# Thermal Evolution of Compact Stars with Quark Superconductivity

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Compact stars are highly dense stars likened to huge nuclei. At the central region of a compact star, the density exceeds the nuclear density, and the matter might be an exotic state which does not appear in the normal nucleus. Many states are considered such as meson condensation, hyperon mixing, quark deconfinement, or superfluidity of nuclei, at these density. The temperature of a compact star is relatively lower than significant temperature at the density, it is very difficult to represent by terrestrial experiments. To explore the matter of a compact star, comparing x-ray observation and theoretical calculation is the most effective method.

Observation of compact stars have done by meny methods, and constrains the internal matter state, for almost half century since the first observation. Recent $2M_\odot$ mass observation give strong constraint for the equation of state of nuclear matter, and the gravitatinal wave from compact star merger event has been detected. However, the internal matter of a compact star is still unknown, and the possibility of exotic states has not been rejected. The state of internal matter of compact star directly connects to the neutrino emission process which is the dominant cooling process of compact stars. Therefore it is possible to give constraint for the internal matter state of compact stars by comparing the simulation of thermal history of an entire star to observation.

We have simulated thermal evolution of isolated compact stars which have the core contains colour superconducting (CSC) quark matter, and examined the effect of CSC state for cooling of stars. We assume that the CSC quarks become colour-flavour-locking (CFL) state either two-flavour-superconducting (2SC) state. As the result, if the quarks become 2SC state, the star which is heavy enough to have quarks cools down drastically, which cannot explain cold compact star observations. Meanwhile, if the star has quarks of CFL state, the temperature does not drop strongly, and cold stars can be explained by fine-tuning of superfluidity of nucleus.