Comparison of Radiative Hydrodynamics and Post-processed Hydrodynamics in Cosmological Simulation of the Local Universe

Joohyun Lee

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I ran a suite of cosmological simulations using massively parallel, N-body AMR hydrodynamics code, Ramses on KNL computation nodes. For weak scaling test, simulation boxes are cube and the length of one side is $1h^{-1}$ cMpc, $2h^{-1}$ cMpc, $4h^{-1}$ cMpc, and $8h^{-1}$ cMpc. All the simulations have same resolution, 23.06 ckpc ($8h^{-1}$cMpc$/512$), and didn't use AMR feature (unigrid simulation). The initial condition is generated using the popular Music code by adopting initial grid of 512^3 cells (refinement level 9). Periodic boundary condition is used, and other subgrid physics such as star formation and cooling is enabled. Initial redshift is 150 and end redshift is 3, which means the lowest physical resolution is 5.765 kpc at z=3. The runs used 1 (1), 8 (1), 64 (8), 512 (64) cores (nodes) to make sure that (# of cells)/(# of cores) is constant. Due to the large memory required for the simulation, I had to use just a little portion of cores in the nodes. Also, I submitted a run using 4096 (128) cores (nodes) but it is still pending.

As shown in Figure 1, the result is quite interesting. If the code scales well in terms of parallel computing performance, the wall clock time is thought to slightly increase when the core number increases, but the time showed very steep increase, which means the efficiency is a lot lower in runs with larger core number. It seems at least for this problem, the weak scaling is not working well. Naturally, I would think that in the large core number run, more non-parallel works are done by the computer. For example, memory I/O can be one of those works. Due to the large memory usage in larger runs, memory I/O time, which can't be parallelized within the memory-sharing nodes, will be a lot larger.

It will be better if I test with small box and small cell number simulations to test weak scaling performance of the code. However, this resolution and box size (or even better resolution and larger box size) is what a research-level typical cosmological simulation needs, so I will leave it here.

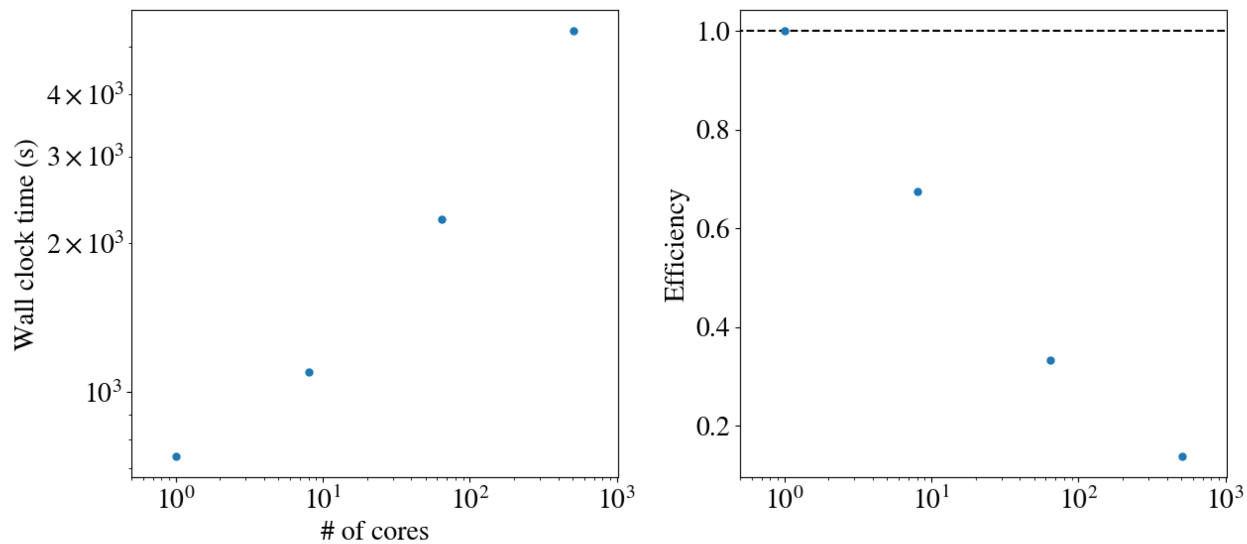

Figure 1. Weak scaling test.

For the strong scaling test, I used $8h^{-1}$ cMpc box as a benchmark run. Again, the simulation box starts with and runs with 512^3 Cartesian cells. All the physics and boundary condition is identical to the weak scaling test. Used core (node) numbers are 32 (4), 64 (8), 128 (16), 256 (32), and 512 (64).

Although with a larger number of cores and nodes more communication between the processors is expected, the code performance scales pretty well with the core number. In Figure 2, this is illustrated and the wall clock time reduces by about a factor of two when the core number increases by two. As expected, the efficiency decreases slightly when the core number increases. One point I should point out is that in 64-core run, the efficiency seems to be maximum. I don't know exactly, but RAMSES code decomposes the whole simulation box with Peano-Hilbert space-filling curve, which is non-periodic, and it is possible that with 64-core, the decomposition was more efficient.

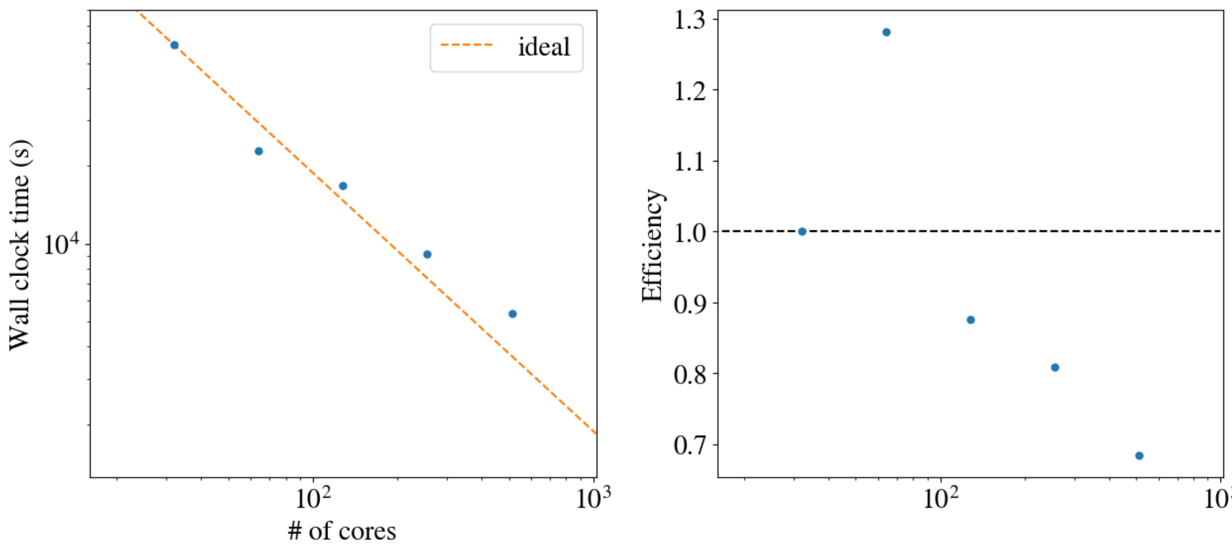

Figure 2. Strong scaling test.