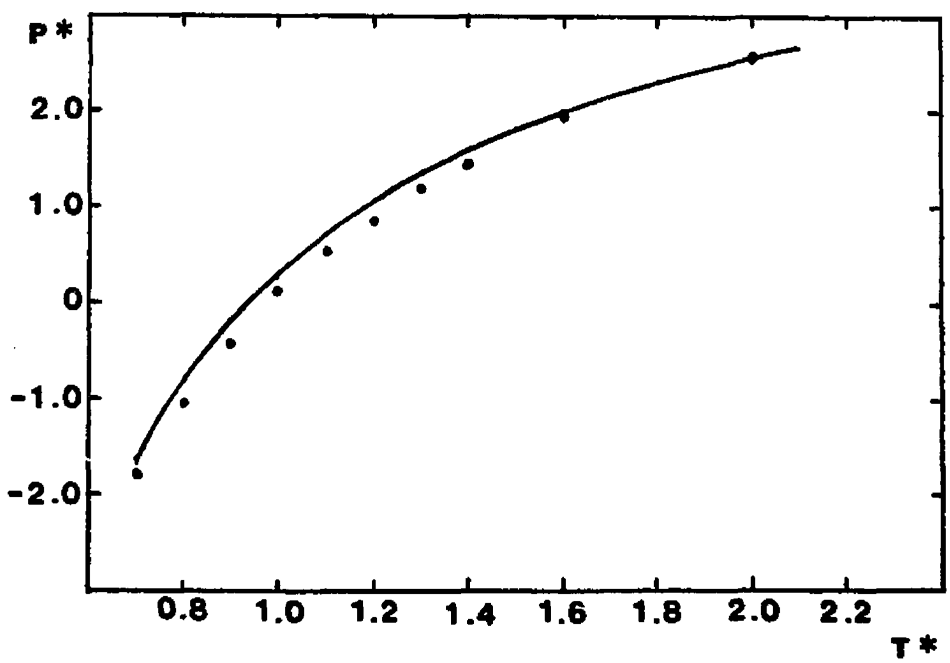

Figure 15. P* versus T* for n* = 0.65. The Points are the Accepted Results of Alder

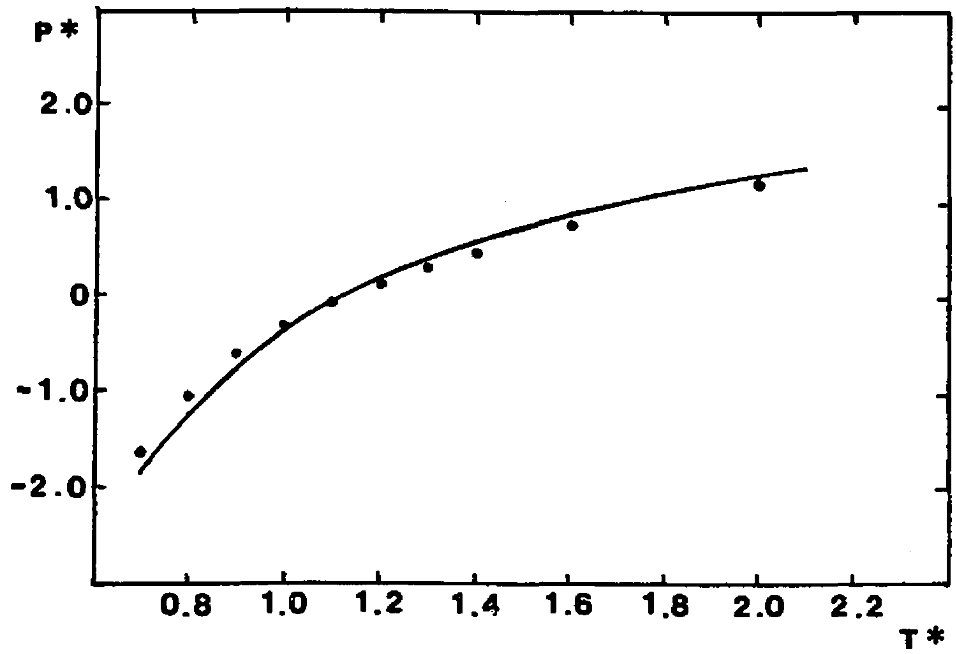

Figure 16. P* versus T* for n* = 0.45. The Points are the Accepted Results of Alder

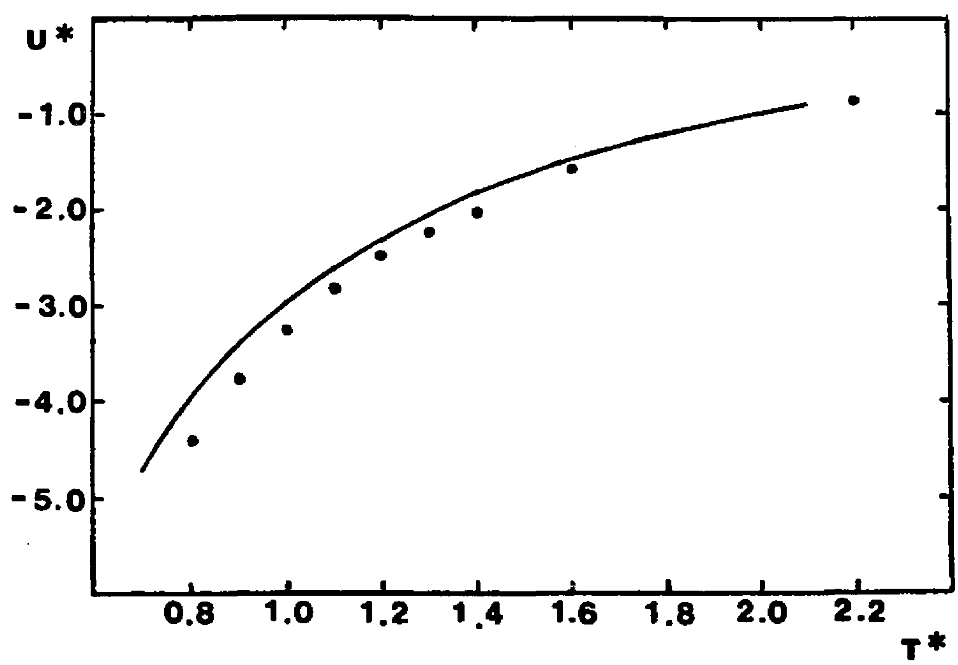

Figure 17. U* versus T* for n* = 0.85. The Points are the Accepted Results of Alder

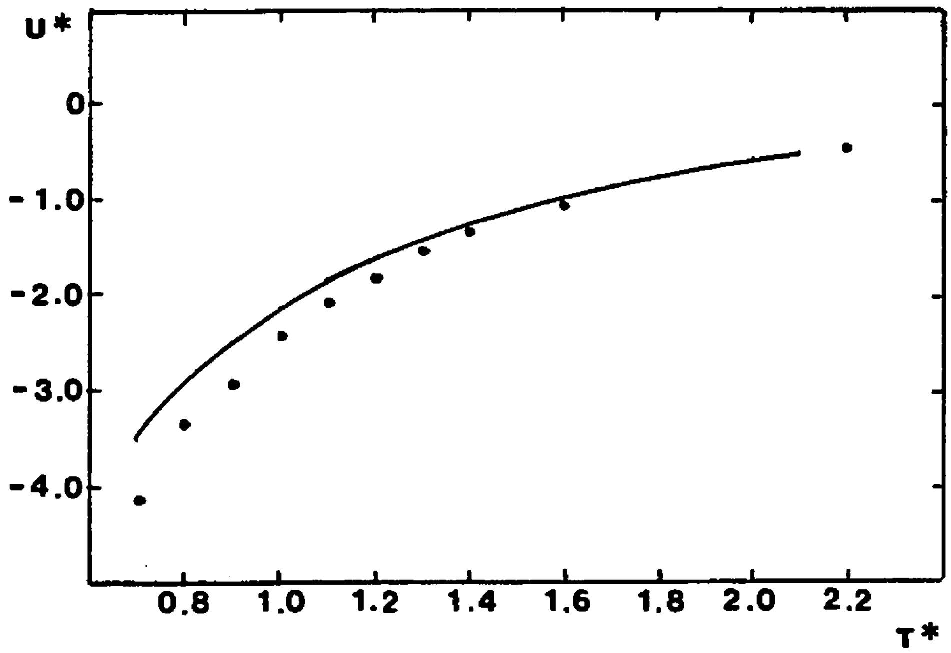

Figure 18. U* versus T* for n* = 0.65. The Points are the Accepted Results of Alder

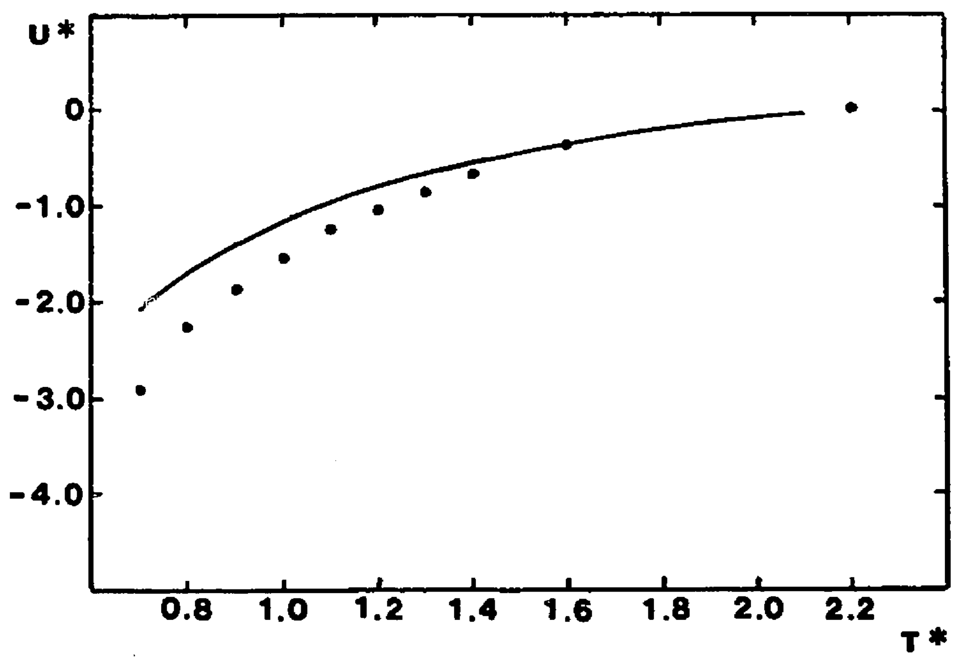

Figure 19. U* versus T* for n* = 0.45. The Points are the Accepted Results of Alder

CHAPTER V

SUMMARY AND CONCLUSIONS

In the first part of this research, equation N, a one parameter integral equation, was solved for a Lennard-Jones potential at $T^* = 1.6$. It was found out that there was no single parameter that produced P^* results equal to the accepted P^* results at a high and intermediate density. Thus equation N results have no better improvement over equation C.

In the second part of this research, equation T was solved for a square-well potential at $T^* = 1.4$, 1.6, and 2.2. The choices of T^* were to keep the perturbation as small as possible but still provide good thermodynamic values. At $T^* = 1.4$ and 1.6, the best choice of parameters were difficult to determine and thus the P^* results obtained were unsatisfactory. However at $T^* = 2.2$, the P^* and U^* results obtained were in good agreement with the accepted results.

The last part of this research was to compute the thermodynamic functions of a square-well potential using the first order perturbation theory. Equation T results at $T^* = 2.2$ were used as the reference system. In summary, the agreement with the accepted results was found to be fairly good for P* results in all the densities tried (n* = 0.45, 0.65, and 0.85) and for U* the results deviate from the accepted results for large perturbations.

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APPENDICES

APPENDIX A

SOLUTIONS OF EQUATION N FOR THE LENNARD-JONES POTENTIAL

The following notations are used:

a	Value of the parameter.
n*	Value of the reduced density.
T*	Value of the reduced temperature.
N	An A in the column indicates the computer gives solutions for 75 points with an x interval of 0.075. A B indicates solutions for 297 points with an x interval of 0.01875.
SDSS	A measurement of the difference between the final guessed value for S and computed value of S. A smaller value of SDSS shows a better convergence.
P*	Value of the reduced pressure.
U*	Value of the reduced internal energy.

TABLE 5

Solutions of Equation N for a Lennard-Jones Potential at T* = 1.6

No.	a	T*	n*	N	SDSS	P*	U*
1	1.0	1.60	0.70	A	.53E-7	1.9324967	-0.875351433
2				B	.19E-6	1.9980859	-0.87126613
3	1.05			A	.25E-7	1.8937119	-0.87965620
4				B	.13E-6	1.9564418	-0.87592185
5	1.10			A	.71E-7	1.8564243	-0.88377237
6				B	.97E-7	1.9165158	-0.88036036
7	1.20			A	.25E-7	1.7860041	-0.89148998
8				B	.17E-6	1.8413405	-0.88865137
9	1.30			A	.27E-7	1.7205099	-0.89859486
10				B	.20E-6	1.7716719	-0.89625132
11	1.40			A	.15E-6	1.6593699	-0.90516150
12				B	.15E-6	1.7068421	-0.90324891
13	1.50			A	.49E-7	1.6020926	-0.91124988
14				B	.16E-6	1.6462976	-0.90971720
15	1.0	1.60	0.90	A	.28E-6	4.7016106	-1.2821085
16				B	.44E-6	4.8757114	-1.2677398
17	1.10			A	.30E-6	4.4014683	-1.3177240
18				B	.48E-6	4.5532546	-1.3063517
19	1.20			A	.13E-6	4.1328001	-1.3491311
20				B	.50E-6	4.2670045	-1.3401062
21	1.30			A	.37E-6	3.8897307	-1.3771310
22				B	.37E-6	4.0096164	-1.3699915

No.	a	T*	n*	N	SDSS	P*	U*
23	1.40			A	.43E-6	3.6681569	-1.4022915
24				B	.49E-6	3.7760890	-1.3967102
25	1.50			A	.31E-6	3.4649289	-1.4250360
26				B	.35E-6	3.5626028	-1.4207706
27	1.35			B	.52E-6	3.8900108	-1.3837137

APPENDIX B

SOLUTIONS OF EQUATION T FOR THE SQUARE-WELL POTENTIAL

The following notations are used:

b_2, b_3	Values of the parameters.
n*	Value of the reduced density.
T*	Value of the reduced temperature.
N	An A in the column indicates the computer gives solutions for 75 points with an x interval of 0.07142857. A B indicates solutions for 297 points with an x interval of 0.01785714.
SDSS	A measurement of the difference between the final guessed value for S and computed value of S. A smaller value of SDSS shows a better convergence.
P*	Value of the reduced pressure.
U*	Value of the reduced internal energy.

TABLE 6

Solutions of Equation T for a Square-Well Potential at T* = 1.4

No.	b_2	b_3	n*	N	SDSS	P*	U*
1	0	0	0.70	A	.17E-6	2.7064407	-1.4663641
2				B	.19E-6	2.9033673	-1.4576738
3	0	0.25		A	.11E-6	2.8045580	-1.4600754
4				B	.28E-6	3.0355175	-1.4509859
5	0	-0.25		A	.13E-6	2.5920277	-1.4739590
6				B	.34E-6	2.7505019	-1.4658368
7	-0.5	0.25		A	.22E-6	2.5974386	-1.4473672
8				B	.39E-6	2.7413003	-1.4379199
9	-0.5	0		A	.17E-6	2.4717321	-1.4518716
10				B	.41E-6	2.5727146	-1.4425888
11	-0.5	-0.25		A	.22E-6	2.3192363	-1.4570236
12				B	.34E-6	2.3715045	-1.4479239
13	-0.5	-0.5		A	.15E-6	2.1222067	-1.4631271
14				B	.36E-6	2.1185274	-1.4542048
15	0	0	0.88	A	.42E-6	6.1765938	-1.9693773
16				B	.52E-6	6.7654791	-1.9444580
17	0.5	0.25		A	.81E-5	7.5623784	-2.0038664
18	0.5	0		A	.28E-6	7.4417601	-2.0691860
19	0	0	0.85	A	.36E-6	5.4541945	-1.8960519
20	0	0	0.88	A	.39E-6	6.1765985	-1.9693773
21				B	.53E-6	6.7654681	-1.9444544
22	0	0.25		A	.21E-6	6.7746091	-1.9537644

No.	b_2	b_3	n*	N	SDSS	P*	U*
23				B	.50E-6	7.7979069	-1.9274399
24	0	-0.2		A	.50E-6	4.9812193	-1.9886978
25				B	.57E-6	4.8585720	-1.9659817
26	-0.2	0		A	.26E-6	5.5312147	-1.9549901
27				B	.50E-6	5.8377342	-1.9289298
28	-0.2	0.25		A	.25E-6	6.4254527	-1.9420483
29	0.2	-0.2		A	.37E-6	6.0312080	-2.0223064
30				B	.68E-6	6.3811374	-2.0052435
31	0.2	0		A	.46E-6	6.6619229	-1.9907377
32				B	.12E-5	7.4946079	-1.9676728
33	-0.5	-0.6	0.70	A	.17E-6	2.0223114	-1.4659705
34				B	.26E-6	1.9942538	-1.4570966
35	-0.7	-0.5		A	.17E-6	1.8423142	-1.4608274
36				B	.25E-6	1.7787014	-1.4514461
37	-0.3	-0.7		A	.13E-6	2.1327565	-1.4751508
38				B	.27E-6	2.1341805	-1.4670484
39	-0.3	-0.6		A	.17E-6	2.2184818	-1.4717984
40				B	.28E-6	2.2432756	-1.4635062
41	-0.6	-0.4		A	.14E-6	2.1062858	-1.4587924
42				B	.32E-6	2.0989339	-1.449648
43	-0.1	0.1	0.88	A	.25E-6	6.2390976	-1.9553459
44				B	.45E-6	6.9311752	-1.9292428
45	-1.22	0.395	0.70	A	.14E-6	2.1167855	-1.4396601
46				B	.18E-6	2.1376228	-1.4302590

No.	b_2	b_3	n*	N	SDSS	P*	U*
47	-1.22	0.395	0.88	A	.42E-6	5.8535619	-1.9307692
48				B	.66E-6	8.8528786	-1.8994110
49				B	.66E-6	8.8528652	-1.8994167
50	-1.07	.175	0.70	B	.22E-6	2.0935967	-1.4342330
51	-1.15	0.30	0.88	B	.84E-6	11.539763	-1.9391854
52	-1.28	0.475		B	.48E-6	8.3722029	-1.8859012
53	-1.30	0.55		B	.59E-6	7.9984784	-1.8763876
54	-1.36	0.590		B	.62E-6	8.3181372	-1.8742921
55	-1.50	0.790		B	.49E-6	8.7128019	-1.8617127
56	-1.18	0.317		B	.75E-6	11.494004	-1.9351859
57	-0.4	0.2		A	.35E-6	5.8305979	-1.9349115
58				B	.45E-6	6.4600992	-1.9071889
59	-0.8	0.2		A	.34E-6	4.2083640	-1.9315255
60				B	.84E-6	5.0330834	-1.9030116
61	-0.8	0.4		A	.23E-6	5.6594925	-1.9151607
62				B	.57E-6	6.5751591	-1.8854182
63	-1.0	0.4		A	.36E-6	5.2838235	-1.9139934
64				B	.62E-6	6.4841747	-1.8834713
65	-1.0	0.6	0.88	A	.28E-6	6.0081081	-1.9043348
66				B	.54E-6	7.3034940	-1.8735385
67	-2.045	1.58		B	.51E-6	10.469301	-1.8324115
68	-1.2	0.7		B	.53E-6	7.7033939	-1.8667598
69	-1.5	0.6		B	.68E-6	9.8892717	-1.8807869
70	0	0	0.85	A	.31E-6	5.4541864	-1.8960524

No.	b_2	b_3	n*	N	SDSS	P*	U*
71				B	.29E-6	5.9487872	-1.8753588
72	0	0.25		A	.18E-6	5.9152632	-1.8815556
73				B	.36E-6	6.7116704	-1.8596077
74	0	-0.25		A	.46E-6	4.4262424	-1.9187689
75				B	.41E-6	4.3592019	-1.9003787
76	-0.5	0.25		A	.18E-6	5.0541596	-1.8612123
77				B	.48E-6	5.5420351	-1.8379946
78	-0.5	0.4		A	.18E-6	5.4383440	-1.8553612
79				B	.42E-6	6.1353631	-1.8317640
80	-0.8	0.3		A	.33E-6	4.4449639	-1.8555832
81				B	.52E-6	4.8830867	-1.8318958
82	-0.8	0.6		A	.24E-6	5.4092269	-1.8423016
83				B	.48E-6	6.2571235	-1.8176932
84	-1.0	0.7		A	.25E-6	5.3592734	-1.8363988
85				B	.38E-6	6.3261275	-1.8112268
86	-1.0	0.5		A	.36E-6	4.8328004	-1.8446145
87				B	.43E-6	5.6197248	-1.8199499
88	-1.2	0.6		A	.26E-6	4.8810878	-1.8408585
89				B	.48E-6	5.9675555	-1.8156517
90	-1.3	0.5		A	.45E-6	4.6970091	-1.8566921
91				B	.51E-6	6.4463358	-1.8322313
92	-1.4	0.65		B	.53E-6	6.6025901	-1.8171647
93	-1.3	0.5		B	.54E-6	6.4463363	-1.8322287

No.	b_2	b_3	n*	N	SDSS	P*	U*
94	-1.3	0.4	0.85	B	.69E-6	8.6997929	-1.8698852
95	-1.3	0.6		B	.50E-6	6.1868677	-1.8182068

TABLE 7

Solutions of Equation T for a Square-Well Potential at T* = 1.6

No.	b_2	b_3	n*	N	SDSS	P*	U*
1	0	0	0.60	A	.215E-6	1.8691945	-0.85430503
2				B	.340E-6	1.9605376	-0.85032463
3	0	-0.25		A	.135E-6	1.8252692	-0.85627973
4				B	.175E-6	1.9074475	-0.85240221
5	-0.5	0		A	.148E-6	1.7977179	-0.84841144
6				B	.183E-6	1.8596156	-0.84428263
7	-0.5	-0.25		A	.270E-6	1.7519943	-0.84980106
8				B	.446E-6	1.8039701	-0.84571457
9	-1.0	-0.25		A	.482E-7	1.6121860	-0.84650528
10				B	.171E-6	1.6306120	-0.84231210
11	-1.0	-0.5		A	.755E-7	1.5492582	-0.84786713
12				B	.166E-6	1.5557830	-0.84367490
13	-1.0	-0.7		A	.111E-6	1.4936109	-0.84903753
14				B	.204E-6	1.4903784	-0.84484112
15	-1.3	-0.4		A	.135E-6	1.4310071	-0.84696090
16				B	.175E-6	1.4172444	-0.84270728
17	-1.3	-0.15		A	.111E-6	1.5106111	-0.84543145
18				B	.264E-6	1.5102673	-0.84120393
19	-1.5	0		A	.148E-6	1.4485084	-0.84489596
20				B	.183E-6	1.4383991	-0.84067762
21	0	0	0.80	A	.222E-6	4.6746984	-1.4074190
22				B	.423E-6	5.0253215	-1.3958354

No.	b_2	b_3	n*	N	SDSS	P*	U*
23	0	-0.25		A	.230E-6	3.9631839	-1.4211581
24				B	.340E-6	3.9980166	-1.4105668
25	-0.3	0		A	.270E-6	4.0540509	-1.4031007
26				B	.446E-6	4.1982503	-1.3909540
27	-0.3	0.25		A	.230E-6	4.6901641	-1.3925028
28				B	.550E-6	5.1130581	-1.3797793
29	-0.5	0.1		A	.354E-6	3.8538678	-1.4000428
30				B	.660E-6	3.9859405	-1.3876967
31	-0.5	0.4		A	.229E-6	4.6834607	-1.3864090
32				B	.512E-6	5.1583395	-1.3732843
33	-0.8	0.25	0.80	A	.347E-6	3.5820916	-1.4015365
34				B	.591E-6	3.7896557	-1.3897009
35	-0.8	0.55		A	.241E-6	4.5673337	-1.3823862
36				B	.333E-6	5.1012182	-1.3689859
37	-1.0	0.7		A	.113E-6	4.6176586	-1.3791394
38				B	.352E-6	5.2640147	-1.3655047
39	-1.94	0.96	0.60	A	.847E-7	1.5097176	-0.84078944
40				B	.144E-6	1.5166358	-0.83673191
41			0.80	A	.496E-6	5.3855863	-1.4054890
42				B	.438E-6	7.6563807	-1.3905199
43	-1.9	0.7	0.60	A	.622E-7	1.4449277	-0.84229720
44				B	.146E-6	1.4388801	-0.83823323
45			0.80	A	.153E-6	7.4341240	-1.4802871
46				B	.542E-6	11.305983	-1.463501

No.	b_2	b_3	n*	N	SDSS	P*	U*
47	-0.5	0.25	0.60	B	.187E-6	1.9120777	-0.84293973
48	-1.0	0.25		B	.257E-6	1.7625946	-0.83983338
49	-1.8	0.55	0.80	B	.654E-6	15.248972	-1.5510526
50	-0.5	0.5	0.60	B	.149E-6	1.9617392	-0.84167314
51	-1.0	0.5		B	.189E-6	1.8216939	-0.83869648
52	-1.0	0		B	.199E-6	1.6991723	-0.84103537
53	-1.5	0.25		B	.218E-6	1.5318680	-0.83917749
54	-1.5	0.5		B	.182E-6	1.6143057	-0.83782256
55	0	0.5		B	.144E-6	2.0571389	-0.84674716
56	-1.9	0.8	0.80	A	.254E-6	6.0166392	-1.4359179
57				B	.457E-6	8.9587574	-1.4207580
58	-1.8	0.7		A	.288E-6	6.1483250	-1.4508893
59				B	.390E-6	9.2330332	-1.4364240
60	-1.7	0.5		A	.349E-6	9.9461813	-1.5726101
61				B	.544E-6	14.911380	-1.5547526
62	-1.8	0.55		A	.327E-6	10.196666	-1.5700102
63				B	.668E-6	15.248972	-1.5510523
64	-1.7	0.5		A	.358E-6	9.9461727	-1.5726089
65				B	.568E-6	14.911425	-1.5547485

TABLE 8

Solutions of Equation T for a Square-Well Potential at T* = 2.2

No.	b_2	b_3	n*	N	SDSS	P*	U*
1	0	0	0.65	A	.117E-6	2.9417796	-0.43090212
2				B	.109E-6	3.0596471	-0.42948377
3	0	0.25		A	.126E-6	3.0865679	-0.42920959
4				B	.182E-6	3.2427082	-0.42774475
5	0	-0.25		A	.119E-6	2.7591805	-0.43298745
6				B	.176E-6	2.8308783	-0.43160701
7	-0.5	0		A	.158E-6	2.4663772	-0.43806720
8				B	.202E-6	2.5026784	-0.43693936
9	-0.5	0.25		A	.104E-6	2.7385952	-0.43410254
10				B	.200E-6	2.8348296	-0.43284488
11	-0.8	0.4		A	.121E-6	2.5877671	-0.43796778
12				B	.202E-6	2.6753817	-0.43701184
13	0	-0.3		A	.105E-6	2.7158422	-0.43347657
14				B	.156E-6	2.7769718	-0.43210042
15	-0.8	0.5		A	.150E-6	2.6908870	-0.43619907
16				B	.218E-6	2.8010728	-0.43514991
17	0	0	0.85	A	.192E-6	6.2781415	-0.82360291
18				B	.505E-6	6.7088246	-0.81408644
19	0	0.25		A	.314E-6	7.1942997	-0.81413543
20				B	.523E-6	8.0834370	-0.80403733
21	-0.5	0.25		A	.437E-6	6.3356385	-0.81860006
22				B	.501E-6	7.1070642	-0.80737972

No.	b_2	b_3	n*	N	SDSS	P*	U*
23	-0.5	0.15		A	.335E-6	5.6297345	-0.82832789
24				B	.680E-6	6.1704793	-0.81750095
25	-0.3	0.15		A	.237E-6	6.2571015	-0.81949794
26				B	.543E-6	6.8481293	-0.80884945
27	-0.3	0.1		A	.318E-6	5.9249916	-0.82297838
28				B	.580E-6	6.3768787	-0.81246257
29	-0.6	0.25		A	.356E-6	6.1428475	-0.82267737
30				B	.434E-6	6.9519725	-0.81133401
31	-0.517	0.208	0.65	A	.644E-7	2.6842237	-0.43494928
32				B	.188E-6	2.7690258	-0.43372631
33			0.85	A	.330E-6	6.0534577	-0.82257223
34				B	.688E-6	6.7438269	-0.81145108
35			0.001	A	0	0.99923414	0.99762475
36				B	0	0.99923420	0.99762601
37			0.01	A	0	0.99254209	0.97631854
38				B	0	0.99254429	0.97633207
39			0.10	A	.722E-8	0.94775707	0.77018553
40				B	.136E-7	0.94805825	0.77045906
41			0.20	A	.111E-7	0.95598066	0.55318999
42				B	.146E-7	0.95762551	0.55392814
43			0.30	A	.245E-7	1.0473721	0.34096867
44				B	.381E-7	1.0525357	0.34204674
45			0.50	A	.705E-7	1.6375816	-0.096763849
46				B	.103E-6	1.6661731	-0.095918298

No.	b_2	b_3	n*	N	SDSS	P*	U*
47			0.60	A	.112E-6	2.2548254	-0.32303154
48				B	.161E-6	2.3131950	-0.32219064
49			0.80	A	.284E-6	4.8495140	-0.74019480
50				B	.450E-6	5.2332501	-0.73362398

APPENDIX C

COMPUTER PROGRAM

This appendix gives a listing of the computer program that was used to compute the thermodynamic functions of a square-well potential using perturbation theory.

```
10     PRINT  'SWPT.BAS-THIS PROGRAM COMPUTES THE THERMODYNAMIC FUNCTIONS'
20     PRINT  'FOR A SQUARE-WELL LIQUID USING PERTURBATION THEORY.'
30     DIM UR(20),F(20,30),FR(20,30),G(20),FP(20,30),P(20,30),U(20,30)
40     REM ENTER UR(REF INT ENER), T1(REF TEMP), A1,...,A6(PADE COEF
50     REM FOR F REF)
60     FOR I = 1 TO 19
70     READ UR(I)
80     NEXT I
90     DATA 0.99762601,0.97633207,.883,.770,.661,.554,.449,.345,.239,.131
100    DATA .019,-.096,-.212,-.326,-.434,-.537,-.634,-.725,-.812
110    READ T1
120    DATA 2.2
130    READ A1,A2,A3,A4,A5,A6
140    DATA -2.33567,4.22295,-1.90424,-1.56833,.796711,-.178773
150    REM CALCULATION OF F(0.001,TSTAR)
160    FOR J = 1 TO 30
170    T2 = .65 + J*.05
180    F(1,J) = LOG(20/T2) - 3.316125579*.001*(EXP(1/T2) - EXP(1/20))
190    NEXT J
200    REM CALCULATION OF FR(.001,TSTAR)
210    FOR J = 1 TO 30
220    T2 = .65 + J*.05
230    FR(1,J) = F(1,J) - (1 - (T1/T2))*(1 - UR(1))
240    NEXT J
250    REM CALCULATION OF FR(NSTAR,TSTAR)
260    PRINT  'TYPE THE NO OF INT PTS'
270    INPUT N1
280    B1 = A1 - A4
290    B2 = A2 - A5 - A4*A1 + A4*A4
300    B3 = A3 - A6 -A5*A1 + A5*A4 - A4*A2 + A4*A5 + A4*A4*A1 - A4*A4*A4
310    DEF FNX1(X) = (2/3)*(LOG(X/.001)+B1*(X-.001)+(B2/2)*(X*X-.000001)+(B3/3)*(X*X*X-1E-09))
320    DEF FNX2(X) = (1+A1*X+A2*X*X+A3*X*X*X)/(1+A4*X+A5*X*X+A6*X*X*X)
330    D = .05/(N1 - 1)
340    G(1) = FNX1(.001)
350    G(2) = FNX1(.01)
360    G(3) = FNX1(.05)
370    G(4) = FNX1(.1)
380    FOR I = 5 TO 19
390    X0 = (I - 3)*.05
400    FOR J = 1 TO N1
410    X = X0 + (J - 1)*D
420    S = S + FNX2(X)/X
430    NEXT J
440    S = S - .5*((FNX2(X0)/X0) + FNX2(X0+.05)/(X0+.05))
450    S = (2*S*D)/3
460    G(I) = G(I - 1) + S
470    S = 0
480    NEXT I
490    FOR J = 1 TO 30
500    FOR I = 1 TO 19
510    FR(I,J) = G(I) + FR(1,J)
520    NEXT I
530    NEXT J
540    REM CALCULATION OF FP(NSTAR,TSTAR)
550    FOR J = 1 TO 30
560    FOR I = 1 TO 19
570    T2 = .65 + J*.05
580    FP(I,J) = (1 - T1/T2)*(1 - UR(I))
590    NEXT I
600    NEXT J
610    REM CALCULATION OF F(NSTAR,TSTAR)
620    FOR J = 1 TO 30
630    FOR I = 1 TO 19
640    F(I,J) = FR(I,J) + FP(I,J)
650    NEXT I
660    NEXT J
670    REM CALCULATION OF P(NSTAR,TSTAR)
680    DN = .05
690    DT = .05
700    CN = 1/(12*DN)
710    CT = 1/(12*DT)
720    FOR J = 1 TO 30
730    P(3,J) = 1.5*.05*CN*(-25*F(3,J)+48*F(4,J)-36*F(5,J)+16*F(6,J)-3*F(7,J))
740    P(4,J) = 1.5*.1*CN*(-3*F(3,J)-10*F(4,J)+18*F(5,J)-6*F(6,J)+F(7,J))
750    FOR I = 5 TO 17
760    D = (I - 2)*.05
770    P(I,J) = 1.5*D*CN*(F(I-2,J)-8*F(I-1,J)+8*F(I+1,J)-F(I+2,J))
780    NEXT I
```

```
790   P(18,J) = 1.5*.8*CN*(-F(15,J)+6*F(16,J)-18*F(17,J)+10*F(18,J)+3*F(19,J))
800   P(19,J) = 1.5*.85*CN*(3*F(15,J)-16*F(16,J)+36*F(17,J)-48*F(18,J)+25*F(19,J))
810   NEXT J
820   REM CALCULATION OF U(NSTAR,TSTAR)
830   FOR I = 3 TO 19
840   U(I,1) = -.7*CT*(-25*F(I,1)+48*F(I,2)-36*F(I,3)+16*F(I,4)-3*F(I,5))
850   U(I,2) = -.75*CT*(-3*F(I,1)-10*F(I,2)+18*F(I,3)-6*F(I,4)+F(I,5))
860   FOR J = 3 TO 28
870   T2 = .65 + J*.05
880   U(I,J) = -T2*CT*(F(I,J-2)-8*F(I,J-1)+8*F(I,J+1)-F(I,J+2))
890   NEXT J
900   U(I,29) = -2.1*CT*(-F(I,26)+6*F(I,27)-18*F(I,28)+10*F(I,29)+3*F(I,30))
910   U(I,30) = -2.15*CT*(3*F(I,26)-16*F(I,27)+36*F(I,28)-48*F(I,29)+25*F(I,30))
920   NEXT I
930   REM PRINT OUT OF N*,F*,P*,U*
940   FOR J = 1 TO 30
950   T2 = .65 + J*.05
960   PRINT
970   PRINT "TSTAR = ";T2
980   PRINT "N-STAR","F-STAR","P-STAR","U-STAR"
990   FOR I = 3 TO 19
1000  D = (I - 2)*.05
1010  PRINT D,F(I,J),P(I,J),U(I,J)
1020  NEXT I
1030  NEXT J
1040  REM PRINT OUT OF N*,S*,H*,G*
1050  FOR J = 1 TO 30
1060  T2 = .65 + J*.05
1070  PRINT
1080  PRINT "T-STAR =";T2
1090  PRINT "N-STAR","S-STAR","H-STAR","G-STAR"
1100  FOR I = 3 TO 19
1110  D = (I - 2)*.05
1120  PRINT D,U(I,J)-F(I,J),U(I,J)+2*P(I,J)/3,F(I,J)+2*P(I,J)/3
1130  NEXT I
1140  NEXT J
1150  END
```

APPENDIX D

RESULTS OF THERMODYNAMIC FUNCTIONS

The following notations are used:

T STAR	Value of the reduced temperature.
N STAR	Value of the reduced density.
F STAR	Value of the reduced Helmholtz free energy.
P STAR	Value of the reduced pressure.
U STAR	Value of the reduced internal energy.
H STAR	Value of the reduced enthalpy.
G STAR	Value of the Gibbs free energy.

TSTAR = .7

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.6813	.516795	.620039
.1	5.88169	.26022	.265046
.15	5.9035	-.111926	-.774673E-01
.2	5.85621	-.407954	-.413601
.25	5.77593	-.682714	-.743477
.3	5.67702	-.967935	-1.07022
.35	5.5623	-1.26149	-1.40331
.4	5.43774	-1.55895	-1.74266
.45	5.30344	-1.85537	-2.09448
.5	5.16507	-2.07101	-2.45581
.55	5.03016	-2.14811	-2.82026
.6	4.90831	-1.98812	-3.17844
.65	4.81159	-1.6372	-3.51777
.7	4.74194	-1.12647	-3.84136
.75	4.70671	-.350649	-4.1461
.8	4.71298	.699812	-4.43197
.85	4.76693	2.03008	-4.70533

TSTAR = .75

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.63758	.5533	.646983
.1	5.86165	.32968	.315476
.15	5.9063	-.102523E-01	-.427485E-02
.2	5.88143	-.274804	-.318174
.25	5.82314	-.519024	-.626207
.3	5.74602	-.770406	-.931312
.35	5.65351	-1.02645	-1.24226
.4	5.55159	-1.28259	-1.55908
.45	5.44075	-1.53362	-1.88764
.5	5.32648	-1.7067	-2.22501
.55	5.21587	-1.74852	-2.56531
.6	5.11791	-1.56855	-2.89974
.65	5.04381	-1.20616	-3.21656
.7	4.99575	-.686107	-3.51871
.75	4.98084	.917092E-01	-3.80329
.8	5.00618	1.14483	-4.07025
.85	5.07835	2.49049	-4.32547

TSTAR = .8

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.59506	.585247	.670323
.1	5.83985	.390453	.359588
.15	5.90448	.787096E-01	.598628E-01
.2	5.89922	-.158295	-.23437
.25	5.86019	-.37579	-.523101
.3	5.80214	-.597568	-.809085
.35	5.72906	-.820809	-1.10057
.4	5.64694	-1.04077	-1.39755
.45	5.55663	-1.25209	-1.70553
.5	5.46344	-1.38793	-2.02176
.55	5.3741	-1.39887	-2.34074
.6	5.29704	-1.20143	-2.65422
.65	5.24274	-.829006	-2.9512
.7	5.21356	-.300774	-3.23443
.75	5.21644	.478788	-3.50117
.8	5.25846	1.53423	-3.7514
.85	5.34659	2.89331	-3.99063

TSTAR = .85

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.5538	.613434	.690675
.1	5.81686	.444078	.398219
.15	5.89913	.157205	.11612
.2	5.91118	-.554955E-01	-.160809
.25	5.88914	-.249414	-.432566
.3	5.84791	-.445063	-.701721
.35	5.79198	-.639346	-.976066
.4	5.72732	-.827395	-1.25558
.45	5.65513	-1.00368	-1.54545
.5	5.58055	-1.10666	-1.84308
.55	5.50997	-1.09037	-2.1433
.6	5.45135	-.877489	-2.43834
.65	5.41453	-.496211	-2.71787
.7	5.40201	.392032E-01	-2.98444
.75	5.42057	.820301	-3.23549
.8	5.47732	1.87782	-3.471
.85	5.57952	3.24875	-3.69617

TSTAR = .9

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.5138	.638489	.70862
.1	5.79312	.491745	.432399
.15	5.89105	.226981	.165972
.2	5.9185	.035888	-.955789E-01
.25	5.91155	-.137078	-.352238
.3	5.88527	-.309505	-.606449
.35	5.84458	-.47805	-.865548
.4	5.79546	-.637743	-1.12953
.45	5.73937	-.782871	-1.4033
.5	5.68133	-.856647	-1.6844
.55	5.62742	-.816148	-1.96794
.6	5.5852	-.589548	-2.2466
.65	5.5639	-.200395	-2.51059
.7	5.56619	.341425	-2.76236
.75	5.59871	1.12389	-2.99947
.8	5.66854	2.18323	-3.22191
.85	5.78325	3.5647	-3.43456

TSTAR = .95

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.47505	.660911	.724545
.1	5.76891	.534393	.462877
.15	5.88087	.289409	.210456
.2	5.92207	.117646	-.373125E-01
.25	5.92863	-.365663E-01	-.280461
.3	5.91574	-.188217	-.5213
.35	5.88869	-.33373	-.766775
.4	5.85346	-.468047	-1.01687
.45	5.81178	-.585305	-1.27624
.5	5.76853	-.632946	-1.54254
.55	5.72955	-.570781	-1.81116
.6	5.70199	-.331922	-2.07516
.65	5.69459	.642786E-01	-2.32525
.7	5.71013	.611824	-2.56377
.75	5.75513	1.3955	-2.78839
.8	5.83667	2.45649	-2.99912
.85	5.96257	3.84741	-3.20058

TSTAR = 1

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.43752	.68108	.738806
.1	5.74446	.57278	.490224
.15	5.86904	.345596	.250427
.2	5.92264	.191228	.150331E-01
.25	5.94135	.538957E-01	-.215963
.3	5.9405	-.790536E-01	-.444755
.35	5.92572	-.203839	-.677958
.4	5.903	-.315318	-.915549
.45	5.87429	-.407498	-1.16194
.5	5.84436	-.431622	-1.41494
.55	5.81881	-.349955	-1.67012
.6	5.80445	-.100047	-1.92092
.65	5.80956	.302488	-2.15852
.7	5.83702	.855186	-2.38511
.75	5.89325	1.63996	-2.59851
.8	5.98532	2.70242	-2.79869
.85	6.1213	4.10179	-2.99009

TSTAR = 1.05

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.40116	.699337	.751658
.1	5.71993	.607508	.514893
.15	5.85593	.396433	.286522
.2	5.92074	.257807	.623304E-01
.25	5.95046	.135741	-.157668
.3	5.9605	.197099E-01	-.375564
.35	5.95683	-.863279E-01	-.597648
.4	5.94542	-.177137	-.823929
.45	5.92844	-.246618	-1.05859
.5	5.91055	-.249466	-1.29954
.55	5.89716	-.150166	-1.54259
.6	5.89474	.109736	-1.78144
.65	5.91116	.518007	-2.00771
.7	5.94942	1.07537	-2.22352
.75	6.01581	1.86113	-2.42676
.8	6.11742	2.92495	-2.61742
.85	6.26251	4.332	-2.79971

TSTAR = 1.1

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.36592	.715934	.763278
.1	5.69546	.639079	.537269
.15	5.84184	.442646	.319273
.2	5.91683	.318331	.105281
.25	5.95655	.210146	-.104716
.3	5.9765	.109492	-.312713
.35	5.98292	.205074E-01	-.5247
.4	5.98179	-.515156E-01	-.7407
.45	5.97549	-.100372	-.9647
.5	5.96855	-.838661E-01	-1.19469
.55	5.96621	.031468	-1.42669
.6	5.97465	.300446	-1.65469
.65	6.00135	.71393	-1.87068
.7	6.04942	1.27554	-2.07668
.75	6.12505	2.06222	-2.27068
.8	6.23532	3.12724	-2.45268
.85	6.3887	4.54127	-2.62667

TSTAR = 1.15

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.33175	.731089	.773828
.1	5.67112	.667904	.557662
.15	5.82698	.484842	.349144
.2	5.91128	.373591	.144448
.25	5.96012	.278081	-.564165E-01
.3	5.98912	.191473	-.255375
.35	6.00475	.118047	-.45815
.4	6.01302	.631804E-01	-.664759
.45	6.01645	.331618E-01	-.879009
.5	6.01952	.673246E-01	-1.099
.55	6.02726	.197306	-1.32092
.6	6.04561	.47458	-1.539
.65	6.08171	.892831	-1.74561
.7	6.13873	1.4583	-1.94265
.75	6.22279	2.2458	-2.12821
.8	6.34098	3.31194	-2.3023
.85	6.50192	4.73232	-2.46873

TSTAR = 1.2

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.29861	.744979	.783487
.1	5.64698	.694327	.576326
.15	5.81153	.523522	.37649
.2	5.90436	.424248	.180341
.25	5.96158	.340354	-.012166
.3	5.99886	.266618	-.202826
.35	6.02295	.207465	-.39716
.4	6.03982	.168317	-.595171
.45	6.05218	.155561	-.80049
.5	6.06441	.205927	-1.01132
.55	6.0814	.349324	-1.22399
.6	6.10884	.634202	-1.43299
.65	6.15355	1.05682	-1.63099
.7	6.21878	1.62582	-1.81982
.75	6.31057	2.41409	-1.99765
.8	6.43601	3.48124	-2.16449
.85	6.60389	4.90745	-2.32396

TSTAR = 1.25

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.26645	.757749	.79236
.1	5.6231	.71864	.593483
.15	5.79565	.559106	.401645
.2	5.89632	.47085	.213329
.25	5.96124	.397648	.285308E-01
.3	6.00615	.335754	-.154507
.35	6.03801	.289729	-.341069
.4	6.0628	.265042	-.531138
.45	6.08337	.268175	-.728265
.5	6.10404	.33343	-.930669
.55	6.12953	.489178	-1.13482
.6	6.16534	.781054	-1.33546
.65	6.21796	1.20768	-1.52553
.7	6.29075	1.77996	-1.70681
.75	6.38965	2.56892	-1.87754
.8	6.52177	3.63697	-2.03769
.85	6.69602	5.06853	-2.1908

TSTAR = 1.3

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.23521	.769552	.800514
.1	5.59951	.741077	.609288
.15	5.77944	.591954	.424827
.2	5.88735	.513868	.243744
.25	5.95938	.450529	.660594E-01
.3	6.01133	.399574	-.109937
.35	6.05036	.365659	-.289323
.4	6.08247	.354327	-.472085
.45	6.11062	.372129	-.661627
.5	6.13907	.451133	-.856245
.55	6.17242	.618276	-1.05255
.6	6.21594	.916602	-1.24547
.65	6.27587	1.34694	-1.42823
.7	6.35563	1.92224	-1.60254
.75	6.46111	2.71183	-1.76669
.8	6.59938	3.78077	-1.92069
.85	6.77952	5.21737	-2.06793

TSTAR = 1.35

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.20485	.780467	.808047
.1	5.57624	.761859	.623904
.15	5.763	.62237	.446263
.2	5.87762	.553699	.271906
.25	5.95623	.499497	.10079
.3	6.01469	.458664	-.686871E-01
.35	6.06037	.435971	-.241421
.4	6.09925	.436997	-.417429
.45	6.13442	.468382	-.599945
.5	6.17008	.560112	-.787357
.55	6.2107	.737809	-.976391
.6	6.26136	1.04212	-1.16217
.65	6.32807	1.47589	-1.33817
.7	6.41428	2.05396	-1.50601
.75	6.52583	2.84416	-1.66408
.8	6.66981	3.9139	-1.81238
.85	6.85541	5.35504	-1.95416

TSTAR = 1.4

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.17534	.790609	.815046
.1	5.5533	.781153	.637463
.15	5.7464	.650612	.466194
.2	5.86725	.590685	.298033
.25	5.95197	.544968	.13304
.3	6.01649	.513529	-.303868E-01
.35	6.06834	.501256	-.196948
.4	6.1135	.51377	-.366666
.45	6.15519	.557756	-.542663
.5	6.19755	.661312	-.723374
.55	6.24491	.848806	-.905667
.6	6.30221	1.15867	-1.08481
.65	6.3752	1.59561	-1.25451
.7	6.46741	2.17628	-1.41637
.75	6.58461	2.96704	-1.5688
.8	6.73388	4.0375	-1.71179
.85	6.92454	5.48293	-1.8485

TSTAR = 1.45

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.14662	.800057	.821523
.1	5.53071	.799111	.650074
.15	5.72971	.676905	.484701
.2	5.85637	.625125	.322352
.25	5.94677	.587298	.163049
.3	6.01693	.564614	.526166E-02
.35	6.07452	.562041	-.15557
.4	6.12553	.585238	-.319426
.45	6.1733	.640965	-.489363
.5	6.22188	.755531	-.663841
.55	6.27553	.952146	-.839842
.6	6.33901	1.26717	-1.0128
.65	6.41785	1.70709	-1.17666
.7	6.51564	2.29017	-1.33294
.75	6.6381	3.08144	-1.48011
.8	6.7923	4.1526	-1.61819
.85	6.98768	5.60199	-1.75017

TSTAR = 1.5

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.11867	.808867	.827565
.1	5.50847	.815877	.661849
.15	5.71299	.701446	.501963
.2	5.84505	.657263	.34505
.25	5.94077	.626811	.191048
.3	6.01618	.612293	.385034E-01
.35	6.07914	.618775	-.11696
.4	6.13561	.651952	-.275366
.45	6.18904	.718628	-.439632
.5	6.24344	.843465	-.608289
.55	6.30296	1.0486	-.778422
.6	6.3722	1.36845	-.945626
.65	6.4565	1.81114	-1.10403
.7	6.5595	2.39647	-1.25509
.75	6.68686	3.18822	-1.39735
.8	6.84567	4.26003	-1.53082
.85	7.04545	5.71308	-1.65843

TSTAR = 1.55

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.09144	.817111	.833233
.1	5.48659	.831562	.672844
.15	5.69626	.724405	.51813
.2	5.83339	.687331	.366272
.25	5.93407	.663775	.217227
.3	6.01441	.6569	.696193E-01
.35	6.08238	.671844	-.808388E-01
.4	6.14396	.714356	-.234133
.45	6.20269	.791284	-.393089
.5	6.26253	.92573	-.556321
.55	6.32754	1.13883	-.720958
.6	6.40217	1.46319	-.882776
.65	6.49158	1.90847	-1.03606
.7	6.59946	2.4959	-1.18226
.75	6.73141	3.2881	-1.31993
.8	6.89452	4.36052	-1.44909
.85	7.09841	5.81706	-1.57257

TSTAR = 1.6

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.0649	.824837	.838523
.1	5.46506	.846268	.683151
.15	5.67957	.745926	.533267
.2	5.82144	.715516	.386155
.25	5.92678	.698428	.241777
.3	6.01173	.698714	.987778E-01
.35	6.0844	.721604	-.469653E-01
.4	6.15078	.772857	-.195477
.45	6.21447	.859395	-.349466
.5	6.27941	1.00285	-.507595
.55	6.34957	1.22342	-.667102
.6	6.42926	1.55202	-.823845
.65	6.52346	1.99972	-.972341
.7	6.6359	2.58913	-1.11397
.75	6.77216	3.38175	-1.24734
.8	6.9393	4.45473	-1.37247
.85	7.14705	5.9145	-1.49209

TSTAR = 1.65

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.03902	.832097	.843486
.1	5.44389	.860079	.692806
.15	5.66294	.766146	.547486
.2	5.80927	.741996	.4048
.25	5.91899	.73098	.264812
.3	6.00827	.737994	.126137
.35	6.08536	.768341	-.151862E-01
.4	6.15623	.827819	-.159183
.45	6.22459	.923376	-.308515
.5	6.29432	1.0753	-.461843
.55	6.36931	1.30289	-.616511
.6	6.45375	1.63544	-.768514
.65	6.55246	2.08544	-.912504
.7	6.66919	2.6767	-1.04984
.75	6.80948	3.46972	-1.17917
.8	6.98042	4.54324	-1.30051
.85	7.1918	6.00604	-1.41651

TSTAR = 1.7

N-STAR	F-STAR	P-STAR	U-STAR
.05	5.01377	.838936	.848151
.1	5.42307	.873077	.701913
.15	5.6464	.785175	.560855
.2	5.79692	.766918	.422379
.25	5.91076	.761616	.286507
.3	6.00412	.774966	.151919
.35	6.08536	.812331	.147371E-01
.4	6.16047	.879542	-.125024
.45	6.23322	.983597	-.26996
.5	6.30747	1.14349	-.418795
.55	6.387	1.37768	-.568899
.6	6.47591	1.71398	-.716433
.65	6.57885	2.16611	-.856198
.7	6.69963	2.75912	-.989482
.75	6.84372	3.55251	-1.11502
.8	7.01823	4.62654	-1.23278
.85	7.23302	6.09222	-1.34537

TSTAR = 1.75

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.98912	.845376	.852542
.1	5.4026	.885334	.7105
.15	5.62996	.803119	.573469
.2	5.78444	.790415	.438959
.25	5.90215	.790502	.306959
.3	5.99936	.809827	.176207
.35	6.08452	.853805	.429457E-01
.4	6.16363	.928311	-.092812
.45	6.24052	1.04038	-.233625
.5	6.31901	1.20778	-.378193
.55	6.40284	1.44819	-.524029
.6	6.49597	1.78802	-.667333
.65	6.6029	2.24218	-.803106
.7	6.72748	2.83683	-.93259
.75	6.87516	3.63057	-1.05453
.8	7.05304	4.70507	-1.16893
.85	7.27104	6.17351	-1.2783

TSTAR = 1.8

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.96505	.85146	.856696
.1	5.38247	.896911	.718572
.15	5.61363	.820064	.585352
.2	5.77185	.812607	.454574
.25	5.89323	.817784	.326235
.3	5.99407	.842747	.199141
.35	6.08294	.892978	.695743E-01
.4	6.16581	.974375	-.624289E-01
.45	6.24662	1.094	-.199315
.5	6.32913	1.26849	-.339861
.55	6.417	1.51479	-.481639
.6	6.51411	1.85794	-.620976
.65	6.62481	2.31403	-.752973
.7	6.75299	2.91023	-.878868
.75	6.90406	3.70429	-.997428
.8	7.08511	4.77924	-1.10864
.85	7.30616	6.2502	-1.21498

TSTAR = 1.85

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.94152	.857219	.860623
.1	5.36268	.907862	.726229
.15	5.59744	.836093	.596619
.2	5.75919	.833599	.469366
.25	5.88404	.84359	.344498
.3	5.98832	.87389	.220831
.35	6.08068	.930037	.094781
.4	6.16713	1.01794	-.336599E-01
.45	6.25163	1.14473	-.166835
.5	6.33794	1.32593	-.303593
.55	6.42965	1.57778	-.441536
.6	6.53052	1.9241	-.577109
.65	6.64479	2.38198	-.705543
.7	6.77637	2.97966	-.828023
.75	6.93065	3.77404	-.943386
.8	7.11471	4.84939	-1.05159
.85	7.33862	6.32283	-1.15506

TSTAR = 1.9

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.91852	.862674	.864313
.1	5.34321	.918236	.733482
.15	5.58139	.851278	.607266
.2	5.74649	.85349	.483378
.25	5.87463	.86804	.361795
.3	5.98215	.903388	.241369
.35	6.07784	.96514	.118649
.4	6.16766	1.05922	-.642196E-02
.45	6.25567	1.19278	-.136104
.5	6.34558	1.38034	-.269245
.55	6.44091	1.63747	-.403577
.6	6.54535	1.98677	-.535578
.65	6.66301	2.44636	-.660629
.7	6.79781	3.04543	-.779887
.75	6.95512	3.84011	-.892194
.8	7.14203	4.91585	-.997567
.85	7.36867	6.39154	-1.09829

TSTAR = 1.95

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.89602	.867841	.867837
.1	5.32407	.92808	.740353
.15	5.56548	.865685	.617368
.2	5.73376	.872355	.496648
.25	5.86501	.891234	.378195
.3	5.97563	.93138	.260854
.35	6.07446	.998445	.141271
.4	6.16749	1.09838	.194397E-01
.45	6.25882	1.23837	-.106928
.5	6.35214	1.43196	-.236681
.55	6.45093	1.69409	-.367546
.6	6.55875	2.04622	-.496156
.65	6.67961	2.50744	-.617993
.7	6.81747	3.10782	-.734224
.75	6.97766	3.9028	-.843643
.8	7.16727	4.97891	-.946309
.85	7.39649	6.45681	-1.04447

TSTAR = 2

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.87401	.872759	.871183
.1	5.30525	.937429	.746875
.15	5.54973	.879372	.626982
.2	5.72102	.89028	.50928
.25	5.85524	.913272	.393769
.3	5.96879	.95797	.279377
.35	6.07061	1.03008	.162781
.4	6.16668	1.13558	.439723E-01
.45	6.26118	1.28169	-.792233E-01
.5	6.35774	1.48101	-.205727
.55	6.4598	1.74788	-.33332
.6	6.57084	2.1027	-.458724
.65	6.69474	2.56546	-.577512
.7	6.83551	3.16711	-.690824
.75	6.99844	3.96234	-.797521
.8	7.19061	5.03884	-.897613
.85	7.42229	6.51877	-.993322

TSTAR = 2.05

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.85246	.877433	.874339
.1	5.28673	.946324	.753085
.15	5.53413	.89239	.636114
.2	5.7083	.907331	.521285
.25	5.84533	.934232	.408603
.3	5.96167	.983262	.296999
.35	6.06634	1.06018	.183235
.4	6.16531	1.17097	.673183E-01
.45	6.26281	1.32289	-.528787E-01
.5	6.36246	1.52766	-.176297
.55	6.46762	1.79904	-.300787
.6	6.58172	2.15642	-.423106
.65	6.70853	2.62066	-.53903
.7	6.85206	3.2235	-.649559
.75	7.01759	4.01898	-.753665
.8	7.2122	5.09581	-.851316
.85	7.44621	6.57772	-.944678

TSTAR = 2.1

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.83135	.881885	.8774
.1	5.26851	.954793	.759009
.15	5.5187	.904791	.644801
.2	5.6956	.923568	.532709
.25	5.83532	.954193	.422687
.3	5.95431	1.00735	.313732
.35	6.06169	1.08884	.202722
.4	6.16342	1.20467	.895882E-01
.45	6.26378	1.36213	-.277777E-01
.5	6.36637	1.57209	-.148254
.55	6.4745	1.84778	-.269772
.6	6.59151	2.20759	-.389214
.65	6.72107	2.67323	-.502341
.7	6.86723	3.2772	-.610234
.75	7.03524	4.07293	-.711872
.8	7.23218	5.15007	-.807168
.85	7.46841	6.63388	-.898358

TSTAR = 2.15

N-STAR	F-STAR	P-STAR	U-STAR
.05	4.81067	.88613	.880223
.1	5.25058	.96287	.764608
.15	5.50343	.916611	.653066
.2	5.68294	.939048	.543602
.25	5.82521	.973228	.436216
.3	5.94674	1.03032	.329814
.35	6.0567	1.11617	.221279
.4	6.16106	1.23681	.110776
.45	6.26415	1.39954	-.382741E-02
.5	6.36954	1.61445	-.121548
.55	6.4805	1.89424	-.240198
.6	6.60029	2.25638	-.356879
.65	6.73248	2.72334	-.467327
.7	6.88115	3.32841	-.5728
.75	7.05152	4.12437	-.672039
.8	7.25068	5.20184	-.765209
.85	7.48903	6.68735	-.854115

T-STAR = .7

N-STAR	S-STAR	H-STAR	G-STAR
.05	-5.06126	.964568	6.02583
.1	-5.61664	.438526	6.05517
.15	-5.98097	-.152085	5.82888
.2	-6.26981	-.68557	5.58424
.25	-6.51941	-1.19862	5.32079
.3	-6.74724	-1.71551	5.03173
.35	-6.96561	-2.24431	4.7213
.4	-7.1804	-2.78195	4.39845
.45	-7.39792	-3.33139	4.06652
.5	-7.62088	-3.83649	3.7844
.55	-7.85042	-4.25233	3.59809
.6	-8.08675	-4.50385	3.5829
.65	-8.32936	-4.60923	3.72012
.7	-8.5833	-4.59234	3.99096
.75	-8.85281	-4.37986	4.47294
.8	-9.14496	-3.96543	5.17952
.85	-9.47226	-3.35195	6.12031

T-STAR = .75

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.99059	1.01585	6.00644
.1	-5.54617	.535263	6.08143
.15	-5.91057	-.111097E-01	5.89946
.2	-6.1996	-.501377	5.69822
.25	-6.44935	-.972223	5.47713
.3	-6.67734	-1.44492	5.23242
.35	-6.89577	-1.92656	4.96921
.4	-7.11067	-2.41414	4.69653
.45	-7.32838	-2.91005	4.41833
.5	-7.55149	-3.36281	4.18868
.55	-7.78118	-3.73099	4.05019
.6	-8.01764	-3.94544	4.07221
.65	-8.26037	-4.02067	4.23971
.7	-8.51446	-3.97612	4.53834
.75	-8.78413	-3.74216	5.04198
.8	-9.07643	-3.30703	5.7694
.85	-9.40383	-2.66514	6.73868

T-STAR = .8

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.92474	1.06049	5.98522
.1	-5.48026	.61989	6.10015
.15	-5.84462	.112336	5.95695
.2	-6.13359	-.3399	5.79369
.25	-6.38329	-.773628	5.60966
.3	-6.61122	-1.20746	5.40376
.35	-6.82963	-1.64777	5.18186
.4	-7.04448	-2.09139	4.95309
.45	-7.26216	-2.54026	4.7219
.5	-7.4852	-2.94704	4.53816
.55	-7.71484	-3.27333	4.44151
.6	-7.95126	-3.45517	4.49609
.65	-8.19395	-3.50387	4.69007
.7	-8.44799	-3.43495	5.01305
.75	-8.7176	-3.18198	5.53563
.8	-9.00986	-2.72858	6.28128
.85	-9.33722	-2.06176	7.27546

T-STAR = .85

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.86312	1.09963	5.96275
.1	-5.41865	.694271	6.11292
.15	-5.78301	.220924	6.00393
.2	-6.07199	-.197806	5.87419
.25	-6.3217	-.598842	5.72286
.3	-6.54963	-.99843	5.5512
.35	-6.76804	-1.4023	5.36574
.4	-6.9829	-1.80718	5.17572
.45	-7.20058	-2.21457	4.98601
.5	-7.42363	-2.58085	4.84278
.55	-7.65327	-2.87021	4.78306
.6	-7.88969	-3.02333	4.86636
.65	-8.13239	-3.04867	5.08372
.7	-8.38645	-2.95831	5.42814
.75	-8.65606	-2.68862	5.96744
.8	-8.94831	-2.21912	6.72919
.85	-9.27568	-1.53033	7.74535

T-STAR = .9

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.80518	1.13428	5.93946
.1	-5.36072	.760229	6.12095
.15	-5.72508	.317292	6.04237
.2	-6.01407	-.716536E-01	5.94242
.25	-6.26378	-.443624	5.82016
.3	-6.49172	-.812786	5.67893
.35	-6.71013	-1.18425	5.52588
.4	-6.92499	-1.55469	5.37029
.45	-7.14267	-1.92521	5.21746
.5	-7.36573	-2.2555	5.11023
.55	-7.59537	-2.51204	5.08332
.6	-7.8318	-2.63964	5.19216
.65	-8.07449	-2.64418	5.43031
.7	-8.32855	-2.53474	5.79381
.75	-8.59818	-2.25021	6.34797
.8	-8.89044	-1.76642	7.12402
.85	-9.21781	-1.0581	8.15971

T-STAR = .95

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.75051	1.16515	5.91566
.1	-5.30603	.819139	6.12517
.15	-5.67041	.403395	6.07381
.2	-5.95939	.411183E-01	6.00051
.25	-6.2091	-.304839	5.90426
.3	-6.43704	-.646778	5.79026
.35	-6.65546	-.989262	5.6662
.4	-6.87033	-1.3289	5.54143
.45	-7.08802	-1.66644	5.42158
.5	-7.31107	-1.96451	5.34657
.55	-7.54072	-2.19168	5.34903
.6	-7.77715	-2.29644	5.48071
.65	-8.01985	-2.2824	5.73745
.7	-8.27391	-2.15589	6.11802
.75	-8.54352	-1.85805	6.68546
.8	-8.83579	-1.36146	7.47433
.85	-9.16315	-.635642	8.52751

T-STAR = 1

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.69871	1.19286	5.89157
.1	-5.25423	.872078	6.12631
.15	-5.61861	.480824	6.09944
.2	-5.9076	.142519	6.05012
.25	-6.15732	-.180032	5.97728
.3	-6.38525	-.497457	5.8878
.35	-6.60368	-.81385	5.78983
.4	-6.81855	-1.12576	5.69278
.45	-7.03623	-1.43361	5.60262
.5	-7.25929	-1.70269	5.55661
.55	-7.48893	-1.90343	5.58551
.6	-7.72537	-1.98762	5.73775
.65	-7.96808	-1.95686	6.01121
.7	-8.22214	-1.81499	6.40715
.75	-8.49176	-1.5052	6.98656
.8	-8.78401	-.997083	7.78693
.85	-9.11139	-.255567	8.85582

T-STAR = 1.05

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.6495	1.21788	5.86738
.1	-5.20504	.919899	6.12494
.15	-5.56941	.55081	6.12022
.2	-5.85841	.234201	6.09261
.25	-6.10812	-.671742E-01	6.04095
.3	-6.33606	-.362424	5.97364
.35	-6.55447	-.6552	5.89927
.4	-6.76934	-.942021	5.82732
.45	-6.98703	-1.223	5.76403
.5	-7.2101	-1.46586	5.74424
.55	-7.43975	-1.6427	5.79705
.6	-7.67618	-1.70828	5.9679
.65	-7.91888	-1.66237	6.2565
.7	-8.17294	-1.50661	6.66633
.75	-8.44257	-1.18601	7.25657
.8	-8.73484	-.667455	8.06738
.85	-9.06222	.08829	9.15051

T-STAR = 1.1

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.60264	1.24057	5.84321
.1	-5.15819	.963321	6.12151
.15	-5.52256	.614371	6.13694
.2	-5.81155	.317501	6.12905
.25	-6.06127	.353809E-01	6.09665
.3	-6.28921	-.239718	6.04949
.35	-6.50762	-.511029	5.99659
.4	-6.72249	-.775043	5.94745
.45	-6.94019	-1.03161	5.90857
.5	-7.16325	-1.2506	5.91264
.55	-7.3929	-1.40571	5.98719
.6	-7.62934	-1.45439	6.17494
.65	-7.87203	-1.39472	6.47731
.7	-8.1261	-1.22632	6.89978
.75	-8.39573	-.895864	7.49986
.8	-8.688	-.367855	8.32014
.85	-9.01536	.400849	9.41621

T-STAR = 1.15

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.55792	1.26122	5.81915
.1	-5.11345	1.00293	6.11639
.15	-5.47783	.672372	6.1502
.2	-5.76683	.393509	6.16034
.25	-6.01654	.128971	6.14551
.3	-6.24449	-.127726	6.11676
.35	-6.4629	-.379452	6.08345
.4	-6.67778	-.622639	6.05514
.45	-6.89546	-.856901	6.03856
.5	-7.11852	-1.05412	6.0644
.55	-7.34818	-1.18938	6.1588
.6	-7.58461	-1.22261	6.362
.65	-7.82732	-1.15039	6.67693
.7	-8.08139	-.970453	7.11093
.75	-8.351	-.631007	7.71999
.8	-8.64328	-.094336	8.54894
.85	-8.97065	.686153	9.6568

T-STAR = 1.2

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.51512	1.28014	5.79526
.1	-5.07066	1.03921	6.10987
.15	-5.43504	.725504	6.16055
.2	-5.72402	.463173	6.18719
.25	-5.97374	.214736	6.18848
.3	-6.20169	-.250809E-01	6.1766
.35	-6.42011	-.25885	6.16126
.4	-6.63499	-.482959	6.15203
.45	-6.85267	-.696783	6.15589
.5	-7.07573	-.874035	6.2017
.55	-7.30539	-.991103	6.31428
.6	-7.54183	-1.01018	6.53164
.65	-7.78454	-.926448	6.85809
.7	-8.0386	-.735934	7.30266
.75	-8.30822	-.388258	7.91997
.8	-8.6005	.156338	8.75684
.85	-8.92785	.947669	9.87552

T-STAR = 1.25

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.47409	1.29753	5.77161
.1	-5.02962	1.07258	6.1022
.15	-5.394	.774382	6.16838
.2	-5.68299	.527229	6.21022
.25	-5.93271	.293629	6.22634
.3	-6.16065	.069329	6.22998
.35	-6.37908	-.147916	6.23116
.4	-6.59394	-.354443	6.2395
.45	-6.81164	-.549482	6.26216
.5	-7.03471	-.708382	6.32633
.55	-7.26435	-.808697	6.45565
.6	-7.5008	-.814759	6.68604
.65	-7.74349	-.720404	7.02308
.7	-7.99756	-.520172	7.47739
.75	-8.26719	-.164925	8.10227
.8	-8.55946	.386953	8.94641
.85	-8.88683	1.18822	10.075

T-STAR = 1.3

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.43469	1.31355	5.74824
.1	-4.99023	1.10334	6.09357
.15	-5.35461	.819463	6.17407
.2	-5.64361	.586323	6.22993
.25	-5.89332	.366412	6.25973
.3	-6.12126	.156446	6.27771
.35	-6.33969	-.04555	6.29414
.4	-6.55455	-.235867	6.31869
.45	-6.77225	-.413542	6.35871
.5	-6.99532	-.555489	6.43983
.55	-7.22497	-.640365	6.5846
.6	-7.4614	-.634397	6.82701
.65	-7.7041	-.530274	7.17383
.7	-7.95817	-.321049	7.63712
.75	-8.2278	.411975E-01	8.26899
.8	-8.52007	.599824	9.11989
.85	-8.84746	1.41031	10.2578

T-STAR = 1.35

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.39681	1.32836	5.72516
.1	-4.95234	1.13181	6.08415
.15	-5.31673	.861176	6.17791
.2	-5.60571	.641039	6.24675
.25	-5.85544	.433788	6.28922
.3	-6.08338	.237089	6.32047
.35	-6.3018	.492261E-01	6.35102
.4	-6.51668	-.126097	6.39058
.45	-6.73437	-.28769	6.44668
.5	-6.95744	-.413949	6.54349
.55	-7.18709	-.484518	6.70257
.6	-7.42353	-.467421	6.95611
.65	-7.66623	-.354245	7.31199
.7	-7.9203	-.136707	7.78359
.75	-8.18992	.232019	8.42194
.8	-8.48219	.796891	9.27908
.85	-8.80956	1.61587	10.4254

T-STAR = 1.4

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.36029	1.34212	5.70241
.1	-4.91584	1.15823	6.07407
.15	-5.28021	.899936	6.18014
.2	-5.56922	.691823	6.26104
.25	-5.81893	.496352	6.31528
.3	-6.04688	.311966	6.35884
.35	-6.26529	.137223	6.40251
.4	-6.48017	-.241531E-01	6.45601
.45	-6.69786	-.170825	6.52703
.5	-6.92092	-.282499	6.63842
.55	-7.15058	-.339797	6.81078
.6	-7.38702	-.312365	7.07466
.65	-7.62971	-.190772	7.43894
.7	-7.88378	.03449	7.91827
.75	-8.15341	.409226	8.56264
.8	-8.44568	.979876	9.42555
.85	-8.77305	1.80678	10.5798

T-STAR = 1.45

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.3251	1.35489	5.67999
.1	-4.88064	1.18282	6.06345
.15	-5.24501	.935971	6.18098
.2	-5.53401	.739102	6.27312
.25	-5.78372	.554581	6.3383
.3	-6.01167	.381671	6.39334
.35	-6.23009	.219124	6.44922
.4	-6.44496	.707327E-01	6.51569
.45	-6.66266	-.620529E-01	6.60061
.5	-6.88572	-.160154	6.72557
.55	-7.11537	-.205078	6.9103
.6	-7.35181	-.168018	7.18379
.65	-7.59451	-.385966E-01	7.55591
.7	-7.84858	.193843	8.04243
.75	-8.11821	.57418	8.69239
.8	-8.41049	1.15021	9.5607
.85	-8.73785	1.98449	10.7223

T-STAR = 1.5

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.2911	1.36681	5.65791
.1	-4.84663	1.20577	6.05239
.15	-5.21103	.969594	6.18062
.2	-5.5	.783225	6.28323
.25	-5.74972	.608922	6.35864
.3	-5.97768	.446699	6.42438
.35	-6.1961	.295557	6.49165
.4	-6.41098	.159268	6.57025
.45	-6.62867	.394531E-01	6.66812
.5	-6.85173	-.045979	6.80575
.55	-7.08138	-.793576E-01	7.00202
.6	-7.31782	-.333259E-01	7.2845
.65	-7.56053	.103402	7.66393
.7	-7.81459	.342556	8.15715
.75	-8.08422	.728127	8.81234
.8	-8.37649	1.3092	9.68569
.85	-8.70387	2.15029	10.8542

T-STAR = 1.55

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.25821	1.37797	5.63618
.1	-4.81375	1.22722	6.04096
.15	-5.17813	1.00107	6.1792
.2	-5.46712	.824493	6.29161
.25	-5.71685	.659743	6.37659
.3	-5.94479	.507553	6.45234
.35	-6.16322	.367057	6.53027
.4	-6.37809	.242105	6.6202
.45	-6.59578	.134433	6.73021
.5	-6.81885	.608324E-01	6.87968
.55	-7.04849	.382618E-01	7.08676
.6	-7.28495	.926862E-01	7.37763
.65	-7.52765	.236248	7.7639
.7	-7.78171	.481678	8.26339
.75	-8.05133	.872143	8.92348
.8	-8.34361	1.45792	9.80153
.85	-8.67098	2.30547	10.9765

T-STAR = 1.6

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.22638	1.38841	5.61479
.1	-4.78191	1.24733	6.02924
.15	-5.14631	1.03055	6.17686
.2	-5.43529	.863166	6.29845
.25	-5.68501	.707396	6.3924
.3	-5.91295	.564587	6.47754
.35	-6.13137	.434104	6.56547
.4	-6.34626	.319761	6.66602
.45	-6.56394	.223464	6.7874
.5	-6.78701	.160972	6.94798
.55	-7.01667	.14851	7.16518
.6	-7.2531	.210833	7.46393
.65	-7.4958	.360804	7.85661
.7	-7.74988	.612112	8.36199
.75	-8.0195	1.00715	9.02665
.8	-8.31178	1.59735	9.90912
.85	-8.63914	2.45091	11.0901

T-STAR = 1.65

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.19554	1.39822	5.59375
.1	-4.75109	1.26619	6.01728
.15	-5.11546	1.05825	6.17371
.2	-5.40447	.899464	6.30393
.25	-5.65418	.752132	6.40631
.3	-5.88213	.618133	6.50027
.35	-6.10054	.497041	6.59758
.4	-6.31542	.392696	6.70811
.45	-6.53311	.307069	6.84018
.5	-6.75617	.255023	7.01119
.55	-6.98582	.25208	7.2379
.6	-7.22227	.321782	7.54405
.65	-7.46496	.477789	7.94275
.7	-7.71903	.734627	8.45366
.75	-7.98866	1.13397	9.12263
.8	-8.28094	1.72831	10.0093
.85	-8.60831	2.58752	11.1958

T-STAR = 1.7

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.16562	1.40744	5.57306
.1	-4.72116	1.28396	6.00513
.15	-5.08554	1.08431	6.16985
.2	-5.37454	.933658	6.3082
.25	-5.62425	.794251	6.4185
.3	-5.8522	.668563	6.52076
.35	-6.07062	.556291	6.62692
.4	-6.2855	.461337	6.74683
.45	-6.50318	.385771	6.88896
.5	-6.72626	.343529	7.06979
.55	-6.9559	.349551	7.30545
.6	-7.19235	.426217	7.61856
.65	-7.43505	.587877	8.02293
.7	-7.68911	.849935	8.53904
.75	-7.95874	1.25332	9.21207
.8	-8.25101	1.85158	10.1026
.85	-8.57839	2.71611	11.2945

T-STAR = 1.75

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.13658	1.41613	5.55271
.1	-4.6921	1.30072	5.99283
.15	-5.05649	1.10888	6.16537
.2	-5.34548	.965902	6.31138
.25	-5.59519	.833961	6.42916
.3	-5.82315	.716092	6.53924
.35	-6.04158	.612149	6.65373
.4	-6.25644	.526062	6.7825
.45	-6.47414	.459961	6.93411
.5	-6.69721	.426993	7.1242
.55	-6.92687	.441431	7.3683
.6	-7.1633	.52468	7.68798
.65	-7.40601	.69168	8.09769
.7	-7.66007	.958631	8.6187
.75	-7.92969	1.36585	9.29555
.8	-8.22196	1.96779	10.1897
.85	-8.54935	2.83737	11.3867

T-STAR = 1.8

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.10835	1.42434	5.53269
.1	-4.6639	1.31651	5.98041
.15	-5.02828	1.13206	6.16034
.2	-5.31728	.996312	6.31359
.25	-5.567	.871425	6.43842
.3	-5.79493	.760973	6.5559
.35	-6.01336	.664893	6.67826
.4	-6.22824	.587154	6.8154
.45	-6.44593	.530021	6.97595
.5	-6.66899	.505801	7.17479
.55	-6.89864	.52822	7.42686
.6	-7.13509	.617653	7.75274
.65	-7.37779	.789711	8.1675
.7	-7.63186	1.06129	8.69315
.75	-7.90149	1.4721	9.37359
.8	-8.19376	2.07751	10.2713
.85	-8.52114	2.95182	11.473

T-STAR = 1.85

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.0809	1.4321	5.513
.1	-4.63645	1.33147	5.96792
.15	-5.00082	1.15401	6.15483
.2	-5.28983	1.0251	6.31493
.25	-5.53955	.906891	6.44644
.3	-5.76748	.803425	6.57091
.35	-5.9859	.714806	6.70071
.4	-6.20079	.644968	6.84575
.45	-6.41846	.596319	7.01478
.5	-6.64153	.58036	7.22189
.55	-6.87118	.610319	7.4815
.6	-7.10763	.705622	7.81325
.65	-7.35034	.882442	8.23278
.7	-7.6044	1.15842	8.76281
.75	-7.87403	1.57264	9.44668
.8	-8.1663	2.18133	10.3476
.85	-8.49368	3.06016	11.5538

T-STAR = 1.9

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.05421	1.43943	5.49364
.1	-4.60973	1.34564	5.95537
.15	-4.97412	1.17478	6.1489
.2	-5.26311	1.05237	6.31548
.25	-5.51283	.940489	6.45332
.3	-5.74078	.843628	6.58441
.35	-5.95919	.762075	6.72126
.4	-6.17408	.699723	6.8738
.45	-6.39177	.659084	7.05086
.5	-6.61482	.650983	7.2658
.55	-6.84449	.688073	7.53256
.6	-7.08093	.788933	7.86986
.65	-7.32364	.970275	8.29391
.7	-7.5777	1.2504	8.8281
.75	-7.84732	1.66788	9.5152
.8	-8.13959	2.27967	10.4193
.85	-8.46696	3.16273	11.6297

T-STAR = 1.95

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.02818	1.4464	5.47458
.1	-4.58372	1.35907	5.94279
.15	-4.94811	1.19449	6.1426
.2	-5.23711	1.07822	6.31533
.25	-5.48682	.972352	6.45917
.3	-5.71477	.881773	6.59655
.35	-5.93319	.806901	6.74009
.4	-6.14805	.751695	6.89974
.45	-6.36575	.718656	7.08441
.5	-6.58883	.717962	7.30679
.55	-6.81847	.761849	7.58032
.6	-7.05491	.867993	7.9229
.65	-7.2976	1.05363	8.35124
.7	-7.5517	1.33766	8.88935
.75	-7.82131	1.75822	9.57953
.8	-8.11358	2.37297	10.4865
.85	-8.44096	3.26007	11.701

T-STAR = 2

N-STAR	S-STAR	H-STAR	G-STAR
.05	-4.00282	1.45302	5.45585
.1	-4.55837	1.37183	5.9302
.15	-4.92275	1.21323	6.13598
.2	-5.21174	1.1028	6.31454
.25	-5.46147	1.00262	6.46409
.3	-5.68941	.918024	6.60744
.35	-5.90783	.849499	6.75733
.4	-6.12271	.801026	6.92374
.45	-6.3404	.775238	7.11564
.5	-6.56347	.78161	7.34508
.55	-6.79312	.831936	7.62505
.6	-7.02956	.943074	7.97264
.65	-7.27225	1.1328	8.40505
.7	-7.52633	1.42059	8.94692
.75	-7.79596	1.84404	9.64
.8	-8.08822	2.46161	10.5498
.85	-8.41561	3.35253	11.7681

T-STAR = 2.05

N-STAR	S-STAR	H-STAR	G-STAR
.05	-3.97812	1.45929	5.43741
.1	-4.53364	1.38397	5.91761
.15	-4.89802	1.23104	6.12906
.2	-5.18701	1.12617	6.31319
.25	-5.43673	1.03142	6.46815
.3	-5.66467	.952507	6.61718
.35	-5.8831	.890022	6.77312
.4	-6.09799	.847965	6.94596
.45	-6.31569	.829049	7.14473
.5	-6.53876	.842141	7.3809
.55	-6.76841	.898576	7.66699
.6	-7.00483	1.01451	8.01934
.65	-7.24756	1.20808	8.45563
.7	-7.50162	1.49944	9.00106
.75	-7.77125	1.92566	9.69691
.8	-8.06352	2.54589	10.6094
.85	-8.39089	3.44047	11.8314

T-STAR = 2.1

N-STAR	S-STAR	H-STAR	G-STAR
.05	-3.95395	1.46532	5.41927
.1	-4.5095	1.39554	5.90504
.15	-4.8739	1.248	6.12189
.2	-5.16289	1.14842	6.31131
.25	-5.41263	1.05881	6.47145
.3	-5.64058	.9853	6.62588
.35	-5.85896	.928616	6.78758
.4	-6.07383	.892704	6.96653
.45	-6.29155	.880309	7.17186
.5	-6.51462	.899804	7.41443
.55	-6.74427	.96208	7.70635
.6	-6.98072	1.08251	8.06324
.65	-7.22341	1.27981	8.50322
.7	-7.47747	1.57456	9.05203
.75	-7.74711	2.00342	9.75053
.8	-8.03935	2.62621	10.6656
.85	-8.36677	3.52423	11.891

T-STAR = 2.15

N-STAR	S-STAR	H-STAR	G-STAR
.05	-3.93045	1.47098	5.40143
.1	-4.48597	1.40652	5.8925
.15	-4.85036	1.26414	6.1145
.2	-5.13933	1.16963	6.30897
.25	-5.389	1.08503	6.47403
.3	-5.61693	1.0167	6.63362
.35	-5.83542	.965393	6.80081
.4	-6.05028	.935316	6.9856
.45	-6.26798	.929201	7.19718
.5	-6.49109	.95475	7.44584
.55	-6.72069	1.02263	7.74333
.6	-6.95716	1.14737	8.10454
.65	-7.19981	1.34824	8.54804
.7	-7.45395	1.64614	9.10009
.75	-7.72356	2.07754	9.8011
.8	-8.01589	2.70268	10.7186
.85	-8.34315	3.60412	11.9473

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