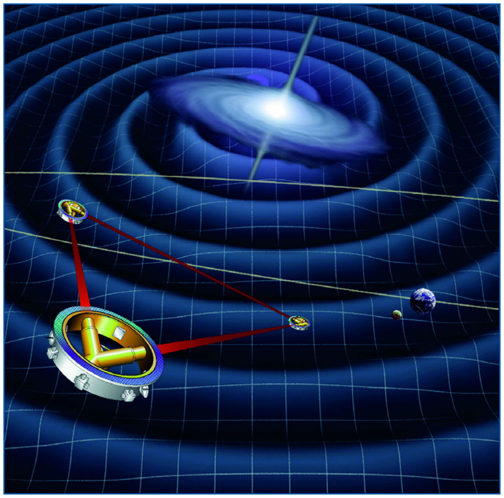
Simulation of Coalescing Binary Neutron Stars

Science Mission Directorate

Researchers at NASA's Jet Propulsion Laboratory (JPL) are are using NASA supercomputers to solve the Einstein field equations, which govern gravitational phenomena. These equations are arguably the most complicated set of nonlinear partial differential equations in classical physics. The wavelengths of the gravitational waves emitted from binary systems are orders of magnitude larger than the objects themselves.

Modern gravitational wave detectors, such as NASA's Laser Interferometer Space Antenna (LISA) and the Laser Interferometer Gravitational-Wave Observatory (LIGO), will require general relativistic simulations of coalescing compact objects (such as neutron stars and black holes) with more accuracy than can be obtained with current state-of-the-art finite difference methods.



LISA, the Laser Interferometer Space Antenna. *Mark Miller, NASA/JPL*

We are using NASA supercomputers to solve the Einstein field equations for binary black hole/neutron star coalescence to enable simulation of the transition from quasi-equilibrium orbits, to tidal disruption and merger, until finally a black hole is formed.

Our newly developed High-Order Shock Capturing scheme converges at 8th order during the inspiral phase for orbiting binary neutron stars. Along with converging at high order for smooth data, the scheme is able to simulate relativistic shocks just as well as traditional high-resolution shock capturing schemes.

"Imaging" the source of gravitaional waves is only possible by matching detected signals with solutions to the Einstein field equations. Analytical techniques are unable to solve the equations in realistic scenarios; only large supercomputers are able to do the job.

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