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APPENDIX A

To derive Eqs. (4.20) to (4.25), we substitute Eqs. (4.19a), (4.19b) and (4.19c) into Eqs. (4.15), (4.16) and (4.17). From Eq. (4.15)

$$(a_{-1}\Delta_{ph}^{-1} + a_1\Delta_{ph})\Delta_{ph} = \omega_n + \frac{\Gamma_s(b_{-1}\Delta_{ph}^{-1}+b_1\Delta_{ph}-a_{-1}\Delta_{ph}^{-1}-a_1\Delta_{ph})}{(1+b_{-1}^2\Delta_{ph}^2+b_1^2\Delta_{ph}^2+2b_{-1}b_1)^{1/2}}$$

$$= \omega_n + \frac{\Gamma_s\left[(b_{-1}-a_{-1})\Delta_{ph}^{-1}+(b_1-a_1)\Delta_{ph}\right]}{b_{-1}\Delta_{ph}^{-1}(b_{-1}^{-2}\Delta_{ph}^2+1+b_{-1}^{-2}b_1^2\Delta_{ph}^4+2b_{-1}^{-1}b_1\Delta_{ph}^2)^{1/2}}$$

Keeping only terms to the second order,

$$a_{-1}+a_1\Delta_{ph}^2 = \omega_n + \frac{\Gamma_s\Delta_{ph}\quad(b_{-1}-a_1)\Delta_{ph}^{-1}+(b_1-a_1)\Delta_{ph}}{b_{-1}\left[1+\left(\frac{1+2b_{-1}b_1}{b_{-1}^2}\right)\Delta_{ph}^2\right]^{1/2}}$$

$$= \omega_n + \frac{\Gamma_s\Delta_{ph}}{b_{-1}}\left[(b_{-1}-a_1)\Delta_{ph}^{-1}+(b_1-a_1)\Delta_{ph}\right]$$

$$\left[1-\frac{\frac{1}{2}(1+2b_{-1}b_1)}{b^2}\Delta_{ph}^2\right]$$

$$= \omega_n + \frac{\Gamma_s}{b_{-1}}\left[(b_{-1}-a_{-1})-\tfrac{1}{2}(b_{-1}-a_{-1})\frac{(1+2b_{-1}b_{-1})}{b_{-1}^2}\Delta_{ph}^2\right.$$

$$\left. + (b_1-a_1)\Delta_{ph}^2\right]$$

Equating the coefficients of Δ_{ph}, we have

$$a_{-1} = \omega_n + \frac{\Gamma_s}{b_{-1}} (b_{-1}-a_{-1}) \tag{A1}$$

$$a_1 = \frac{\Gamma_s}{b_{-1}} \left[(b_1-a_1) - \tfrac{1}{2}(b_{-1}-a_{-1}) \frac{(1+2b_{-1}b_1)}{b_{-1}^2} \right] \tag{A2}$$

From Eqs. (4.16) and (4.17), we have

$$\frac{\Gamma_N}{a_{-1}} (b_{-1}-a_{-1}) = \omega_n + \frac{n_I \Gamma_d}{\pi N_N(0)} \frac{(c_{-1}-b_{-1})}{c_{-1}^2} \left(\frac{b_{-1}}{b_{-1}+\Gamma_d} \right) \tag{A3}$$

$$\frac{\Gamma_N}{a_{-1}} \left[(b_1-a_1) - \tfrac{1}{2}(b_{-1}-a_{-1}) \frac{(1+2a_{-1}a_1)}{a_{-1}^2} \right] = \frac{n_I \Gamma_d}{\pi N_N(0)} \frac{1}{c_{-1}^2} \left(\frac{b_{-1}}{\alpha b_{-1}^2+\Gamma_d} \right) \left[(c_1-b_1) + \frac{\Gamma_d}{2b_{-1}} (c_{-1}-b_{-1}) \left(\frac{b_{-1}}{b_{-1}+\Gamma_d} \right) \frac{(1+2b_{-1}b)}{b_{-1}^2} - (c_{-1}-b_{-1}) \frac{(1+2c_{-1}c)}{c_{-1}^2} \right] \tag{A4}$$

and

$$c_1 = \frac{\Gamma_d}{\alpha b_{-1}} \left[(b_1-c_1) - \tfrac{1}{2}(b_{-1}-c_{-1}) \frac{(1+2b_{-1}b_1)}{b_{-1}^2} \right] \tag{A5}$$

$$c_{-1} = \frac{\omega_n}{\alpha} + \frac{\Gamma_d}{\alpha b_{-1}} (b_{-1}-c_{-1}) \tag{A6}$$

Eqs.(A1) and (A6) can be rewritten

$$a_{-1} = \frac{(\omega_n + \Gamma_s) b_{-1}}{(b_{-1} + \Gamma_s)} \tag{A7}$$

$$c_{-1} = \frac{(\omega_n + \Gamma_d)\, b_{-1}}{(\, b_{-1} + \Gamma_d)} \tag{A8}$$

Substituting Eqs.(A7) and (A8) into Eq.(A3) and factoring out b_{-1}, we obtain

$$b_{-1} = \frac{\omega_n + \dfrac{\Gamma_N\, \omega_n}{(\omega_n + \Gamma_s)} + \dfrac{n_I \Gamma_d}{\pi N_N(O)} \dfrac{\omega_n}{(\omega_n + \Gamma_d)^2}}{\dfrac{\Gamma_N}{(\omega_n + \Gamma_s)} + \dfrac{n_I \Gamma_d}{\pi N_N(O)} \dfrac{\alpha}{(\omega_n + \Gamma_d)^2}} \tag{A9}$$

Eqs. (A2) and (A5) can be rewritten

$$a_1 = \frac{\Gamma_s\, a_{-1} b_1}{b_{-1}(b_{-1} + \Gamma_s)} - \frac{\Gamma_s (b_{-1} - a_{-1})}{2b_{-1}^2 (b_{-1} + \Gamma_s)} \tag{A10}$$

$$c_1 = \frac{\Gamma_d c_{-1} b_1}{b_{-1}(\alpha b_{-1} + \Gamma_d)} - \frac{\Gamma_d\, (b_{-1} - c_{-1})}{2b_{-1}^2 (\alpha b_{-1} + \Gamma_d)} \tag{A11}$$

Substituting Eqs.(A10) and (A11) into Eq.(A4), we obtain

$$b_1 = \left[\frac{n_I \Gamma_d (c_{-1} - b_{-1})(\Gamma_d c_{-1} - \Gamma_d b_{-1} - \alpha b_{-1}^2)}{\pi N_N(O)\, c_{-1}^4 (\alpha b_{-1} + \Gamma_d)^2} \right.$$

$$\left. + \frac{\Gamma_N (a_{-1} - b_{-1})(\Gamma_s a_{-1} - \Gamma_s b_{-1} - b_{-1}^2)}{2a_{-1}^3\, b_{-1} (b_{-1} + \Gamma_s)} \right] \Big/ \Big[\tag{A12}$$

$$\frac{\Gamma_N b_{-1}}{a_{-1}(b_{-1}+\Gamma_s)} + \frac{\alpha\, n_I\, \Gamma_d\; b_{-1}^2}{\pi\, N_N(0)\, c_{-1}^2(\alpha b_{-1}+\Gamma_d)^2}\Bigg]$$

APPENDIX B

To derive Eq. (4.36) we may start from deriving a formula to calculate by a purely thermodynamic method various mean values. To do so, we assume that a body undergoes an adiabatic process, and determine the time derivative dE/dt of its energy. By definition the thermodynamic energy is

$$E = \langle H(p, q; \lambda) \rangle$$

where $H(p,q;\lambda)$ is the Hamiltonian of the body, depending on λ as a parameter describing an external condition; $\langle \ldots\ldots \rangle$ represents the average over the statistical distribution. We know from mechanics that the total time derivative of the Hamiltonian is equal to its partial time derivative:

$$\frac{dH(p,q;\lambda)}{dt} = \frac{\partial H(p,q;\lambda)}{\partial t}$$

In the present case $H(p,q;\lambda)$ depends explicitly on the time through $\lambda(t)$, and we can therefore write

$$\frac{dH(p,q;\lambda)}{dt} = \frac{\partial H(p,q;\lambda)}{\partial \lambda} \frac{d\lambda}{dt}$$

Since the operations of the averaging over the statistical distribution and differentiating with respect to time can clearly be interchange, we have

$$\frac{dE}{dt} = \left\langle \frac{dH(p,q;\lambda)}{dt} \right\rangle = \left\langle \frac{\partial H(p,q;\lambda)}{\partial \lambda} \right\rangle \frac{d\lambda}{dt} \qquad \text{(B1)}$$

The derivative $d\lambda/dt$ is a given function of time , and can be taken outside the averaging.

The derivative dE/dt can also be written in another form by regarding the thermodynamic quantity E as a function of the entropy S of the body and the external parameter λ . Since, in an adiabatic process, the entropy S remains constant, we have

$$\frac{dE}{dt} = \left(\frac{\partial E}{\partial \lambda}\right)_S \frac{d\lambda}{dt} \tag{B2}$$

where the subscript to the parenthesis indicates that the derivative is taken for constant S. Comparison of Eq. (B1) and Eq. (B2) shows that

$$\left\langle \frac{\partial H(p,q;\lambda)}{\partial \lambda} \right\rangle = \left(\frac{\partial E}{\partial \lambda}\right)_S \tag{B3}$$

In our case it is convenient to start from the thermodynamic potential Ω , since the whole discussion takes place for a constant chemical potential of the system, not a constant number of particles in it. The thermodynamic potential Ω is defined by

$$\Omega = E = TS + PV$$

If there are other parameter λ_i besides the volume which define the state of the system, the expression for the differential of the energy must be augmented by terms proportional to the differentials $d\lambda_i$:

$$dE = TdS - PdV + \sum_i \Lambda_i \, d\lambda_i \tag{B4}$$

where Λ_i are some functions of the state of the body. Since the transformation to other potentials does not affect the variable λ_i, it is clear that similar terms will be added to the differentials Ω :

$$d\Omega = - SdT + VdP + \sum_i \Lambda_i \, d\lambda_i \tag{B5}$$

Using Eq. (B3) we can write down the analogous relation

$$\left(\frac{\partial\Omega}{\partial\lambda}\right)_{P,T} = \left\langle \frac{\partial H(p,q;\lambda)}{\partial\lambda} \right\rangle \tag{B6}$$

We get from this

$$\Omega_s - \Omega_n = \int_0^{\Delta_s^{ph}} d\,\Delta_S^{ph} \,(\Delta_S^{ph})^2 \,\frac{d(1/\lambda_s)}{d\,\Delta_S^{ph}}$$

where we have taken λ in Eq. (B6) to be the pairing constant λ_S .

APPENDIX C

In this appendix, we show the computer program in BASIC and the numerical results for the calculations of T_c/T_{co} and $\Delta C/\Delta C_o$ from Eqs.(4.26) and (4.35).

```
10 KB = 1.38062E - 23 / 1.60219E -
   19
20 PI = 3.1415926:TB = 7.193
30 GD = .75
40 GB = 1.76 * KB * TB
50 GN = .8 * GB
60 GS = .2 * GB
70 AL =  - 4
75 T = TB:N = 0: GOSUB 670
76 BB = S
80  PRINT "n","Tc/Tco","DC/DCo"
85  PRINT "----","-------","------
   "
90  DEF  FN R(Z) =  INT (10 ^ 4 *
   Z + .5) / 10 ^ 4
100  FOR N = 0 TO 3 STEP .05
110 A = 1:B = 11:H = (B - A) / 10

120 T1 = A:T = T1: GOSUB 530
130 S1 = S:Y1 =  LOG (T1 / TB) +
    S1
140  IF Y1 = 0 THEN 350
150 T2 = B:T = T2: GOSUB 530
160 S2 = S:Y2 =  LOG (T2 / TB) +
    S2
170  IF Y2 = 0 THEN 360
180  IF Y1 * Y2 > 0 THEN 480
190  IF  ABS (Y1) <  ABS (Y2) THEN
    210
200  IF  ABS (Y1) >  ABS (Y2) THEN
    260
210 T2 = T1 + H:T = T2: GOSUB 530

220 S2 = S:Y2 =  LOG (T2 / TB) +
    S2
230  IF Y2 = 0 THEN 360
240  IF Y1 * Y2 < 0 THEN 310
250 T1 = T2:S1 = S2:Y1 = Y2: GOTO
    210
260 T1 = T2 - H:T = T1: GOSUB 530

270 S1 = S:Y1 =  LOG (T1 / TB) +
```

```
     S1
280  IF Y1 = 0 THEN 350
290  IF Y1 * Y2 < 0 THEN 310
300 T2 = T1:S2 = S1:Y2 = Y1: GOTO
     260
310  IF H < 1E - 05 THEN 330
320 H = (T2 - T1) / 10: GOTO 190
330  IF  ABS (Y1) <  ABS (Y2) THEN
     350
340  IF  ABS (Y1) >  ABS (Y2) THEN
     360
350 TC = T1:B = S1: GOTO 370
360 TC = T2:B = S2
370  REM CALCULATE B0 PRIME
380 T = TC + 1E - 04: GOSUB 530
390 BD = S
400 Y = (BD - B) / 1E - 04
410  REM  CALCULATE B1
420 T = TC: GOSUB 670
430  REM  CALCULATE HEAT JUMP
440 V = (TC * BB * (1 + TC * Y) ^
     2) / (TB * S)
450  PRINT N, FN R(TC / TB), FN R
     (V)
460  NEXT N
470  END
480  PRINT "OUT OF RANGE IN 110"
490  END
530 S = 0
540  FOR K = 1 TO 61 STEP 2
550 W = K * PI * KB * T
560 B1 = (GN * W) / (W + GS)
570 B2 = (N * GD * W) / (PI * 0.2
     9 * (W + GD) ^ 2)
580 B3 = GN / (W + GS)
590 B4 = (N * GD * AL) / (PI * 0.
     29 * (W + GD) ^ 2)
600 BM = (W + B1 + B2) / (B3 + B4
     )
610 AM = (W + GS) * BM / (BM + GS
     )
630 SI = ((1 / W) - (1 / AM)) * 2
      * PI * KB * T
640 S = S + SI
```

```
650  NEXT K
660  RETURN
670 S = 0
680  FOR K = 1 TO 61 STEP 2
690 W = K * PI * KB * T
700 B1 = (GN * W) / (W + GS)
710 B2 = (N * GD * W) / (PI * 0.2
     9 * (W + GD) ^ 2)
720 B3 = GN / (W + GS)
730 B4 = (N * GD * AL) / (PI * 0.
     29 * (W + GD) ^ 2)
740 BM = (W + B1 + B2) / (B3 + B4
     )
750 AM = (W + GS) * BM / (BM + GS
     )
760 CM = (W + GD) * BM / (AL * BM
      + GD)
770 B5 = (N * GD * (CM - BM) * (G
     D * CM - GD * BM - AL * BM ^
     2)) / (PI * .29 * CM ^ 4 * (
     AL * BM + GD) ^ 2)
780 B6 = (GN * (AM - BM) * (GS *
     AM - GS * BM - BM * BM)) / (
     2 * AM ^ 3 * BM * (BM + GS))

790 B7 = (AL * N * GD * BM ^ 2) /
     (PI * .29 * CM ^ 2 * (AL * B
     M + GD) ^ 2)
800 B8 = (GN * BM) / (AM * BM + A
     M * GS)
810 BP = (B5 + B6) / (B7 + B8)
813 A1 = (GS * AM * BP) / (BM * B
     M + BM * GS)
815 A2 = (GS * (AM - BM)) / (2 *
     BM * BM * (BM + GS))
820 AP = A1 + A2
830 SI = (2 * PI * KB * T) ^ 3 *
     (2 * AP + (1 / AM)) * (1 / A
     M) ^ 2
840 S = S + SI
850  NEXT K
860  RETURN
```

Numerical Result

For $\alpha = -1$

n	Tc/Tco	DC/DCc
0	.8035	.6058
.05	.7853	.5827
.1	.7686	.5614
.15	.7532	.5418
.2	.7388	.5235
.25	.7254	.5064
.3	.7129	.4907
.35	.7011	.476
.4	.6899	.4623
.45	.6794	.4493
.5	.6695	.4371
.55	.66	.4257
.6	.651	.415
.65	.6424	.4048
.7	.6342	.3952
.75	.6263	.3861
.80	.6188	.3774
.85	.6115	.3692
.90	.6046	.3613
.95	.5979	.3538
1	.5914	.3467
1.05	.5851	.3398
1.1	.5791	.3333
1.15	.5732	.3269
1.2	.5676	.3208
1.25	.5621	.3151
1.3	.5568	.3094
1.35	.5516	.304
1.4	.5465	.2988
1.45	.5416	.2938
1.5	.5369	.289
1.55	.5322	.2843
1.6	.5277	.2797
1.65	.5232	.2754
1.7	.5189	.2711
1.75	.5147	.2669
1.8	.5106	.263
1.85	.5065	.2591
1.9	.5026	.2553
1.95	.4987	.2517

2	.4949	.2481
2.05	.4911	.2447
2.1	.4875	.2413
2.15	.4839	.238
2.2	.4803	.2348
2.25	.4769	.2317
2.3	.4735	.2286
2.35	.4701	.2257
2.4	.4668	.2228
2.45	.4636	.22
2.5	.4604	.2172
2.55	.4572	.2145
2.6	.4541	.2118
2.65	.451	.2093
2.7	.448	.2067
2.75	.445	.2043
2.8	.4421	.2019
2.85	.4392	.1995
2.9	.4363	.1972
2.95	.4334	.1949

For $\alpha = -2$

n	Tc/Tco	DC/DCo
0	.8035	.6058
.05	.7709	.5664
.1	.7408	.5301
.15	.7126	.4971
.2	.6862	.4669
.25	.6612	.4391
.3	.6375	.4138
.35	.6149	.3906
.4	.5933	.3691
.45	.5725	.3493
.5	.5525	.331
.55	.5331	.314
.6	.5142	.2982
.65	.4957	.2835
.7	.4777	.2699
.75	.4599	.2572
.80	.4424	.2455
.85	.425	.2347
.90	.4077	.2248
.95	.3903	.2161
1	.3729	.2087
1.05	.3552	.2028
1.1	.3371	.1993

For $\alpha = -4$

n	Tc/Tco	DC/DCo
0	.8035	.6058
.05	.7419	.5339
.1	.6837	.4696
.15	.6282	.4135
.2	.5746	.3648
.25	.5224	.3228
.3	.4708	.2873
.35	.4192	.2581
.4	.3667	.2367
.45	.3123	.2284

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