Livermore loops optimization with OpenMP

Kernel 21:

- optimization manner:
  - changing loops order (bigger loop be outer)
  - loop unrolling (5 times)
  - omp_set_num_threads(THEADS);
  - #pragma omp parallel shared(px, vy, cx) private(k, i, j)
  - collapsing two inner loops

- compiling:

```
gcc -fopenmp ker21.c -m64 -lrt -lc -lm -o ker21
```

- analyzing best number of threads:

average speedup per 20 time of run

Threads	2	3	4	5
N = 101 (array size)	1.780	2.908	3.217	2.264

Threads	6	8	10	12
N = 1001 (array size)	7.373	9.508	0.862	0.782

- results:

```
saleh@saleh-afzoon:~/Desktop/Link to Master
list size n = 101
number of threads= 4
times of run = 20.
-------------
average serial time: 1631.800 microsecond
average paralel time: 507.250 microsecond
-------------
speed up: 3.217 microsecond
```

```
saleh@saleh-afzoon:~/Desktop/Link to Master
list size n = 1001
number of threads= 8
times of run = 20.
-------------
average serial time: 39311.150 microsecond
average paralel time: 4134.400 microsecond
-------------
speed up: 9.508 microsecond
```

Kernel 22:

- optimization manner:
  - loop unrolling (4 times)
  - omp_set_num_threads(THEADS);
  - #pragma omp parallel shared(y, u, v, w, x) private(k)

- compiling:

```
gcc -fopenmp ker22.c -m64 -lrt -lc -lm -o ker22
```

- results:

```
saleh@saleh-afzoon:~/Desktop/Link to Master/
list size n = 101
number of threads= 3
times of run = 20.
-------------
average serial time: 24.050 microsecond
average paralel time: 20.550 microsecond
-------------
speed up: 1.170 microsecond
```

```
saleh@saleh-afzoon:~/Desktop/Link to Master/
list size n = 1001
number of threads= 5
times of run = 20.
-------------
average serial time: 53.650 microsecond
average paralel time: 40.350 microsecond
-------------
speed up: 1.330 microsecond
```

Kernel 23:

- optimization manner:

  - changing loops order (bigger loop be outer)
  - loop unrolling (2 times)
  - omp_set_num_threads(THEADS);
  - #pragma omp parallel private(j)
  - collapsing nested loops with #pragma omp collapse(2)

- compiling:

```
gcc -fopenmp ker23.c -m64 -lrt -lc -lm -o ker23
```

- results:

```
saleh@saleh-afzoon:~/Desktop/Link to Master
list size n = 101
number of threads= 4
times of run = 40.
-------------
average serial time: 112.500 microsecond
average paralel time: 32.950 microsecond
-------------
speed up: 3.414 microsecond
```

```
saleh@saleh-afzoon:~/Desktop/Link to Master/
list size n = 1001
number of threads= 5
times of run = 40.
-------------
average serial time: 418.975 microsecond
average paralel time: 63.675 microsecond
-------------
speed up: 6.580 microsecond
```

Kernel 24:

- optimization manner:
  - loop unrolling (4 times)
  - omp_set_num_threads(THEADS);
  - #pragma omp parallel private(k)
- compiling:

```
gcc -fopenmp ker24.c -m64 -lrt -lc -lm -o ker24
```

- results:

```
saleh@saleh-afzoon:~/Desktop/Link to Master
list size n = 1001
number of threads= 4
times of run = 20.
-------------
average serial time: 27.350 microsecond
average paralel time: 21.450 microsecond
-------------
speed up: 1.275 microsecond
```

System configuration:

CPU: core i5 8 th generation
RAM: 8GB
OS: Ubuntu 16
Cache: 1L = 256KB, 2L = 1MB, 3L = 6MB