3. Problem definition (example, problem size, other parameters)

Given a simulation where the maximum resolution that will be needed is 100,000^(3 dimensions), the problem size of a static grid becomes untenable. With field updates that must occur at every grid point at every time step, updating the static grid would take O(N3) complexity with N=100,000.

With an adaptive grid, the only area that requires this high resolution are those of high field intensity, i.e. primarily near a laser pulse. Since such a pulse is in our case an order of magnitude smaller than the grid size in every dimension, the highest resolution grid is only required in approximately N/10 grid points in each dimension, giving us O(N3/1000), which for N=100,000 becomes (10,000)3. This is the complexity of a static grid that is 10x less fine, so it’s as though we get an order of magnitude finer grid for no cost in complexity!

The time to compute the many less fine grid points on our dynamic grid is at worst the same order as computing the small number of finest grid points. This can be seen by considering (at worst case) all of those grid points to require Nsmall=10,000 fineness. Since they take up all except 1/1000th of the 3D grid, their complexity is O((Nsmall)3), or (10,000)3, which is the same complexity we found for the fine grid points. Therefore our total complexity is of the same order as the complexity for only our finest grid points, assuming (as in our case) a highly localized laser pulse.