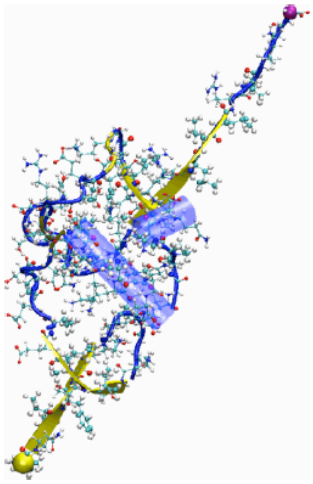
NAMD TUTORIAL



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The NAMD Configuration File / 1

Files needed:

```
structure          mypsf.psf
coordinates        mypdb.pdb
```

Define temperature

```
set temperature    310
     ;# target temperature used several times below
```

Starting simulation with random velocities

```
# starting from scratch
temperature         $temperature
       ;# initialize velocities randomly
```

The NAMD Configuration File / 2

Continuing a simulation with positions and velocities from previous run

```
# continuing a run
set inputname      myinput          ;# only need to edit this in one place!
binCoordinates     $inputname.coor  ;# coordinates from last run (binary)
binVelocities      $inputname.vel   ;# velocities from last run (binary)
extendedSystem    $inputname.xsc   ;# cell dimensions from last run
firsttimestep      50000            ;# last step of previous run
numsteps           100000           ;# run stops when this step is reached
```

The NAMD Configuration File / 3

Organizing output

```
outputName          myoutput
        ;# base name for output from this run

restartfreq         500     ;# 500 steps = every 1ps
dcdfreq             500
xstFreq             500

outputEnergies      100     ;# 100 steps = every 0.2 ps
outputTiming       1000
          ;# shows time per step and time to completion
```

The NAMD Configuration File / 4

```
# Force-Field Parameters
paraTypeCharmm     on
parameters          par_all27_prot_lipid.inp

# These are specified by CHARMM
exclude             scaled1-4
1-4scaling          1.0
switching           on

# You have some freedom choosing the cutoff
cutoff              12. ;# may use smaller, maybe 10., with PME
switchdist          10. ;# cutoff - 2.

# Promise that atom won't move more than 2A in a cycle
pairlistdist        14. ;# cutoff + 2.

stepspercycle       10   ;# redo pairlists every ten steps

# Integrator Parameters
timestep            2.0  ;# 2fs/step
rigidBonds          all  ;# needed for 2fs steps
nonbondedFreq       1    ;# nonbonded forces every step
fullElectFrequency  2    ;# PME only every other step
```

The NAMD Configuration File / 5

Controlling temperature

```
{\small \begin{verbatim}
# Constant Temperature Control
langevin            on            ;# langevin dynamics

langevinDamping     5.            ;# damping coefficient of 5/ps
langevinTemp        $temperature  ;# random noise at this level
langevinHydrogen    no            ;# don't couple bath to hydrogens
```

Underlying Langevin equation for all atoms

$$m_i \frac{d^2 x_i(t)}{dt^2} = F_{i,\mathrm{ff}} - \gamma m_i \frac{dx_i(t)}{dt} + R_i(t)$$

$$\langle R_i(t)\, R_i(t') \rangle \;=\; 2 k_B T_{\mathrm{target}} \gamma_i\, \delta(t - t')$$

The NAMD Configuration File / 6

Using periodic boundary conditions
(avoids surface effects; permits Particle-Mesh-Ewald (PME) electrostatics; permits pressure control)

```
# Periodic Boundary conditions
cellBasisVector1    31.2   0.   0.  ;# vector to the next image
cellBasisVector2     0.   44.8  0.
cellBasisVector3     0.    0   51.3
cellOrigin           0.    0.   0.  ;# the *center* of the cell

wrapWater           on              ;# wrap water to central cell
wrapAll             on              ;# wrap other molecules too
wrapNearest         off             ;# use for non-rectangular cells
```

The NAMD Configuration File / 7

Particle-Mesh-Ewald electrostatics
(avoids cut-off of long-range Coulomb forces)

```
#PME (for full-system periodic electrostatics)
PME                 yes
PMEGridSizeX        32  ;# 2^5, close to 31.2
PMEGridSizeY        45  ;# 3^2 * 5, close to 44.8
PMEGridSizeZ        54  ;# 2 * 3^3, close to 51.3
```

The NAMD Configuration File / 8

Pressure Control

```
# Constant Pressure Control (variable volume)
useGroupPressure      yes ;# needed for rigid bonds
useFlexibleCell       no  ;# no for water box, yes for membrane
useConstantArea       no  ;# no for water box, maybe for membrane

langevinPiston        on
langevinPistonTarget  1.01325      ;# pressure in bar -> 1 atm
langevinPistonPeriod  100.         ;# oscillation period around 100 fs
langevinPistonDecay   50.          ;# oscillation decay time of 50 fs
langevinPistonTemp    $temperature ;# coupled to heat bath
```

Underlying Langevin equation for all atoms

$$P = \rho k_B T + \frac{1}{Vd} \sum_{i<j} \langle r_{ij} \frac{dU_{tot}(r_{ij})}{dr_{ij}} \rangle$$

$$\frac{d^2V(t)}{dt^2} = \frac{1}{m_{\text{pist}}} \left[P(t) - P_{\text{target}} \right] - \gamma_P \frac{dV(t)}{dt} + R_P(t)$$

$$\langle R_P(t)\, R_P(t') \rangle \;=\; \frac{2 k_B T_{\text{target}} \gamma_P\, \delta(t-t')}{m_{\text{pist}}}$$

The NAMD Configuration File / 9

Fix atoms

```
fixedAtoms          on
fixedAtomsFile      myfixedatoms.pdb  ;# flags are in this file
fixedAtomsCol       B                 ;# set beta non-zero to fix an atom
```

The NAMD Configuration File / 10

Energy-minimize structure (T=0) , reset temperature T, run:

```
minimize            1000          ;# lower potential energy for 1000 steps
reinitvels          $temperature  ;# since minimization zeros velocities
run 50000 ;# 100ps
```

The NAMD Output File / 1

Preamble

```
Info: NAMD 2.5b2ss03 for Linux-i686-Clustermatic
Info:
Info: Please visit http://www.ks.uiuc.edu/Research/namd/
Info: and send feedback or bug reports to namd@ks.uiuc.edu
Info:
Info: Please cite Kale et al., J. Comp. Phys. 151:283-312 (1999)
Info: in all publications reporting results obtained with NAMD.
Info:
Info: Built Fri May 30 13:09:06 CDT 2003 by jim on umbriel
Info: Sending usage information to NAMD developers via UDP.
Info: Sent data is: 1 NAMD  2.5b2ss03  Linux-i686-Clustermatic 47 umbriel jim
Info: Running on 47 processors.
```

The NAMD Output File / 2

Energies

```
ETITLE:      TS           BOND          ANGLE          DIHED          IMPRP
           ELECT            VDW       BOUNDARY           MISC       KINETIC
           TOTAL           TEMP         TOTAL2         TOTAL3        TEMPAVG
        PRESSURE     GPRESSURE         VOLUME      PRESSAVG     GPRESSAVG

ENERGY:     1000         0.0000         0.0000         0.0000         0.0000
    -97022.1848      9595.3175         0.0000         0.0000     14319.5268
    -73107.3405       300.2464    -73076.6148    -73084.1411       297.7598
      -626.5205      -636.6638    240716.1374      -616.5673      -616.6619
```

The NAMD Output File / 1

Writing out trajectories

```
OPENING COORDINATE DCD FILE
WRITING COORDINATES TO DCD FILE AT STEP 1000
```

Performance information

```
Info: Benchmark time: 47 CPUs 0.0475851 s/step 0.275377 days/ns 13540 kB memory

TIMING: 1000  CPU: 18.35, 0.01831/step  Wall: 50.1581, 0.0499508/step, 6.92374
hours remaining, 14244 kB of memory in use.

TIMING: 1000  CPU: 18.35, 0.01831/step  Wall: 50.1581, 0.0499508/step, 6.92374
hours remaining, 14244 kB of memory in use.
```

Warnings

```
Warning: Pairlistdist is too small for 1 patches during timestep 17.
Warning: Pairlists partially disabled; reduced performance likely.
Warning: 20 pairlist warnings since previous energy output.
```

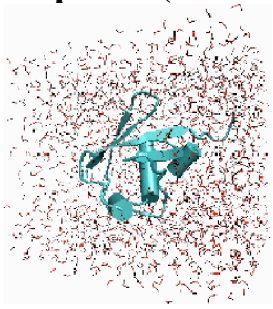
The NAMD Experience / 1

You will first simulate ubiquitin in a water sphere and water box:

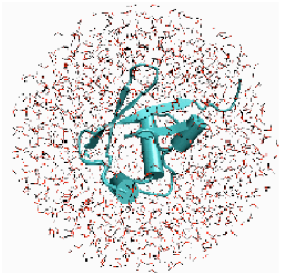
Generating a Protein Structure File (PSF)

- Go to 1-1-build directory
- Open VMD, choose extension TkCon
- Make from 1UBQ.pdb a structure without hydrogens, ubqp.pdb
- Create psf file for ubqp.pdb: ubq.pdb and ubq.psf
- Check if files exist

Solvate the protein in a water sphere (from VMD)



Solvate the protein in a water box (from VMD)



The NAMD Experience / 2

- **RMSD value for equlibration**
- **Atomic RMSD values of equilibrated protein**
- **Velocity distribution**
- **Temperature distribution**
- **Specific heat**
- **Diffusion of whole protein**
- **Heat diffusion**
- **Temperature Echoes**