History of Soliton Experiments

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In the theory of a soliton, or a solitary wave, we often encounter the situation that a soliton has the maximum amplitude. One example is an ion acoustic solitary wave in a plasma with zero ion temperature, $T_\mathrm{i} = 0$, and finite electron temperature, $T_\mathrm{e} \neq 0$. In the wave frame of a solitary wave, all the ions in front of a solitary wave approach a solitary wave with the velocity c which means the velocity of a solitary wave in the laboratory frame. The ions are decelerated in the leading edge of the wave potential φ and then accelerated in the trailing edge. In this case, the solitary wave is stable. When the wave potential becomes large and the condition $e\varphi > Mc^2/2$ is satisfied, the ions are reflected from the wave potential, which leads to the collapse of a solitary wave. Here the ion charge is designated by e and the ion mass, by M. In the real plasma, the ion temperature is much smaller the electron temperature, but it is finite. Then a part of ions are reflected by the wave potential, which brings about the damping of a solitary wave.

The second example is a shallow water solitary wave. Since the observation of a solitary wave by John Scott Russell, the theoretical and experimental studies on nonlinear shallow water wave have been carried out extensively. The breakdown of perturbation approach leads to find the existence of the maximum energy of a solitary wave. At present, we know that the solitary wave is stable when the amplitude is lower that the maximum amplitude corresponding to the maximum energy, and then becomes unstable when the amplitude exceeds the critical one. The instability is characterized by a breaking of a solitary wave.

In this talk, I will present a brief history of the experiments on soliton together with our experimental results of the maximum amplitude and the instability of the shallow water solitary wave.