3D Hydrodynamic Simulation of Classical Nova Explosions

Kendrick, Coleman

This project investigates the formation and lifecycle of classical novae and determines how parameters such as: white dwarf mass, star mass and separation affect the evolution of the rotating binary system. These parameters affect the accretion rate, frequency of the nova explosions and light curves. Each particle in the simulation represents a volume of hydrogen gas and are initialized randomly in the outer shell of the companion star. The forces on each particle include: gravity, centrifugal, coriolis, friction, and Langevin. The friction and Langevin forces are used to model the viscosity and internal pressure of the gas. A velocity Verlet method with a one second time step is used to compute velocities and positions of the particles. A new particle recycling method was developed which was critical for computing an accurate and stable accretion rate and keeping the particle count reasonable. I used C++ and OpenCL to create my simulations and ran them on two Nvidia GTX580s. My simulations used up to 1 million particles and required up to 10 hours to complete. My simulation results for novae U Scorpii and DD Circinus are consistent with professional hydrodynamic simulations and observed experimental data (light curves and outburst frequencies). When the white dwarf mass is increased, the time between explosions decreases dramatically. My model was used to make the first prediction for the next outburst of nova DD Circinus. My simulations also show that the companion star blocks the expanding gas shell leading to an asymmetrical expanding shell.

Awards Won:

Second Award of $2,000