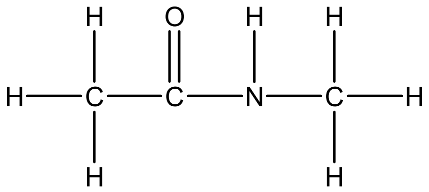
Supplemental Information for: Walker, R.C., Crowley, M.F., Case, D.A., "The Implementation of a Fast and Efficient Hybrid QM/MM Potential Method in AMBER", J.Comp.Chem, 2007

Reproducing AMBER Gas Phase Pure QM Numbers

The following information explains how to modify various semiempirical quantum chemistry codes in order to reproduce the energies reported by AMBER's QM/MM routines. These changes only address problems with the energy calculations they do not fix issues with the gradients.

The following system (NMA) was simulated as pure QM in gas phase for a single energy evaluation:



Coordinates used for all calculations:

```
ATOM      1 1HH3 ACE     1       0.607   2.037   1.244
ATOM      2  CH3 ACE     1       1.220   1.233   0.842
ATOM      3 2HH3 ACE     1       1.949   0.900   1.607
ATOM      4 3HH3 ACE     1       1.789   1.703   0.001
ATOM      5  C   ACE     1       0.317   0.082   0.291
ATOM      6  O   ACE     1      -0.853   0.027   0.665
ATOM      7  N   NME     2       0.801  -0.782  -0.721
ATOM      8  H   NME     2       1.486  -0.497  -1.392
ATOM      9  CH3 NME     2      -0.084  -1.889  -1.266
ATOM     10 1HH3 NME     2      -1.150  -1.599  -1.223
ATOM     11 2HH3 NME     2       0.220  -2.247  -2.261
ATOM     12 3HH3 NME     2       0.026  -2.732  -0.586
TER
END
```

All coordinate values beyond the third decimal place were truncated with zeros.

Calculation Details:

All atoms treated quantum mechanically.
Gas Phase with no periodic boundaries.
Single point energy evaluation only.
SCF Convergence = 1.0×10^{-8}

Summary of Results

Where the necessary code did not print the energy to a sufficient number of places a print statement was added to the code to print the SCF energy to 8 decimal places.

AM1/PM3 SCF Energy (kcal/mol)

Distributed Code

Code	AM1 ESCF	PM3 ESCF
AMBER v9.0	-34.92134208	-44.35423579
CHARMM c33b1	-34.97754796	-44.40827788
MOPAC v6.0[a]	-34.82651486	-44.27659532
MOPAC 2007[b]	-34.90320	-44.39969
DYNAMO v2.0	-34.92134208	-44.35423579
Gaussian 03 Rev C.01	-34.92688286 -34.97477068[c]	-44.42158626 -44.40566821[c]

[a] It was not possible to compile a working version of Mopac 7.0.
[b] Source code not available so higher precision printing not possible.
[c] with iop(4/22=100) set

After Modifications Detailed Below

Code	AM1 ESCF	PM3 ESCF
AMBER v9.0	-34.92134208	-44.35423579
CHARMM c33b1	-34.92134208	-44.35423579
MOPAC v6.0	-34.92134209	-44.35423579
MOPAC 2007[a]	N/A	N/A
DYNAMO v2.0	-34.92134208	-44.35423579
Gaussian 03 Rev C.01	-34.92134208	-44.35423579

[a] Source code for MOPAC 2007 was not available at the time of writing and so the use of consistent constants or cut offs could not be checked.

Input Files (AM1 input files shown)

AMBER 9.0

```
&cntrl
   imin =0,irest=0,ntx=1,
   nstlim=0,0
   ntb=0, cut=999.,
   ntt=0,tempi=0.0,
   ifqnt=1
 /
 &qmmm
   qmmask='@*',
   qmtheory=2, qmcharge=0, scfconv=1.0d-8,
   verbosity=3,
 /
```

CHARMM c33b1

```
open read form unit 11 name top_all27_prot_na.rtf
read rtf card unit 11
close unit 11

open read form unit 11 name par_all27_prot_na.prm
read param card unit 11
close unit 11

read rtf card append
**
*
   30    1

RESI NMA          0.00 ! N-methylacetamide
GROUP
ATOM CL   CT3    0.000
ATOM HL1  HA     0.000
ATOM HL2  HA     0.000
ATOM HL3  HA     0.000
ATOM C    C      0.000
ATOM O    O      0.000
ATOM N    NH1    0.000
ATOM H    H      0.000
ATOM CR   CT3    0.000
ATOM HR1  HA     0.000
ATOM HR2  HA     0.000
ATOM HR3  HA     0.000
END

Read sequ card
* nma
*
1
NMA

Generate nma setup  angle dihedral first none last none
autogenerate angle dihed

open unit 1 form read name nma.pdb
read coor pdb unit 1

quantum am1 scfcrt 1.0d-8 analyt sele all end
ener
stop
```

MOPAC v6.0 & MOPAC2007

```
AM1 NOMM GEO-OK SCFCRT=1.0D-8 ANALYT 1SCF


  H    0.607000  1    2.037000  1    1.244000  1
  C    1.220000  1    1.233000  1    0.842000  1
  H    1.949000  1    0.900000  1    1.607000  1
  H    1.789000  1    1.703000  1    0.001000  1
  C    0.317000  1    0.082000  1    0.291000  1
  O   -0.853000  1    0.027000  1    0.665000  1
```

```
  N    0.801000  1   -0.782000  1   -0.721000  1
  H    1.486000  1   -0.497000  1   -1.392000  1
  C   -0.084000  1   -1.889000  1   -1.266000  1
  H   -1.150000  1   -1.599000  1   -1.223000  1
  H    0.220000  1   -2.247000  1   -2.261000  1
  H    0.026000  1   -2.732000  1   -0.586000  1
```

DYNAMO v2.0

```
program nma_energy
use dynamo
implicit none
call dynamo_header
call xyz_define("nma.xyz")
call mopac_setup("AM1")
call mopac_scf_parameters( ACCURACY = 4.184D-09 )
call energy
end program nma_energy
```

Gaussian 2003 C.01.

```
#P AM1 scf=(conver=8) iop(4/22=100)

NMA Energy

 0  1
H       0.607  2.037  1.244
C       1.220  1.233  0.842
H       1.949  0.900  1.607
H       1.789  1.703  0.001
C       0.317  0.082  0.291
O      -0.853  0.027  0.665
N       0.801 -0.782 -0.721
H       1.486 -0.497 -1.392
C      -0.084 -1.889 -1.266
H      -1.150 -1.599 -1.223
H       0.220 -2.247 -2.261
H       0.026 -2.732 -0.586
```

Note: For original (unmodified) Gaussian run do not include the iop statement.

Code Changes Required

CHARMM c33b1

1) quantum/qmene.src

Line 3240: AOC = 0.529167D0 **--->** AOC = 0.529177249D0
Line 3250: AOC = 0.529167D0 **--->** AOC = 0.529177249D0
Line 3371: AOC = 0.529167D0 **--->** AOC = 0.529177249D0
Line 4080: AOC = 0.529167D0 **--->** AOC = 0.529177249D0

2) quantum/qmjunc.src

Line 1524: AOC = 0.529167D0 **--->** AOC = 0.529177249D0

3) quantum/qmleps.src

Line 370: F1 = 627.5095D0 **--->** F1 = 627.509D0

Line 371: F2 = 0.529177106D0 ---> F2 = 0.529177249D0
Line 558: PARAMETER (CKCAL = 627.5095D0) --->
PARAMETER (CKCAL = 627.509D0)
Line 559: PARAMETER (CANGS = 0.529177106D0) --->
PARAMETER (CANGS = 0.529177249D0)
Line 743: F1 = 627.5095D0 ---> F1 = 627.509D0
Line 744: F2 = 0.529177106D0 ---> F2 = 0.529177249D0
Line 743: F1 = 627.5095D0 ---> F1 = 627.509D0
Line 952: F2 = 0.529177106D0 ---> F2 = 0.529177249D0
Line 1247: PARAMETER (CKCAL = 627.5095D0) --->
PARAMETER (CKCAL = 627.509D0)
Line 1248: PARAMETER (CANGS = 0.529177106D0) --->
PARAMETER (CANGS = 0.529177249D0)
Line 1278: PARAMETER (CKCAL = 627.5095D0) --->
PARAMETER (CKCAL = 627.509D0)
Line 1279: PARAMETER (CANGS = 0.529177106D0) --->
PARAMETER (CANGS = 0.529177249D0)

4) quantum/qmpac.src
Line 2679: 1-XJ(NBT))*3.5711928576D0 ---> 1-XJ(NBT))*(1.0d0/0.529177249D0**2)
Line 2683: TOMB=(XI(NAT)-XJ(NAT)*1.877976D0 --->
TOMB=(XI(NAT)-XJ(NAT)*(1.0d0/0.529177249D0)
Line 2687: TOMB=(XI(NBT)-XJ(NBT)*1.877976D0 --->
TOMB=(XI(NBT)-XJ(NBT)*(1.0d0/0.529177249D0)
Line 2931: AOC = 0.529167D0 ---> AOC = 0.529177249D0

MOPAC v6.0

NOTE: These changes fix both bugs and inconsistent use of constants. Note that part of the reason that MOPAC and related codes have poor gradient accuracy is due to the inconsistent use of conversion factors. For example in MOPAC v6 the conversion from Bohrs to Angstroms used in hcore.f is 0.529177 while in analyt.f, delri.f, ders.f, diat2.f, diat.f and gover.f it is 0.529167 Similarly MOPAC uses 1.88976 to represent 1.0/0.529177 and 3.5711928576 to represent $(1.0/0.529177)^2$.

1) analyt.f
Line 47: A0=0.529167D0 ---> A0=0.529177249D0

2) delri.f
Line 22: A0=0.529167D0 ---> A0=0.529177249D0

3) ders.f
Line 20: A0=0.529167D0 ---> A0=0.529177249D0

4) diat.f
Line 27: LOGICAL ANALYT ---> LOGICAL ANALYT; SAVE ANALYT
Line 142: R=R1/0.529167D0 ---> R=R1/0.529177249D0

5) diat2.f
Line 37: RAB=R12/0.529167D0 ---> RAB=R12/0.529177249D0

6) ef.f
Line 193: XINC=0.00529167D0 ---> XINC=0.00529177249D0

7) esp.f

Line 503: BOHR = 0.529167D00 ---> BOHR = 0.529177249D00
Line 681: DATA BOHR/0.529167D0/ ---> DATA BOHR/0.529177249D0/
Line 1012: BOHR = 0.529167D00 ---> BOHR = 0.529177249D00
Line 1014: CF=5.2917715D-11*1.601917D-19/3.33564D-30 --->
CF=5.29177249D-11*1.601917D-19/3.33564D-30
Line 1109: RMS=RMS*627.51D0 ---> RMS=RMS*627.509D0
Line 1327: DATA BOHR/0.529167D0/ ---> DATA BOHR/0.529177249D0/
Line 1474: DATA BOHR/0.529167D0/ ---> DATA BOHR/0.529177249D0/
Line 1682: DATA BOHR/0.529167D0/ ---> DATA BOHR/0.529177249D0/

8) gover.f
Line 40: R=R/0.529167D0 ---> R=R/0.529177249D0
Line 57: 1-XJ(NBT))*3.5711928576D0 ---> 1-XJ(NBT))*(1.0d0/0.529177249D0**2)
Line 61: TOMB=(XI(NAT)-XJ(NAT))*1.88976D0 --->
TOMB=(XI(NAT)-XJ(NAT))*(1.0d0/0.529177249D0)
Line 65: TOMB=(XI(NBT)-XJ(NBT))*1.88976D0 --->
TOMB=(XI(NBT)-XJ(NBT))* (1.0d0/0.529177249D0)
Line 78: IF((ADB*R).LT.90.D0) THEN ---> IF((ADB*R).LT.30.D0) THEN
Line 82: ABN=2.*TOMB*Z(I,K)*SQRT(Z(J,L))/AMB --->
ABN=2.0d0*TOMB*Z(I,K)*SQRT(Z(J,L))/AMB
Line 84: ABN=-2.*TOMB*Z(J,L)*SQRT(Z(I,K))/AMB --->
ABN=-2.*TOMB*Z(J,L)*SQRT(Z(I,K))/AMB
Line 89: S(K,L)=SQRT((2.*SQRT(APB)/AMB)**3)*EXP(-ADB*R)*ABN --->
S(K,L)=SQRT((2.0d0*SQRT(APB)/AMB)**3)*EXP(-ADB*R)*ABN

9) hcore.f
Line 72: HTERME = -0.529177D00*DD(NI)*EFIELD(1)*FLDCON --->
HTERME = -0.529177249D00*DD(NI)*EFIELD(1)*FLDCON
Line 76: HTERME = -0.529177D00*DD(NI)*EFIELD(2)*FLDCON --->
HTERME = -0.529177249D00*DD(NI)*EFIELD(2)*FLDCON
Line 80: HTERME = -0.529177D00*DD(NI)*EFIELD(3)*FLDCON --->
HTERME = -0.529177249D00*DD(NI)*EFIELD(3)*FLDCON
Immediately before line 103 (call to hcore) add:
*if (((COORD(1,I)-COORD(1,J))**2+(COORD(2,I)-COORD(2,J))**2+*
*1(COORD(1,I)-COORD(1,J))**2) >= 100.0d0) goto 45*
Immediately after line 113: H(II)=H(II)+DI(I2,J2) add:
45 CONTINUE

10) powsq.f
Line 69: XINC=0.00529167D0 ---> XINC=0.00529177249D0
Line 321: 350 BMAT(K,ID) = SIG(K)/0.529167D0 --->
350 BMAT(K,ID) = SIG(K)/0.529177249D0

11) repp.f
Line 50: DATA A0/0.529167D0/ ,EV/27.21D0/, EV1/13.605D0/, EV2/6.8025D0/, --->
DATA A0/0.529177249D0/ ,EV/27.21D0/, EV1/13.605D0/, EV2/6.8025D0/,

12) calpar.f
Line 129: GDD1= (P2*HSP(I)/(27.21* 4.*DD(I)**2))**(1./3.) --->
GDD1= (P2*HSP(I)/(27.21D0* 4.0D0*DD(I)**2))**(1.0D0/3.0D0)
Line 130: GQQ= (P4*HPP/(27.21*48.*QQ(I)**4))**0.2 --->
GQQ= (P4*HPP/(27.21D0*48.0D0*QQ(I)**4))**0.2D0
Line 132: D2=GDD1+0.04 ---> D2=GDD1+0.04D0
Line 133: Q2=GQQ+0.04 ---> Q2=GQQ+0.04D0
Line 137: HSP1= 2.*D1 - 2./SQRT(4.*DD(I)**2+1./D1**2) --->
HSP1= 2.0D0*D1 - 2.0D0/SQRT(4.0D0*DD(I)**2+1.0D0/D1**2)

Line 138: HSP2= 2.*D2 - 2./SQRT(4.*DD(I)**2+1./D2**2) **--->**
HSP2= 2.0D0*D2 - 2.0D0/SQRT(4.0D0*DD(I)**2+1.0D0/D2**2)
Line 141: D3= D1 + DF*(HSP(I)/27.21-HSP1)/(HSP2-HSP1) **--->**
D3= D1 + DF*(HSP(I)/27.21D0-HSP1)/(HSP2-HSP1)
Lines 147 -> 150

```
HPP1= 4.*Q1 - 8./SQRT(4.*QQ(I)**2+1./Q1**2)
1          + 4./SQRT(8.*QQ(I)**2+1./Q1**2)
HPP2= 4.*Q2 - 8./SQRT(4.*QQ(I)**2+1./Q2**2)
1          + 4./SQRT(8.*QQ(I)**2+1./Q2**2)
```

change to

```
HPP1= 4.0D0*Q1 - 8.0D0/SQRT(4.0D0*QQ(I)**2+1.0D0/Q1**2)
1          + 4.0D0/SQRT(8.0D0*QQ(I)**2+1.0D0/Q1**2)
HPP2= 4.0D0*Q2 - 8.0D0/SQRT(4.0D0*QQ(I)**2+1.0D0/Q2**2)
1          + 4.0D0/SQRT(8.0D0*QQ(I)**2+1.0D0/Q2**2)
```

Line 153: Q3= Q1 + QF*(HPP/27.21-HPP1)/(HPP2-HPP1) **--->**
Q3= Q1 + QF*(HPP/27.21D0-HPP1)/(HPP2-HPP1)
Line 157: AM(I)= GSS(I)/27.21 **--->** AM(I)= GSS(I)/27.21D0

13) ffhpol.f
Line 47: AUTOKC = 23.061D+00*27.2107D+00 **--->** AUTOKC = 23.061D+00*27.21D+00
Line 196: HNUCJ = HNUCJ*23.061 **--->** HNUCJ = HNUCJ*23.061D0

14) iter.f
Line 835: ESCF=(EE+ENUCLR)*23.061 +ATHEAT **--->**
ESCF=(EE+ENUCLR)*23.061D0 +ATHEAT

15) compfg.f
Line 81: DEGREE(2)=180.D0/3.141592652589D0 **--->**
DEGREE(2)=180.D0/3.1415926535897932D0

16) deriv.f
Line 219: J=XPARAM(I)/3.141D0 **--->** J=XPARAM(I)/3.1415926535897932D0
Line 221: 1 ABS(XPARAM(I)-J*3.1415926D0).LT.0.005D0)THEN **--->**
1 ABS(XPARAM(I)-J*3.1415926535897932D0).LT.0.005D0)THEN

17) anavib.f
Line 138: ANS=100.D0*SQRT(FIJ(IJ)*1.D5*6.023D23)/(2.998D10*3.14159D0*2.D0)/EIGS(K)
--->
ANS=100.D0*SQRT(FIJ(IJ)*1.D5*6.023D23)/(2.998D10*3.1415926535897932D0*2.D0)/EIGS(K)

18) freqcy.f
Line 30: C2PI=1.D0/(2.998D10*3.141592653598D0*2.D0) **--->**
C2PI=1.D0/(2.998D10*3.1415926535897932D0*2.D0)

19) getgeo.f
Line 237: CONST=3.141592653598D0/180.D0 **--->** CONST=3.1415926535897932D0/180.D0

20) grid.f
Line 64: DEGREE=180.D0/3.14159265359D0 **--->** DEGREE=180.D0/3.1415926535897932D0

21) haddon.f
Line 14: PI = 3.1415926536D00 **--->** PI = 3.1415926535897932D0

22) pathk.f
Line 31: DEGREE=180.D0/3.14159265359D0 **--->** DEGREE=180.D0/3.1415926535897932D0

23) thermo.f
Line 45: DATA PI /3.14159D0 / **--->** DATA PI /3.1415926535897932D0 /

24) xyzint.f
Line 112: IF(ANGL.GT.3.1415926D0-TOL.OR.ANGL.LT.TOL)THEN **--->**
IF(ANGL.GT. 3.1415926535897932D0-TOL.OR.ANGL.LT.TOL)THEN
Line 123: IF(ANGL.LT.3.1415926D0-TOL.AND.ANGL.GT.TOL)THEN **--->**
IF(ANGL.LT. 3.1415926535897932D0-TOL.AND.ANGL.GT.TOL)THEN

25) h1elec.f
Line 55: SMAT(I,J)=0 **--->** SMAT(I,J)=0.0D0

DYNAMO v2.0

Dynamo and AMBER should give the same answers. However, dynamo bases its convergence criteria on the maximum difference in the density matrix while AMBER bases it on the absolute difference in the energy if tight_p_conv=0 or a combination of the energy and density matrix if tight_p_conv=1. Therefore to get strictly the same convergence behavior you can modify Dynamo's convergence criteria to use energy by:

1) mopac_scf.f90
Line 240: DIFF = MAXVAL (ABS (DENMAT - OLDDEN)) **--->** DIFF = ABS(DTOT)

Gaussian 03 C01

1) l402.F
Cut out the deck: **Deck Gover* and append it to the end of utilam.F
Line 820: A0=0.52917706D0 **--->** A0=0.529177249D0
Line 2223: A0=0.52917706D0 **--->** A0=0.529177249D0
Line 2457: A0=0.52917706D0 **--->** A0=0.529177249D0
Line 3554: 1.d0,2.d0,4.d0,8.d0,16.d0,0.52917706D00,0.25d0,27.21D00/ **--->**
1.d0,2.d0,4.d0,8.d0,16.d0,0.529177249D00,0.25d0,27.21D00/

2) utilam.F
Line 63879: RAB=R12/0.52917706D0 **--->** RAB=R12/0.529177249D0
Line 64060: Call GauErr('No old analytic.') **--->** comment out this line.
Line 64061: Call Gover(NI,NJ,XI,XJ,R,DI) **--->** uncomment this line.
Immediately before line 117759 (call to hcore) add:
if (((COORD(1,I)-COORD(1,J))**2+(COORD(2,I)-COORD(2,J))**2+
1(COORD(1,I)-COORD(1,J))**2) >= 100.0d0) goto 45
Immediately before line 117778:Call RotaMN add:
45 CONTINUE
Line 154968: R=R/0.52917706D0 **--->** R=R/0.529177249D0
Line 154985: $-XJ(NBT))*3.5711928576D0 **--->** $-XJ(NBT))*(1.0d0/0.529177249D0**2)
Line 154989: TOMB=(XI(NAT)-XJ(NAT))*1.88976D0 **--->**
TOMB=(XI(NAT)-XJ(NAT))*(1.0d0/0.529177249D0)
Line 154993: TOMB=(XI(NAT)-XJ(NAT))*1.88976D0 **--->**
TOMB=(XI(NAT)-XJ(NAT))*(1.0d0/0.529177249D0)
Line 155007: IF((ADB*R).LT.90.D0) THEN **--->** IF((ADB*R).LT.30.D0) THEN

3) l113.F
Line 676: DATA TOANG/0.52917706d0/, HARTRE/4.359814D0/ **--->**
DATA TOANG/0.529177249d0/, HARTRE/4.359814D0/

4) l510.F

Line 95438: Edcpau=Edcp*0.52917d0/gdist **--->** Edcpau=Edcp*0.529177249d0/gdist

5) utilnz.F

Line 29353: Data (PhyDat(ToAng,I),I=1,NConst)/0.52917706D+00,0.529177249D+00,
$ 0.5291772083d0/ **--->**
Data (PhyDat(ToAng,I),I=1,NConst)/0.529177249D+00,0.529177249D+00,
$ 0.529177249d0/

Line 49689: Parameter(Fac1=0.52917706D00,fac2=27.21D00) **--->**
Parameter(Fac1=0.529177249D00,fac2=27.21D00)

Line 49797: R=RIJ/0.52917706D00 **--->** R=RIJ/0.529177249D00

Line 68117: R = R1/0.52917706D00 **--->** R = R1/0.529177249D00

How to Match AMBER's QM/MM PME Results with CHARMM Ewald Results

The following information explains how to match AMBER's QM/MM PME energy with CHARMM's QM/MM Ewald energy. To make the PME and Ewald method match it is necessary to increase the precision (number of kvectors, number of FFT grid points, spline order etc.) of both methods.

In order for the numbers to match you first need to modify the CHARMM c33b1 source code as explained above as well as make the following extra modification:

1) fcm/consta.fcm

Line 66: PARAMETER (CCELEC=332.0716D0) **--->**
PARAMETER (CCELEC=332.0522173D0)

Or alternatively you can specify AMBER in the pref.dat file.

For this example we setup the following system consisting of two water molecules with the following coordinates:

```
REMARK  TP3
ATOM      1  O   WAT     1       0.000   0.000   0.000  1.00  0.00      WAT
ATOM      2  H1  WAT     1       0.957   0.000   0.000  1.00  0.00      WAT
ATOM      3  H2  WAT     1      -0.240   0.927   0.000  1.00  0.00      WAT
TER
ATOM      1  O   WAT     2       5.000   0.000   0.000  1.00  0.00      WAT
ATOM      2  H1  WAT     2       5.957   0.000   0.000  1.00  0.00      WAT
ATOM      3  H2  WAT     2       4.760   0.927   0.000  1.00  0.00      WAT
TER
END
```

These two water molecules are placed in a orthorhombic box of dimensions 26.197 x 20.927 x 20.000

The leap script to create the AMBER prmtop and inpcrd files is:

```
source leaprc.ff99SB
molec = loadpdb 2_waters.pdb
setbox molec centers 10.0
saveamberparm molec 2_waters.prmtop 2_waters.inpcrd
quit
```

The first water molecule will be treated quantum mechanically using PM3 while the second water molecule will be treated molecular mechanically as a TIP3P water molecule.

SCF Energy from both codes will be = -53.28909255 kcal/mol

AMBER INPUT

```
2 waters in periodic box
 &cntrl
  imin=0, nstlim=0, ntpr=1, cut=8.0, ntb=1, ntc=1, ntf=1,
  tempi=0.0, ifqnt=1, /
 &ewald use_pme=1, order=7, nfft1=64,nfft2=64,nfft3=64, /
 &qmmm
  qmmask=':1', qmtheory=1, verbosity=3,
  qm_ewald=1, qm_pme=1, ksqmaxq=512,kmaxqx=8,kmaxqy=8,kmaxqz=8, /
```

CHARMM INPUT

```
* water in box
*

READ RTF CARD
* Residue topology file for glycerol and tip3p waters
* ...
*
   20    1
MASS     1 HT     1.00800 ! TIPS3P water model hydrogen
MASS     2 OW    16.00000 ! TIP3P water model oxygen

AUTOGEN ANGLES
DEFAULT FIRST NONE LAST NONE

RESI WAT      .000   ! TIPS3P WATER MODEL
GROUP
ATOM O    OW     -0.834
ATOM H1   HT      0.417
ATOM H2   HT      0.417
BOND O H1 O H2 H1 H2
ANGL  H1 O H2

END

READ PARA CARD
* Parameter file water.
*
BOND
HT   HT       0.0       1.5139
HT   OW     450.0       0.9572

THETAS
HT   HT   OW       0.0     127.74
HT   OW   HT      55.0     104.5

NBONDED  NBXMOD 5  ATOM CDIEL SWITCH VATOM VDISTANCE VSWITCH -
  CUTNB 15.0 CTONNB 11.0 CTOFNB 14.0 EPS 1.0 E14FAC 0.5 WMIN 1.5
HT       0.044   -0.0498       0.920
OW       0.84    -0.1521       1.768

NBFIX
OW   OW     -0.152073  3.5365
HT   HT     -0.04598   0.4490
HT   OW     -0.08363   1.9927

END
```

```
read sequence card
* tip 3 water
*
2
WAT WAT

generate wat first none last none setup warn noangl nodihe

open unit 1 form read name 2_waters.pdb
read coor pdb unit 1 resid

crystal define ortho 26.1970000  20.9270000  20.0000000 90.0 90.0 90.0
CRYStal BUILd  CUTOff 30.0
image byres xcen 0.0 ycen 0.0 zcen 0.0 sele all end

update -
    elec group switch cdie eps 1. -
    ewald KAPPA 0.348639005902742 spline PMEWald ORDEr 7 -
    FFTX 64 FFTY 64 FFTZ 64 -
    vdw vgroup vswitch -
    cutnb 9.0 ctofnb 8.0 ctonnb 7.0  -
    inbfrq -1 cutim 13.0 imgfrq -1 wmin 0.5

quantum newd 1 pm3 scfcrt 1.0d-8 kmax 9 ksqmax 729 analyt sele residue
1 end
energy

stop
```