Charge Screened Boson Stars in a Spontaneous Broken U(1) Gauge Theory

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Nontopological solitons are interesting excitations in field theories, where field configurations have the lowest energy for fixed conserved charge in global U(1)-invariant theories. Friedberg, Lee and Sirlin [1] introduced the nontopological solitons in a coupled system of scalar fields, and Coleman [2] showed the simplest example of the nontopological solitons, so-called Q-balls, can appear in a system of a self-interacting single complex scalar field.

Generalizations of the Q-balls in local U(1)-invariant theories by introduction of a gauge field are also studied [3]. There are significant differences between gauged and ungauged Q-balls , i.e., an ungauged Q-ball with arbitrary large charge is allowed, while upper bound of charge appears for a gauged Q-ball.

We investigated the coupled system consisting of a complex matter scalar field, a U(1) gauge field, and a complex Higgs scalar field that causes spontaneously symmetry breaking. Our system is a generalization of the Friedberg-Lee-Sirlin model [1]. We show, by numerical calculations, that there are Q-ball solutions in this system. It is shown that the Q-balls in this system have the following properties: charge density of the matter scalar field is screened by counter charge cloud of the Higgs and gauge field everywhere; an arbitrary large size is allowed [4].

In this talk, taking the Einstein gravity into account, we investigate gravitational fields that is produced by the charge screened Q-balls and how the gravity affects field profiles of the Q-balls. In the case of small mass, where gravity is weak, we have stable boson stars, while in the case of large mass, where the pressure fails to sustain the gravity, the boson star collapse to black holes. We discuss possibilities of production of primordial black holes and/or super massive black holes in the central region of galaxies.

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