Soliton Stars in a Spontaneously Broken U(1) Gauge Theory

In a system that consists of a bosonic field and a gravitational field, it is known that soliton like solutions which are called boson stars exist. Though the boson stars have not been observed in the universe, they are expected as a candidate of dark matter and an origin of super massive black holes. For these reasons, the boson stars are interesting exotic objects. I attempt to construct the boson stars in a system that consists of two complex scalar fields, a gauge field, and a gravitational field.

Even if the gravity does not exist, Q-ball solutions exist as bound states of bosonic particles in the system. The boson stars in the systems which admit the Q-balls are also called soliton stars. In the model, in the limit of the gravitational coupling is zero, the soliton stars approach to the Q-balls that are supported by the interaction between the matter fields. On the other hand, we expect that as the gravitational coupling is larger, the gravitational collapse happens in the cases that the mass of the soliton stars is large. Then, an upper mass for the stable soliton stars exist. It is an interesting issue that investigating a dependence of the upper mass and the coupling constants. We study the gravitational effects of dust balls, shell balls, and potential balls. Since they have different configurations inside the Q-balls, I expect that they yield different gravitational properties.

Stability for Soliton Stars by Numerical Calculations

In order to discuss a stability of the soliton stars, there are several ways. The simplest way is consideration of energy. Since the soliton stars can be interpreted as condensation of bosonic particles, we can obtain a condition to divide the soliton star into free bosonic particles by comparing the energy of the soliton star as a bound state of the bosonic particles and energy of free bosonic particles of the same numbers. However, since it is not enough discussion for the stability of the soliton stars, we will try other methods.

The first method is analysis of the linearized equation. This is achieved by solving the equations of linear perturbation for the classical fields which construct the soliton stars. The stability is characterized by the sign of energy eigenvalues of the perturbed state.

The second method is study of time evolution for the soliton stars by numerical simulation. I want to investigate stability for nonlinear perturbations. To investigate time evolution for the Einstein equations, I decompose four dimensional spacetime to space parts and time one, and evolve the metric of the space parts. By using this method, I can observe a process of a collapsing the soliton star to a black hole.