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Image of a soliton wave occurring on a body of water
University of Washington

Electrical Soliton Wave in Space, a First

Solitons maintain shape and speed while traveling

This is the first time when an electrical soliton wave was found in space and measured by the Cluster mission. The so-called soliton waves are a special type of wave which travel great distances without changing shape. The term soliton wave was first coined by John Scott Russell in 1834, while observing that at the bow of a boat which travels through water, a strange wave takes shape and continues to travel on, even when the boat stops, without changing shape or speed.

As you can see, soliton waves have been first observed in water channels on Earth, but they can also form within optical fibers or in space in the form of an electrical wave. The Cluster mission monitors changes in the space surrounding Earth, but mostly the magnetosphere of the planet were the magnetic field is the dominant force, to observe changes in particle motion and fields.

Data collected in 2002 with the Cluster spacecraft reveals that the electrical soliton wave originated somewhere about 50,000 kilometers away from Earth, was traveling at a speed of about 8 kilometers per second and was probably generated by a magnetospheric turbulence in the outer edge of the magnetosphere.

Usually, localized hump-shaped waves traveling through water lose shape and momentum relatively quickly, however soliton waves are able to avoid that simply by having the right shape. Real waves traveling through a flat body of water are composed of multiple wavelengths, while solitons are undulating waves consisting of a single wavelength which keeps its shape. The main reason why real waves lose shape and speed relatively easy in water is that longer wavelengths travel faster than the shorter ones, thus enabling it to spread out.

Alternatively, soliton waves are able to slow down longer wavelengths while speeding up the shorter ones, so that they both travel at the same pace through space. Russell described the solitons when he first discovered them as a wave "assuming the form of a large solitary elevation, a rounded, smooth and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed."

Soliton waves are extremely important in fiber optics, as by maintaining their shape they are able to travel thousands of kilometers before experiencing even the slightest change. Aside oceanic and atmospheric waves, solitons may be routinely experienced in magnets and Josephson junctions, or in ionised plasma of space.