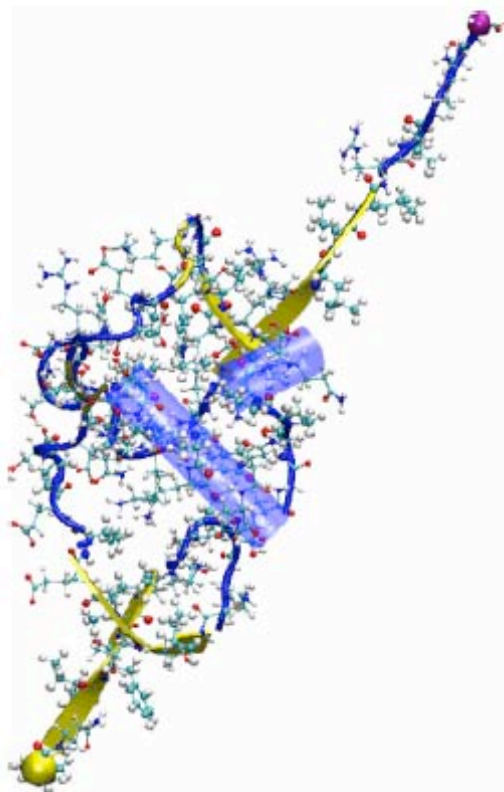# NAMD TUTORIAL

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Elizabeth Villa

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

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

$$\langle R_i(t) - R_i(t') \rangle = 6 k_B T_{\text{target}} \gamma_i (t - t')$$

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

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

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

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

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.
```
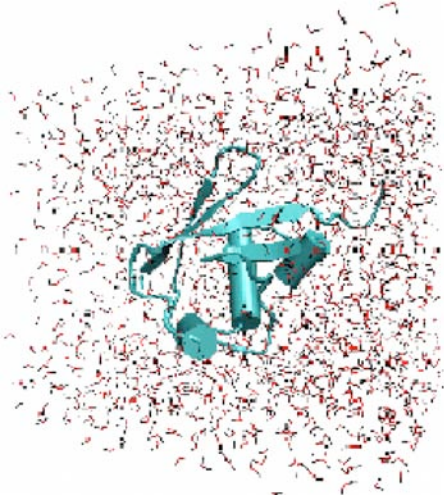
The NAMD Experience / 1

You will first simulate ubiquitin in a water sphere and water box:
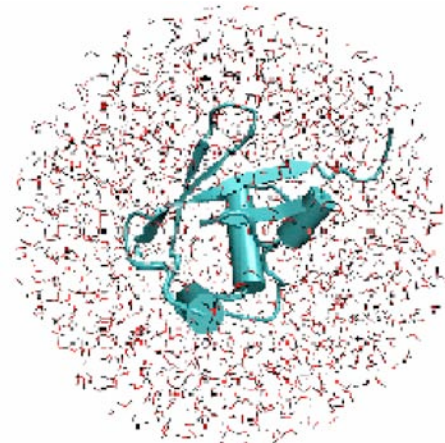
Generating a Protein Structure File (PSF)
- Go to 1-1-build directory
- Open VMD, choose extension TkCon
- Make from 1UBQ.pdb a structure without hydrogens, ubqp.pdb
- Create psf file for ubqp.pdb: ubq.pdb and ubq.psf
- Check if files exist

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