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Blue Gene/P to Simulate Supernova Explosions

In order to better understand dark energy

The Argonne Blue Gene/P supercomputer may be the most powerful in the world but it will still require 22 million computational hours in order to simulate a process that in real life only takes 5 seconds to unfold. Robert Fisher and Cal Jordan from the University of Chicago's Center for Astrophysical Thermonuclear Flashes, will use Argonne's National Laboratory supercomputer to simulate phenomena occurring in extreme pressure and temperature conditions, such as those experienced during the supernova explosion of a star. "The Argonne Blue Gene/P supercomputer is one of the largest and fastest supercomputers in the world. It has massive computational resources that are not available on smaller platforms elsewhere. It's a different scale of computation. It's computation at the cutting edge of science", explained Fisher. By comparison, the Blue Gene/P supercomputer is 160,000 times more powerful than a typical desktop personal computer.The Flash Center was founded at the University of Chicago in 1997 and was granted access to the Blue Gene/P supercomputer through the U.S. Department of Energy's Innovative and Novel Computational Impact on Theory and Experiment Program. The object of study: Type Ia supernova explosions. This type of supernovae are determined through the explosion of white dwarf stars during which time matter can reach temperatures of hundreds of millions degrees Celsius.With the help of these simulations, researchers hope to achieve a better understanding of dark energy, believed to be responsible for more than 70 percent of the mass of the universe and the acceleration of the expansion of the universe. Type Ia supernova explosions are routinely used to make measurements of the expansion rate of the universe. Knowing that Type Ia supernovae experience roughly the same brightness during the explosion proves extremely valuable while measuring large distances across the universe as well."To really understand dark energy, you have to nail this variation to about 1 percent", says Jordan while explaining that Type Ia supernovae present a brightness variation of 15 percent.White dwarfs are extremely dense in comparison with their progenitor stars. "If one were able to scoop out a cubic centimeter roughly a teaspoon - of material from that white dwarf, it would weight a thousand metric tons. These are incredibly dense objects", says Fisher. But white dwarfs experience Type Ia supernova explosions only when in a binary system with another star. Gravitational interactions between the two would convey material towards the white dwarf, until it becomes unstable and explodes. "This takes place over hundreds of millions of years. As the white dwarf becomes more and more dense with matter compressing on top of it, an ignition takes place in its core. This ignition burns through the star and eventually leads to a huge explosion. Imagine a pool of gasoline and throw a match on it. That kind of burning across the pool of gasoline is a deflagration. A detonation is simply if you were to light a stick of dynamite and allow it to explode", says Jordan.During the simulation, the explosion of the white dwarf star takes place off-center, allowing less dense ash to emerge to the surface on one side and be ejected into space on the opposite side. "This fast-moving ash stays confined to the surface, flows around the white dwarf and collides on the opposite side of breakout. To understand how the simulations relate to the actual supernovae, we have to do more than a thousand different simulations this year to vary the parameters within the models to see how the parameters affect the supernovae", explains Jordan.