Evolution of Structure in the Universe

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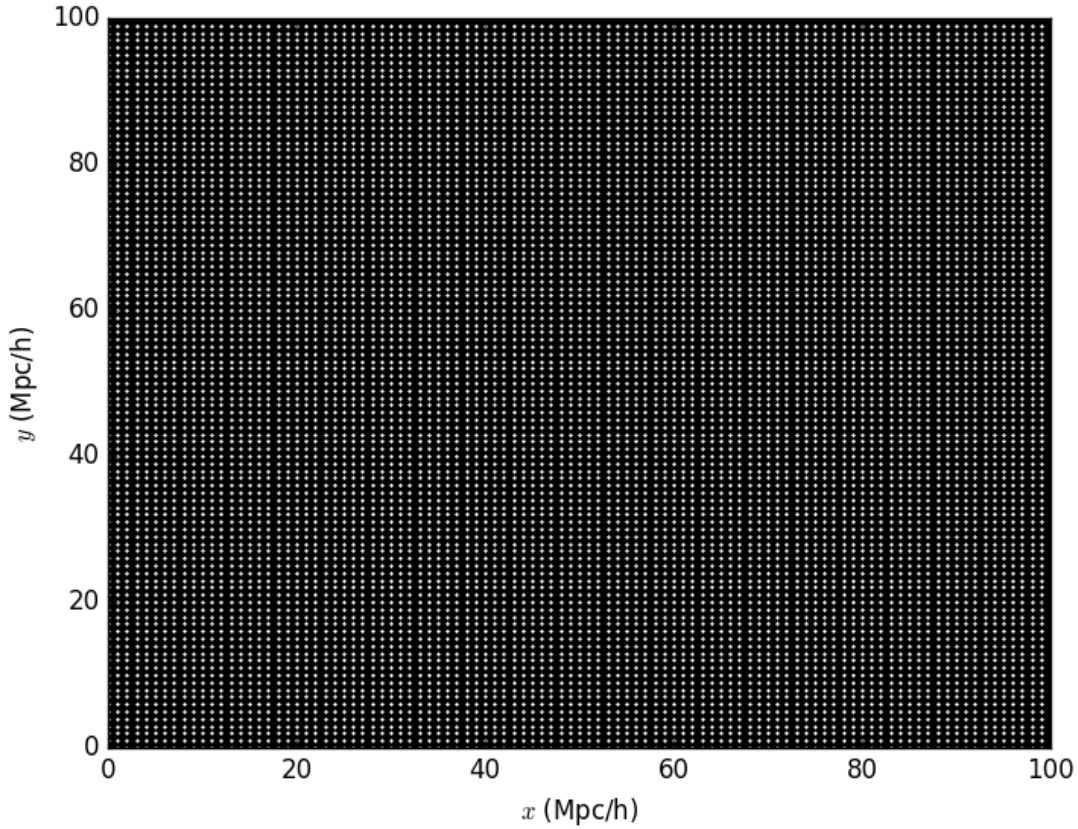
Background

- Structure in universe today caused by perturbations in the early universe
- Zel’dovich approximation good for estimating perturbations for redshifts of 40-70
- Rest of evolution done by solving equation of motion in particle mesh

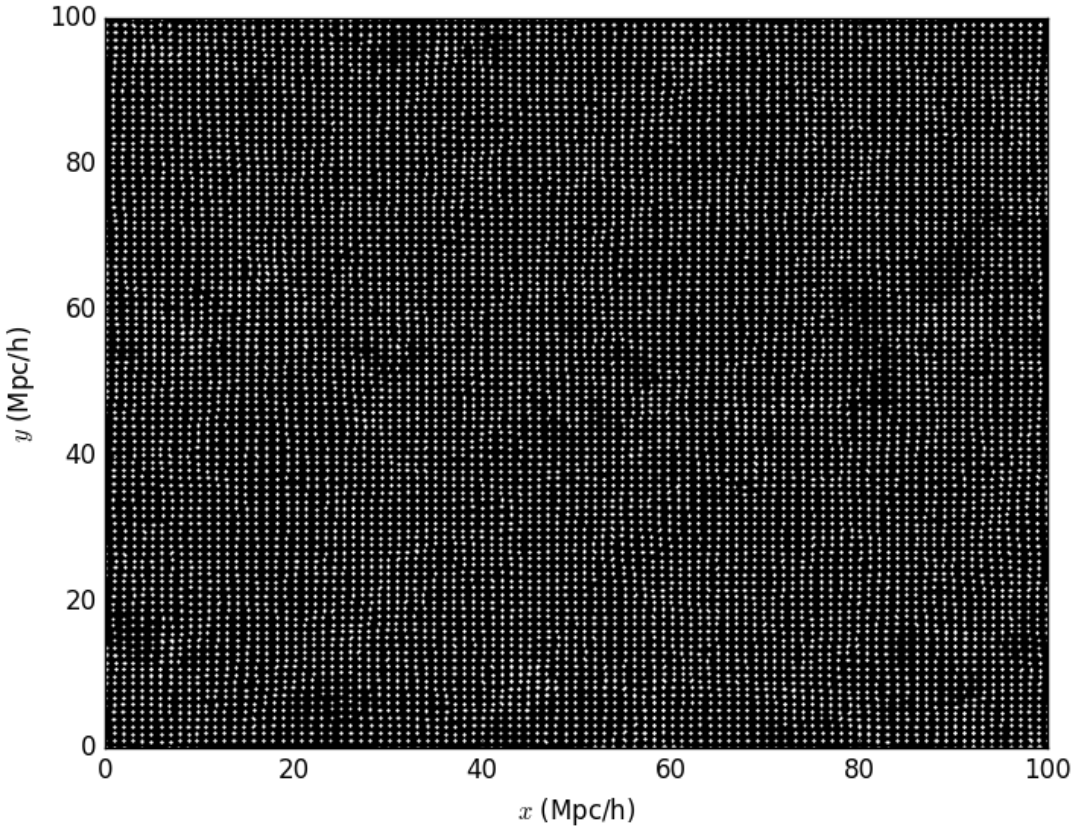
Computational Methods Used

- FFT to solve for initial conditions from power spectrum
- Cloud-in-Cell Interpolation to solve for grid density at each time step
- FFT to solve Poisson equation for gravitational potential and force from grid density
- Reverse Cloud-in-Cell Interpolation to assign forces to particles from grid centers
- Runge-Kutta of order 4 to solve equations of motion

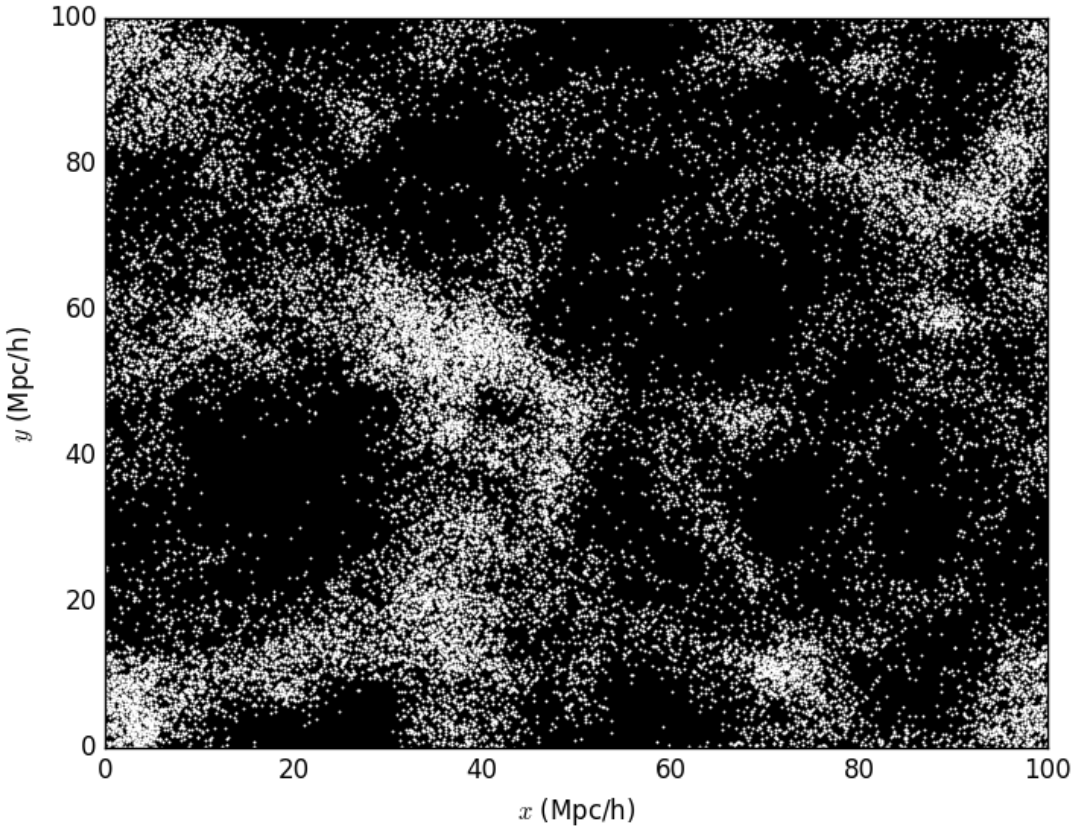
Initial Conditions: Grid



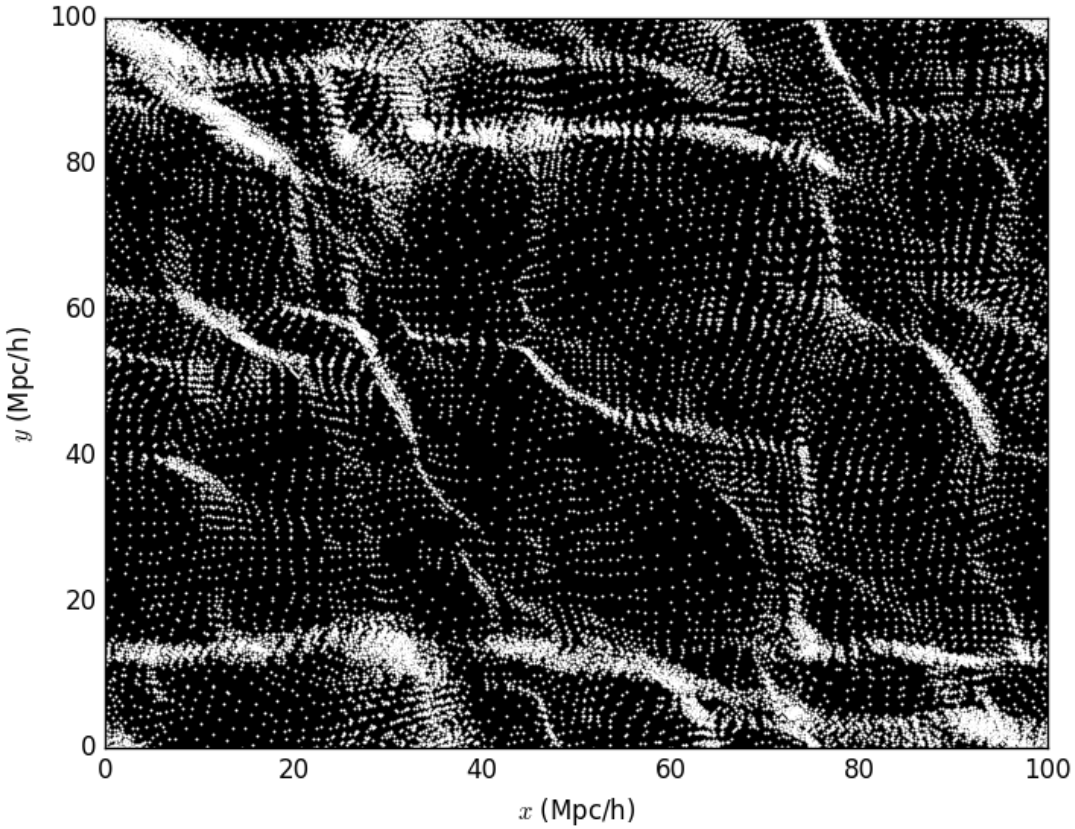
Initial Conditions: Perturbations



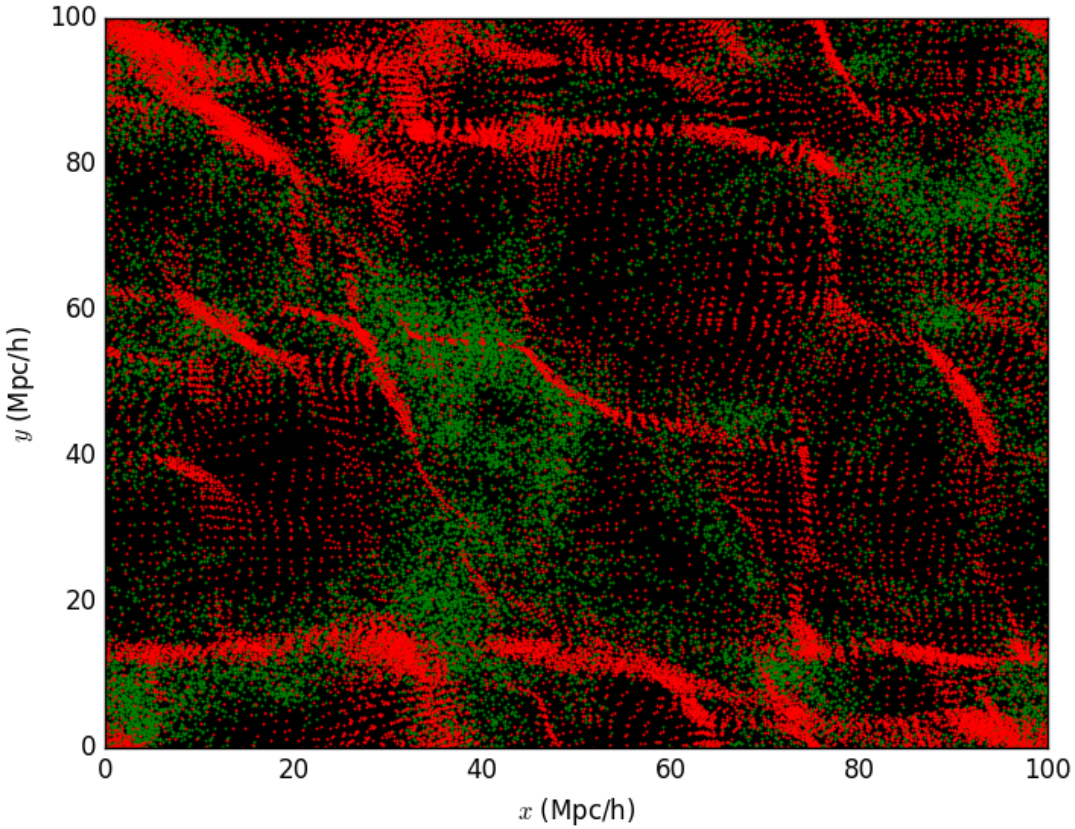
Final Conditions: Approximate Expectations



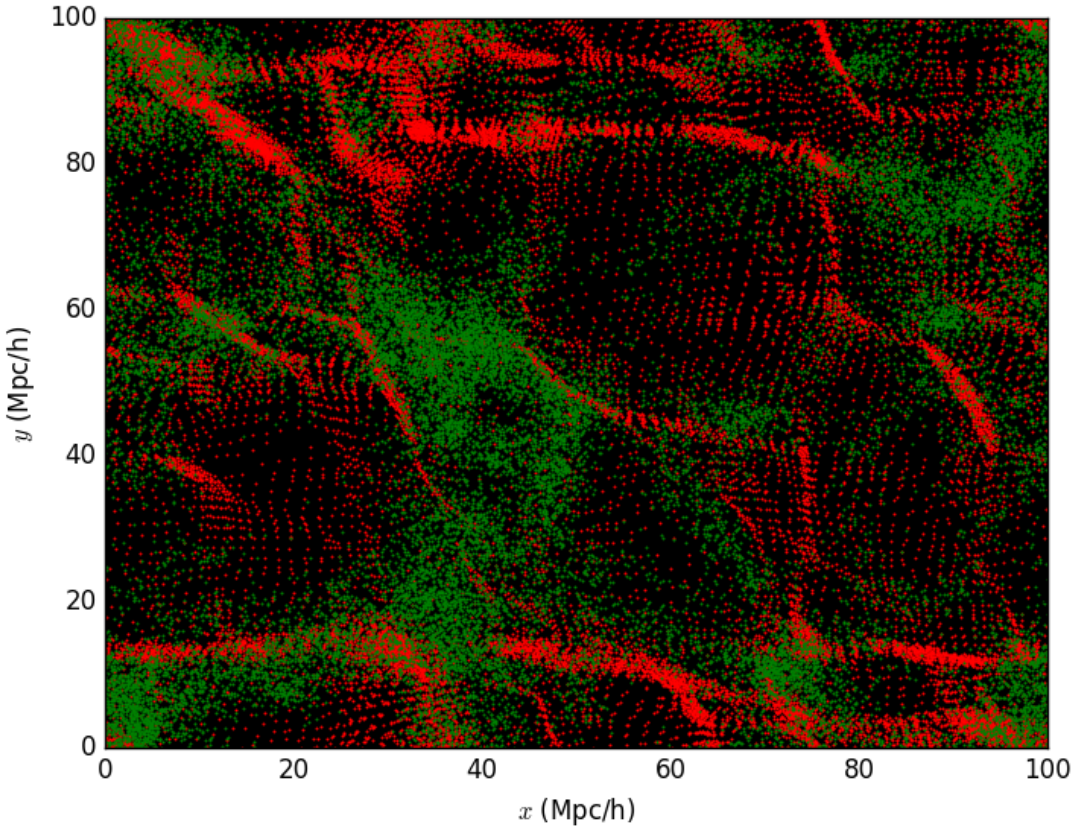
Final Conditions: Results



Final Conditions: Comparisons



Final Conditions: Comparisons



Conclusion

- Particle Mesh method good at evolving large numbers of particles
- Method very modular, so can solve for different power spectra and different equations of motion

Looking Forward

- Find runtimes
- Reproduce Power Spectrum from final results to further test accuracy
- Test for more particles, if computationally feasible

Thank You!

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