## Compilation of code on Codeblocks

# Screenshot of output for smaller values (n=64 and limit=100)

```
"C:\Users\Namitha Shaji\OneDrive\Desktop\MP\laplaceparallel.exe"
10.00
        10.00
                 10.00
                          10.00
                                  10.00
10.00
        10.00
                 10.00
                          10.00
                                  10.02
                                           10.60
11.65
                                                    15.58
                                                            10.00
10.00
        10.00
                 10.00
                          10.00
                                  10.05
                                                    29.02
                                                            100.00
10.00
                          10.00
                                  10.06
                                           12.05
                                                    32.75
                                                            100.00
        10.00
                 10.00
10.00
        10.00
                 10.00
                          10.00
                                  10.05
                                           11.65
                                                    29.02
                                                            100.00
10.00
        10.00
                 10.00
                          10.00
                                  10.02
                                           10.60
                                                    15.58
                                                            10.00
10.00
        10.00
                          10.00
                                  10.00
                 10.00
                                           10.07
                                                             10.00
10.00
        10.00
                 10.00
                          10.00
                                  10.00
                                           10.00
                                                    10.00
                                                             10.00
Number of iterations it went through: 100
Time taken : 4.000000
 rocess returned 0 (0x0)
                            execution time : 0.975 s
 ress any key to continue.
```

# Screenshot of the compilation and output on Barkla

```
NODES NODELIST(REASON)
            JOBID PARTITION
                                NAME
                                         USER ST
         38974540
                    course run_seri sgnkunna R
                                                      3:36
                                                                1 node060
sgnkunna@login1[ba
                   kla] ~]$ [sgnkunna@login1[barkla] ~]$ sbatch -c 2 runparallel.sh
ubmitted batch job 38974565
sgnkunna@login1[barkla] ~]$ sbatch -c 4 runparallel.sh
ubmitted batch job 38974567
[sgnkunna@login1[barkla] ~]$ sbatch -c 8 runparallel.sh
 bmitted batch job 38974568
sgnkunna@login1[barkla] ~]$ sbatch -c 16 runparallel.sh
ubmitted batch job 38974569
sgnkunna@login1[barkla] ~]$ sbatch -c 32 runparallel.sh
ubmitted batch job 38974570
sgnkunna@login1[barkla] ~]$ squeue -u sgnkunna
                                                      TIME NODES NODELIST(REASON)
           JOBID PARTITION
                             NAME
                                        USER ST
         38974570
                    course runparal sgnkunna PD
                                                      0:00
                                                                1 (Resources)
         38974569
                    course runparal sgnkunna R
                                                                 1 node060
         38974568
                    course runparal sgnkunna R
                                                                 1 node060
         38974567
                    course runparal sgnkunna R
                                                       0:23
                                                                 1 node868
                    course runparal sgnkunna R
        38974565
                                                      0:35
                                                                 1 node060
 gnkunna@login1[barkla] ~|$ sbatch runparallel.sh
```

#### Serial Code run

```
gnkunna@login1[barkla] ~]$ cat slurm-38974540.out
  sgnkunna@login1[burkla] ~]$ cat sounded list : node@66 umber of nodes allocated : 1 or 1 umber of threads or processes umber of processes per node : 1 equested tasks per node : equested CPUs per task : cheduling priority : 0 ompiling Laplace.c to Laplace.exe
                            10.01 10.06 10.32
10.02 10.15 10.76
10.03 10.23 11.20
10.04 10.26 11.39
10.03 10.23 11.20
10.03 10.23 11.20
10.02 10.15 10.76
10.01 10.06 10.32
10.00 10.00 10.00
                                                                                                                                      11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                                                                            13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                        12.87
18.28
24.98
27.88
24.98
18.28
12.87
                                                                                                                                                                                                                                                 10.00
10.00
100.00
100.00
100.00
10.00
10.00
10.00
10.00
10.00
10.00
10.00
10.00
   umber of iterations it went through: 100000
Time taken : 184.650000
                             10.01
10.02
10.03
10.04
10.03
10.02
10.01
                                                                 10.06
10.15
10.23
10.26
10.23
10.15
10.06
                                                                                                    10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                                                        11.17
12.92
14.83
15.67
14.83
12.92
11.17
                                                                                                                                                                                                            13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                                                                                 10.00
10.00
100.00
100.00
100.00
10.00
10.00
   umber of iterations it went through:
Time taken : 215.230000
10.00
10.00
10.00
10.00
10.00
                              10.01
10.02
10.03
10.04
10.03
10.02
                                                                 10.06
10.15
10.23
10.26
10.23
10.15
                                                                                                    10.32
10.76
11.20
11.39
11.20
10.76
                                                                                                                                    11.17
12.92
14.83
15.67
14.83
12.92
                                                                                                                                                                        12.87
18.28
24.98
27.88
24.98
18.28
                                                                                                                                                                                                           13.86
26.15
47.74
54.99
47.74
26.15
                                                                                                                                                                                                                                              10.00
10.00
100.00
100.00
100.00
```

```
Number of iterations it went through: 100000
Time taken : 215.230000
      10.01 10.06 10.32 11.17 12.87 13.86
10.00
                                                10.00
     10.02 10.15 10.76 12.92 18.28 26.15
10.00
                                                10.00
                    11.20
                           14.83
                                  24.98
                                         47.74
10.00
      10.03
             10.23
                                                100.00
10.00
      10.04
             10.26
                    11.39
                           15.67
                                  27.88
                                         54.99
                                                 100.00
10.00
      10.03
                           14.83
                                  24.98
                                         47.74
                                                 100.00
             10.23
                    11.20
10.00
     10.02
            10.15
                    10.76 12.92 18.28 26.15
                                                10.00
                    10.32 11.17
10.00
      10.01 10.06
                                  12.87
                                         13.86
                                                10.00
10.00 10.00 10.00 10.00 10.00 10.00 10.00
                                                10.00
Number of iterations it went through: 100000
Time taken : 194.190000
```

### 1 CORE

```
Scheduling priority : 0
compiling laplaceparallel.c to laplaceparallel.exe
using 1 OpenMP threads
                      10.01
10.02
10.03
10.04
10.03
10.02
10.01
10.00
                                                                            10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                       11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                            13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
10.00
10.00
10.00
                                                   10.06
10.15
10.23
                                                                                                                                12.87
18.28
24.98
27.88
24.98
18.28
                                                                                                                                                                                      10.00
10.00
100.00
                                                 10.23
10.26
10.23
10.15
10.06
10.00
                                                                                                                                                                                      100.00
100.00
10.00
10.00
10.00
10.00
10.00
10.00
10.00
10.00
                                                                                                                                   12.87
10.00
   lumber of iterations it went through: 100000
Time taken : 130.058646
                                                                                                                                 12.87
18.28
24.98
27.88
24.98
18.28
12.87
                                                                                                       11.17
12.92
14.83
15.67
14.83
12.92
11.17
                                                  10.06
10.15
10.23
10.26
  10.00
                      10.01 10.06
10.02 10.15
10.03 10.23
10.04 10.26
10.03 10.23
10.02 10.15
10.01 10.06
10.00 10.00
                                                                            10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                                                                            26.15
47.74
54.99
47.74
26.15
13.86
10.00
10.00
10.00
10.00
                                                                                                                                                                                      10.00
100.00
100.00
10.00
10.00
10.00
10.00
                                                                                                                                                                                      100.00
10.00
10.00
10.00
                                                                                                                                   10.00
                                                                                                        10.00
   lumber of iterations it went through: 100000
Time taken : 120.546889
                       10.01
10.02
10.03
10.04
10.03
10.02
                                                                            10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                       11.17
12.92
14.83
15.67
14.83
12.92
11.17
                                                                                                                                  12.87
18.28
24.98
27.88
24.98
18.28
12.87
10.00
                                                                                                                                                            13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                      10.00
10.00
100.00
100.00
100.00
10.00
10.00
10.00
10.00
10.00
10.00
                                                   10.06
10.15
                                                  10.23
10.26
10.23
10.15
10.00
10.00
                        10.01
10.00
                                                  10.06
                                                                                                                                                                                      10.00
Number of iterations it went through: 100000
Time taken : 121.093170
```

#### 2 CORES

```
Isgnkunna@login1:~

[sgnkunna@login1[barkla] ~]$ cat slurm-38974565.out Node list : node060

Number of nodes allocated : 1 or 1

Number of threads or processes : Number of processes per node : 1

Requested tasks per node : Requested CPUs per task : 2

Scheduling priority : 0

compiling laplaceparallel.ct to laplaceparallel.exe using 2 OpenMP threads
  10.00 10.01 10.06 10.32

10.00 10.02 10.15 10.76

10.00 10.03 10.23 11.20

10.00 10.04 10.25 11.39

10.00 10.04 10.23 11.20

10.00 10.04 10.23 11.20

10.00 10.03 10.23 11.20

10.00 10.00 10.15 10.76

10.00 10.10 10.06 10.32

10.00 10.00 10.00 10.00
                                                                                                                                                               11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                                                                        12.87
18.28
24.98
27.88
24.98
18.28
12.87
10.00
                                                                                                                                                                                                                                                13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                                                                                                                        10.00
10.00
100.00
100.00
100.00
10.00
Number of iterations it went through: 100000
Time taken: 163.311403

10.00 10.01 10.06 10.32 11.17 12.87
10.00 10.01 10.06 10.32 11.17 12.87
10.00 10.02 10.15 10.76 12.92 18.25
10.00 10.04 10.23 11.20 14.83 24.95
10.00 10.04 10.26 11.39 15.67 27.88
10.00 10.04 10.26 11.39 15.67 27.88
10.00 10.03 10.23 11.20 14.83 24.95
10.00 10.02 10.15 10.76 12.92 18.25
10.00 10.00 10.00 10.00 10.00 10.00
                                                                                                                                                                                                        12.87
18.28
24.98
27.88
24.98
18.28
12.87
                                                                                                                                                                                                                                                13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                                                                                                                        10.00
10.00
100.00
100.00
100.00
10.00
10.00
  10.00
10.00
10.00
10.00
10.00
                                   10.01
10.02
10.03
10.04
10.03
                                                                              10.06
10.15
10.23
10.26
10.23
                                                                                                                      10.32
10.76
11.20
11.39
11.20
                                                                                                                                                               11.17
12.92
14.83
15.67
14.83
                                                                                                                                                                                                       12.87
18.28
24.98
27.88
24.98
                                                                                                                                                                                                                                              13.86
26.15
47.74
54.99
47.74
                                                                                                                                                                                                                                                                                        10.00
10.00
100.00
100.00
100.00
      10.06
10.15
10.23
10.26
10.23
10.15
10.06
10.00
                                                                                                                    10.32
10.76
11.20
11.39
11.20
10.76
10.32
                                                                                                                                                              11.17
12.92
14.83
15.67
14.83
12.92
11.17
                                                                                                                                                                                                     12.87
18.28
24.98
27.88
24.98
18.28
12.87
   10.00
                                                                                                                                                                                                                                                                                         10.00
10.00
100.00
100.00
10.00
10.00
                                     10.01
10.02
10.03
10.04
10.03
10.02
                                                                                                                                                                                                                                                 26.15
47.74
54.99
47.74
26.15
13.86
  10.00
10.00
10.00
  10.00
10.00
10.00
10.00
                                      10.00
                                                                                                                       10.00
                                                                                                                                                                10.00
                                                                                                                                                                                                         10.00
                                                                                                                                                                                                                                                  10.00
                                                                                                                                                                                                                                                                                           10.00
```

#### **4 CORES**

Number of iterations it went through: 100000 Time taken : 144.438354 [sgnkunna@login1[barkla] ~]\$

```
Ex sgnkunna@login1:

[sgnkunna@login1[barkla] ~]$ cat slurm-38974567.out

Node list : node060

Number of nodes allocated : 1 or 1

Number of threads or processes :

Number of processes per node : 1

Requested tasks per node : 2

Requested CPUs per task : 4

Scheduling priority : 0

compiling laplaceparallel.ct to laplaceparallel.exe

using 4 OpenMP threads
   8.00 10.01 10.06 10.32 11.17 12.87
                                                                                                                                                                                                                                                    10.00
10.00
100.00
100.00
100.00
10.00
10.00
                                                                                                                                                                        12.87
18.28
24.98
27.88
24.98
18.28
12.87
10.00
                                                                                                                                                                                                                   13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                10.01
10.02
10.03
10.04
10.03
10.02
10.01
10.00
                                                                     10.06
10.15
10.23
10.26
10.23
10.15
10.06
10.00
                                                                                                       10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                                                             11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                                                                                                                     10.00
10.00
100.00
100.00
100.00
10.00
10.00
                                                                                                                                                                                12.87
18.28
24.98
27.88
24.98
18.28
12.87
10.00
                                                                                                                                                                                                                   13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
  10.00
10.00
10.00
10.00
10.00
10.00
10.00
     Number of iterations it went through: 100000
Time taken: 159.289710
                                                                                                       10.32 11.17 12.87
10.76 12.92 18.28
11.20 14.83 24.98
11.39 15.67 27.88
11.20 14.83 24.98
                                                                                                                                                                                                                                                     10.00
10.00
100.00
100.00
100.00
   10.00
10.00
10.00
10.00
10.00
                                  10.01
10.02
10.03
10.04
10.03
                                                                      10.06
10.15
10.23
10.26
10.23
                                                                                                                                                                                                                   13.86
26.15
47.74
54.99
47.74
```

```
lumber of iterations it went through: 100000
Time taken : 159.289710
 10.00
           10.01
                      10.06
                                  10.32
                                              11.17
                                                                     13.86
                                                                                 10.00
10.00
10.00
           10.02
                      10.15
10.23
10.26
                                              12.92
14.83
15.67
                                                         18.28
24.98
                                                                    26.15
47.74
                                                                                10.00
100.00
                                  11.20
10.00
           10.04
                                  11.39
                                                         27.88
                                                                     54.99
                                                                                 100.00
                                                                    47.74
26.15
10.00
10.00
          10.03
10.02
                      10.23
10.15
                                 11.20
10.76
10.32
                                              14.83
12.92
                                                         24.98
18.28
                                                                                 100.00
                                                                                 10.00
10.00
           10.01
                      10.06
                                                         12.87
                                                                     13.86
                                                                                 10.00
10.00
          10.00 10.00 10.00
                                              10.00
                                                         10.00
                                                                     10.00
                                                                                 10.00
Number of iterations it went through: 100000
Time taken : 151.049111
[sgnkunna@login1[barkla] ~]$
```

#### **8 CORES**

```
Signkunna@login1: arXiv : cat slurm-38974568.out
Node list : node060
Number of nodes allocated : 1 or 1
Number of threads or processes :
Number of processes per node : 1
Requested tasks per node : :
Requested CPUs per task : 8
Scheduling priority : 0
compiling laplaceparallel.c to laplaceparallel.exe
using 8 OpenMP threads
                                                                                                                                                                                             12.87
18.28
24.98
27.88
24.98
18.28
12.87
                                   10.01
10.02
10.03
10.04
10.03
10.02
10.01
10.00
                                                                           10.06
10.15
10.23
10.26
10.23
10.15
10.06
10.00
                                                                                                                 10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                                                                         11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                                                                                                     13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                                                                                                             10.00
10.00
100.00
100.00
100.00
10.00
10.00
  10.00
10.00
10.00
10.00
10.00
10.00
10.00
      Number of iterations it went through: 100000
Time taken : 147.759796
                                    10.01
10.02
10.03
10.04
10.03
10.02
10.01
10.00
                                                                           10.06
10.15
10.23
10.26
10.23
10.15
10.06
10.00
 10.00
10.00
10.00
10.00
10.00
10.00
10.00
                                                                                                                 10.32
10.76
11.20
11.39
11.20
10.76
10.32
10.00
                                                                                                                                                         11.17
12.92
14.83
15.67
14.83
12.92
11.17
10.00
                                                                                                                                                                                                12.87
18.28
24.98
27.88
24.98
18.28
12.87
10.00
                                                                                                                                                                                                                                      13.86
26.15
47.74
54.99
47.74
26.15
13.86
10.00
                                                                                                                                                                                                                                                                             10.00
10.00
100.00
100.00
100.00
10.00
10.00
      Number of iterations it went through:
Time taken : 167.649660
 10.00
10.00
10.00
10.00
10.00
                                   10.01
10.02
10.03
10.04
10.03
                                                                                                                                                                                                                                                                             10.00
10.00
100.00
100.00
100.00
                                                                            10.06
10.15
10.23
10.26
10.23
                                                                                                                    10.32
10.76
11.20
11.39
11.20
                                                                                                                                                         11.17
12.92
14.83
15.67
14.83
                                                                                                                                                                                                12.87
18.28
24.98
27.88
24.98
                                                                                                                                                                                                                                     13.86
26.15
47.74
54.99
47.74
```

```
mber of iterations it went through: 100000
  Time taken : 167.649660
                10.01
10.02
10.03
10.04
10.03
10.02
10.01
                                   10.06
10.15
10.23
10.26
10.23
10.15
10.06
10.00
                                                                                          12.87
18.28
24.98
27.88
24.98
18.28
12.87
 10.00
10.00
10.00
                                                     10.32
10.76
11.20
                                                                        11.17
12.92
14.83
                                                                                                            13.86
26.15
47.74
                                                                                                                               10.00
10.00
100.00
                                                                                                            54.99
47.74
26.15
13.86
 10.00
10.00
10.00
10.00
                                                     11.39
11.20
10.76
10.32
                                                                        15.67
14.83
12.92
11.17
                                                                                                                               100.00
100.00
                                                                                                                               10.00
10.00
  10.00
                 10.00
                                                      10.00
                                                                        10.00
                                                                                           10.00
                                                                                                                                10.00
                                                                                                              10.00
Number of iterations it went through: 100000
Time taken : 149.736113
[sgnkunna@login1[barkla] ~]$
```

#### 16 CORES

```
[sgmkunna@login1[barkla] ~]$ cat slurm-38974569.out
Node list : node969
Number of nodes allocated : 1 or 1
Number of threads or processes :
Number of processes per node : 1
Requested tasks per node : :
Requested CPUs per task : 16
Scheduling priority : 0
compiling laplaceparallel.c to laplaceparallel.exe
using 16 OpenMP threads
10.00 10.01 10.06 10.32 11.17 12.87 13.
10.00 10.02 10.15 10.76 12.92 18.28 26.
10.00 10.04 10.26 11.39 15.67 27.88 54.
10.00 10.04 10.26 11.39 15.67 27.88 54.
10.00 10.04 10.05 10.25 11.20 14.83 24.98 47.
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10.00
        Number of iterations it went through: 100000
Time taken: 148.457595
                                                                                                                                               148.4579

10.06

10.15

10.23

10.26

10.23

10.15

10.06

10.00
                                                                             10.01
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10.01
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        Number of iterations it went through: 100000
Time taken : 149.451124
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10.00 10.04
10.00 10.03
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11.20 14.83 24.98
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lumber of iterations it went through: 100000
 Time taken : 149.451124
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11.20
10.76
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10.00
                           10.06
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12.92
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                                                                        18.28
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10.00
10.00
                            10.15
10.00
10.00
            10.02
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                                                         12.92
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12.87
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13.86
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                                                        10.00
                                                                        10.00
                                                                                       10.00
                                                                                                      10.00
  umber of iterations it went through: 100000
Time taken : 146.661355
[sgnkunna@login1[barkla] ~]$
```

# 32 CORES

```
Expledtsghkunna@login1:

[sgnkunna@login1[barkla] ~]$ cat slurm-38974578.out
Node list : node060
Number of nodes allocated : 1 or 1
Number of threads or processes
Number of processes per node : 1
Requested tasks per node : Requested tasks per node : Requested CPUs per task : 32
Scheduling priority : 0
compiling laplaceparallel.c to laplaceparallel.exe
using 32 OpenMP threads
                                10.01 10.06
10.02 10.15
10.03 10.23
10.04 10.26
10.03 10.23
10.02 10.15
10.01 10.06
10.00 10.00
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26.15
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100.00
100.00
10.00
10.00
      Number of iterations it went through: 100000
Time taken : 121.088827
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10.03
10.04
10.03
10.02
10.01
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10.23
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10.23
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10.06
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                                                                                                                  10.32
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26.15
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54.99
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26.15
13.86
10.00
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Number of iterations it went through: 100000
Time taken : 124.977086
   10.00
10.00
10.00
10.00
10.00
                                  10.01
10.02
10.03
10.04
10.03
                                                                          10.06
10.15
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10.76
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12.92 18.28
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14.83 24.98
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26.15
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54.99
47.74
```

```
Number of iterations it went through: 100000
Time taken : 124.977086
10.00 10.01 10.06 10.32 11.17 12.87
10.00 10.02 10.15 10.76 12.92 18.28
10.00 10.03 10.23 11.20 14.83 24.98
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10.00 10.01 10.06 10.32 11.17 12.87
10.00 10.00 10.00 10.00 10.00 10.00

Number of iterations it went through: 100000
Time taken: 124.681408
[sgnkunna@login1[barkla] ~]$
                                                                                                                                                                                                                                                              13.86
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