Newton's Law of Gravity – Tyler Camp, for *Origin and Fate of the Universe*

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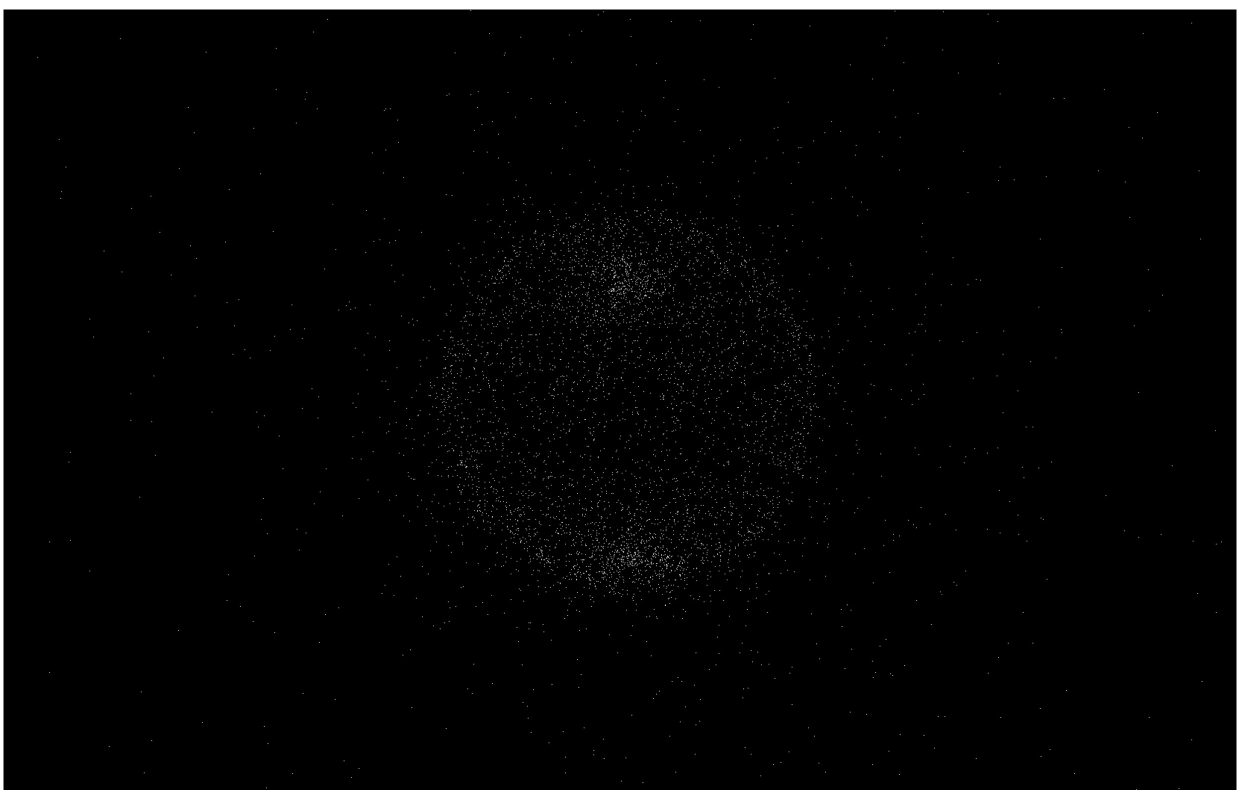
My name is Tyler, I am a senior game programming major, and I am a bit of a math geek. When I first saw Newton's law of Universal Gravitation, I found it to be awesomely expressive and simple.

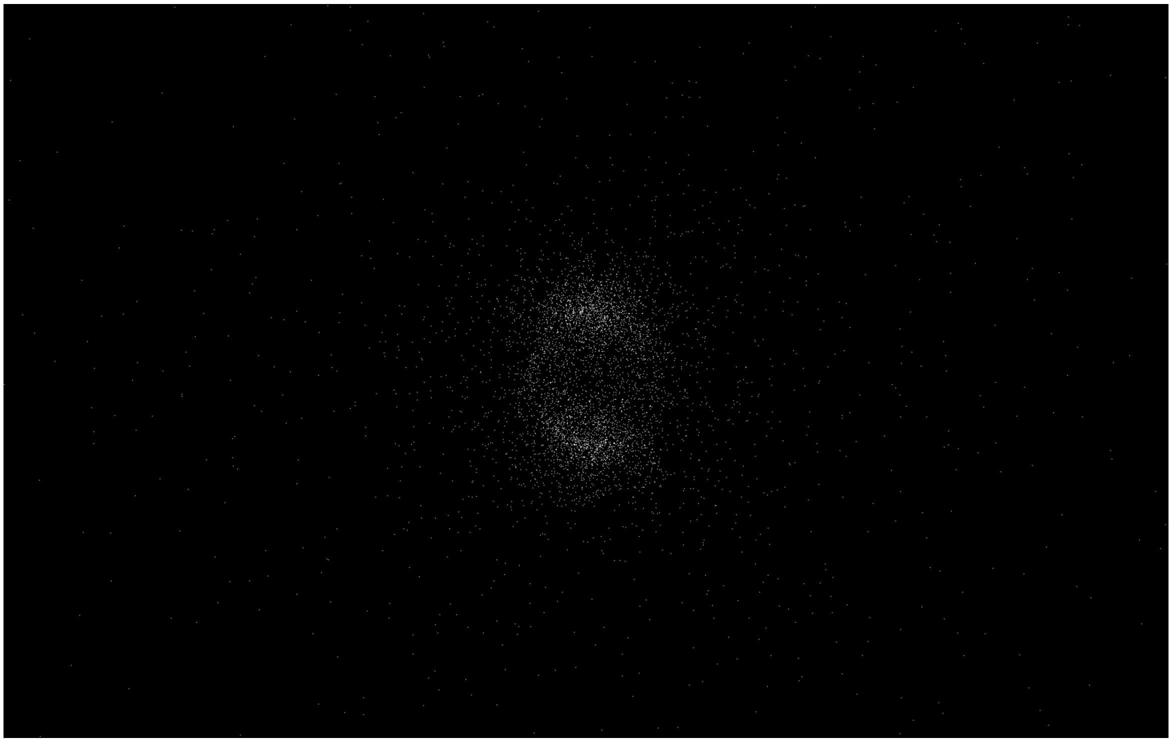
$$F_g = G\frac{m_1 m_2}{r^2}$$

I had to see the effects of this equation for myself. I combined my current studies – data processing and simulation on the GPU, the powerhouse of modern games – with this desire to observe the system with my own eyes.

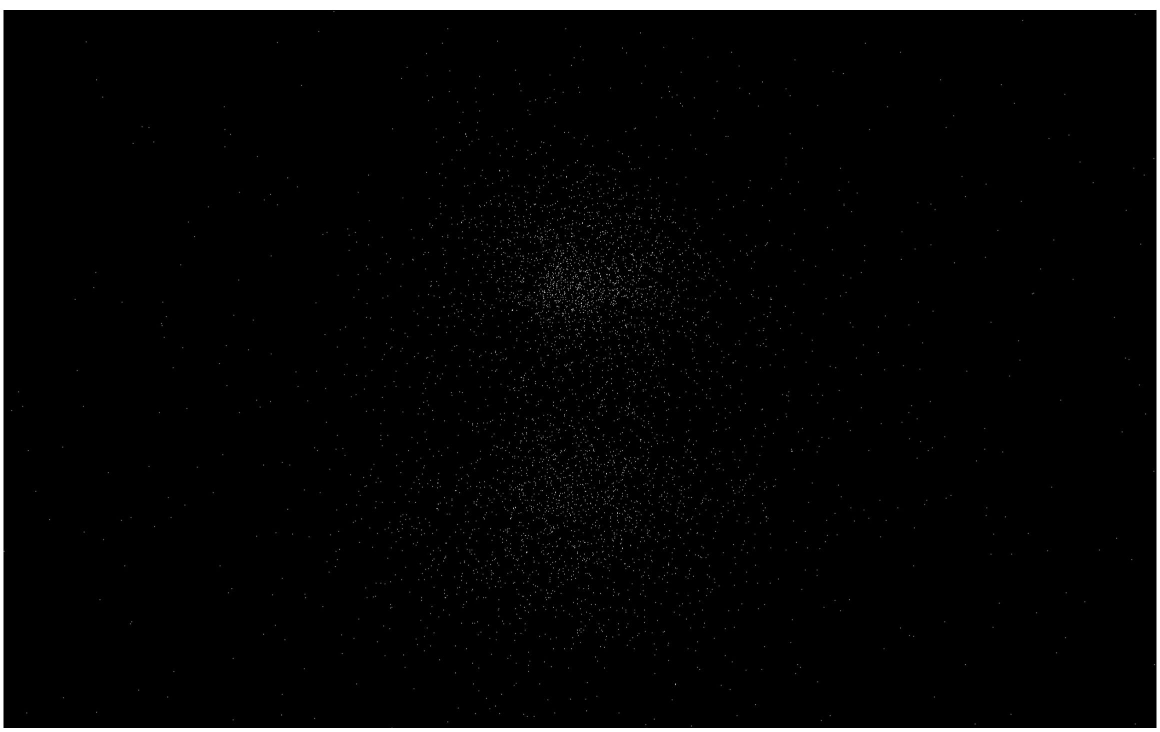
I created a program that runs interactively on my laptop – employing the GPU to run an N-body all-pairs simulation for 4000 celestial bodies with simple visual style. Since gravity is such a weak force, time has been scaled as much as 300 simulated years per second to allow us to see the effects of gravity in a meaningful way.



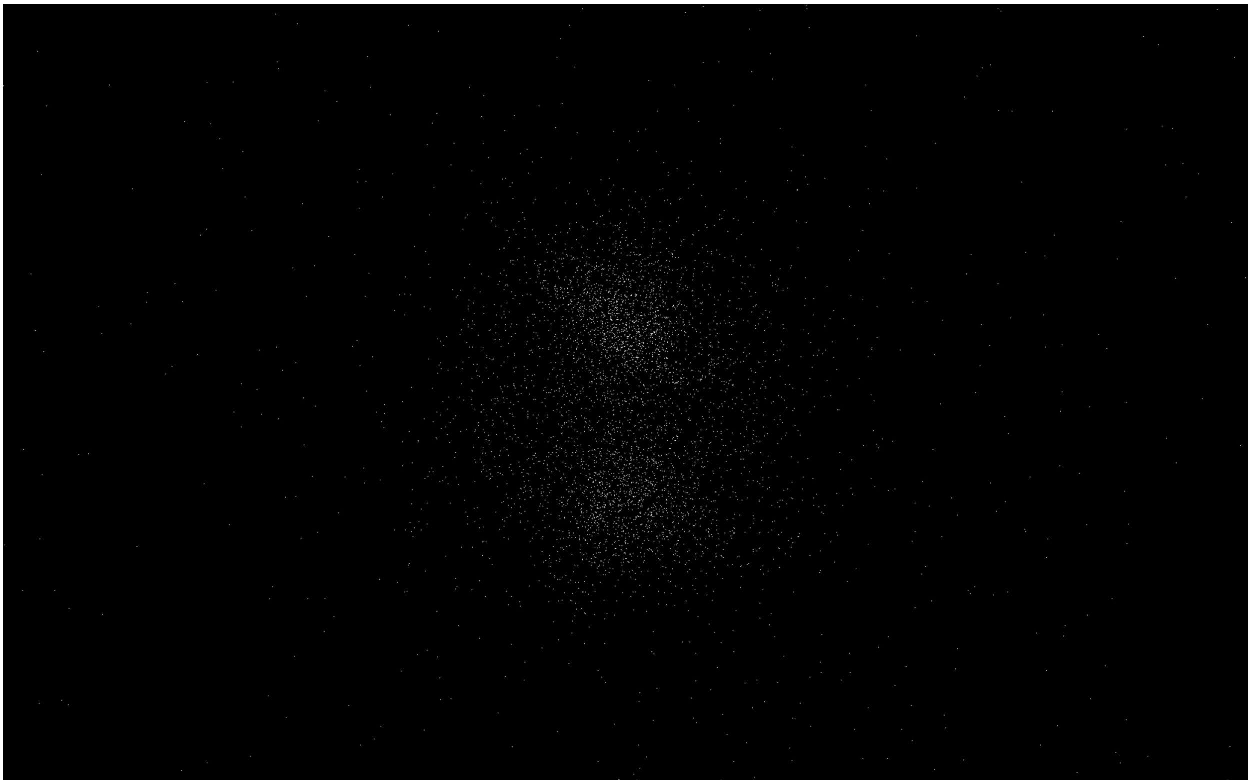
Initial Simulation Setup



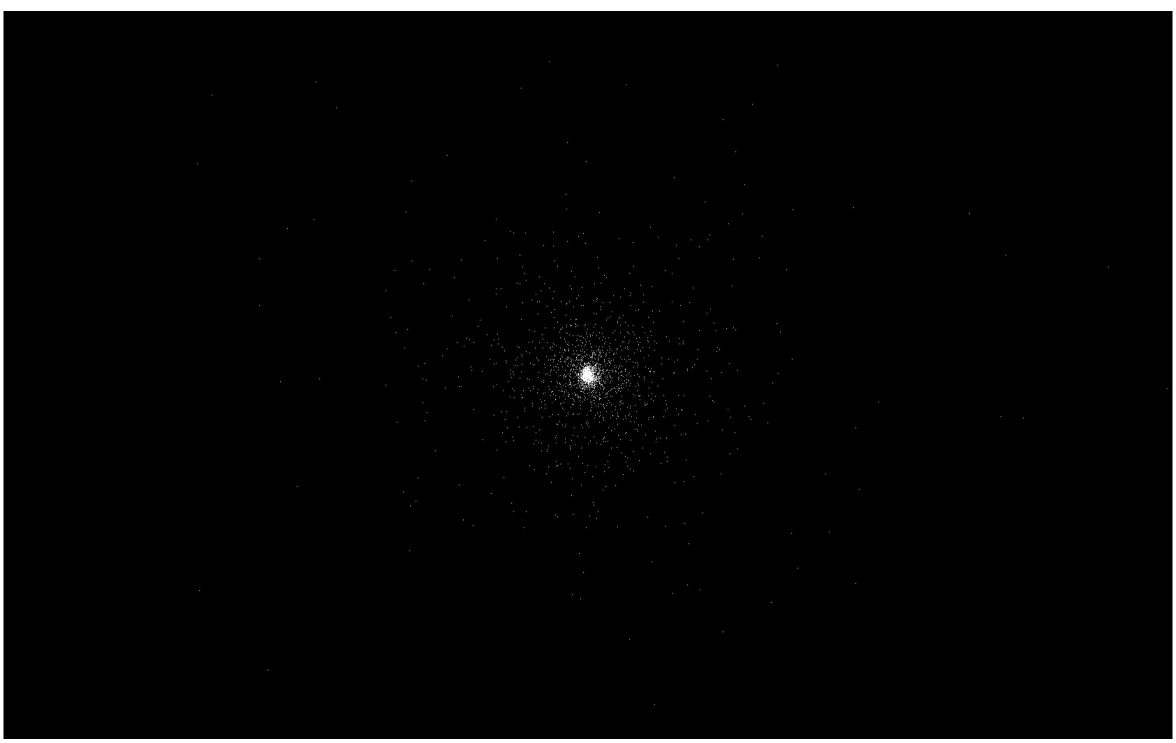
The bodies making up the original sphere are collapsing towards center of gravity. Notice the abnormally high densities towards the top and bottom of the system – two large groups of bodies have been created (caused by inequal distribution of masses in the initial configuration – I use evenly-spaced spherical coordinates, which cause shifted distribution towards the poles)



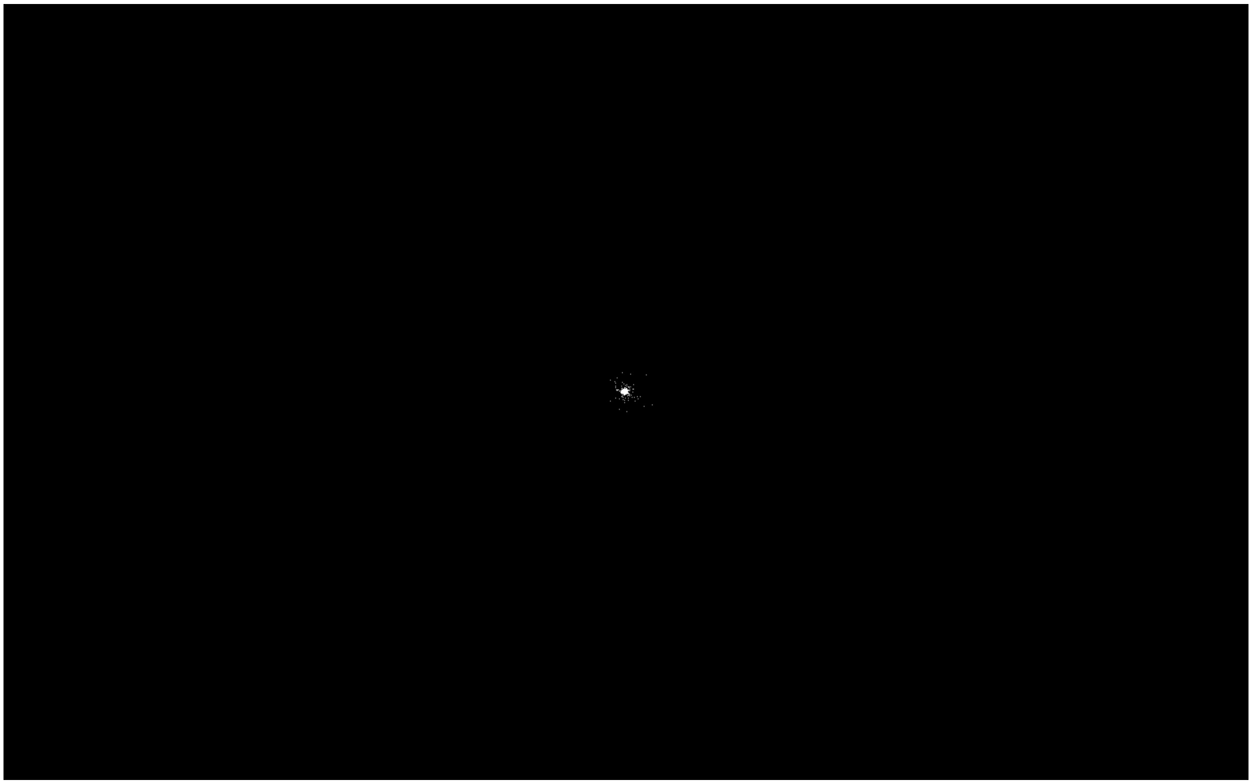
The bodies pass through each other, but the original two large groups of bodies (top and bottom) stay intact and restabilize themselves



Over time the two large groups of bodies gravitate towards each other, and form a single, high-velocity system of orbiting bodies.



Same system viewed at a distance of $1 * 10^7$*(Initial distance is* 10^5*)*



Scaled at $1 * 10^9$*, bodies can be seen at the very edges of the simulation area, which have been ejected out of the system due to orbiting too close to larger bodies. A similar method is used to take advantage of the gravity of planets in our solar system – probes are shot into space, on a course to interact with the gravity of a planet, which will accelerate the probe and enable it to travel further while conserving fuel.*

Finally, while this program is good at displaying the effects of large simulations, I found it lackluster as a simulator of stars. I created a second program, which uses the same simulation on a smaller scale, as well as various game graphics effects to create a more impressive display. Stars are colored by temperature, and temperature is directly calculated as a function of star mass.