論文の内容の要旨

論文題目　Hadron-Quark Crossover and Massive Neutron Stars
(ハドロンクォーククロスオーバーと重い中性子星)

氏名　益田　晃太

Bulk properties of cold and hot neutron stars (NSs) are studied on the basis of the hadron-quark crossover picture where a smooth transition from the hadronic phase to the quark phase takes place at finite baryon density.

We developed a phenomenological equation of state (EOS) "CRover" EOS, which interpolates the two phases at around 3 times the nuclear matter density (ρ_0), and found that the cold NSs with the gravitational mass larger than $2M_\odot$ can be sustained. This is in sharp contrast to the case of the first-order hadron-quark transition where the quark matter inevitably leads to soft EOS. We show this novel stiffening of EOS by the appearance of quark matter through the hadron-quark crossover does not depend on the methods of interpolation nor the choice of hadronic EOSs. The radii of the cold NSs with the CRover EOS are in the narrow range (12.5 ± 0.5) km which is insensitive to the NS masses. Due to the stiffening of the EOS induced by the hadron-quark crossover, the central density of the NSs is at most 4 ρ_0 and the hyperon-mixing barely occurs inside the NS core if we have the repulsive three body force between hyperons. This constitutes a solution of the long-standing hyperon puzzle about the maximum mass and the rapid cooling of neutron stars with hyperons. The effect of color superconductivity (CSC) on the NS structures is also examined with the hadron-quark crossover. For the typical strength of the diquark attraction, a slight softening of the EOS due to two-flavor CSC (2SC) takes place at the core of neutron stars and the maximum mass is reduced by about 0.2 $M_\odot$. However, the maximum mass of NSs sustained by this phenomenological EOS with CSC can still exceed $2M_\odot$. Through the percolation of nucleons to quarks with the diquark correlation, the effects of CSC can be seen even in low mass neutron stars.

The CRover EOS is also generalized to the supernova matter at finite temperature to describe the hot NSs at birth. The hadron-quark crossover is found to decrease the central temperature of the hot NSs under isentropic condition due to the color degrees of freedom. The gravitational energy release and the spin-up rate during the contraction from the hot NS to the cold NS are also estimated.