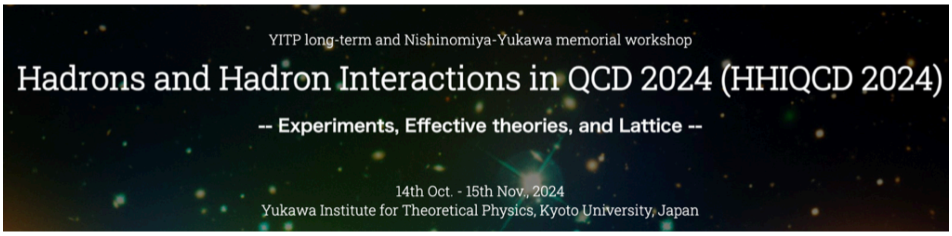

Contribution ID: **60** Type: **4th week (Nuclear matter under extreme conditions)**

Superfluids of parity-doubled baryons in neutron stars

Thursday, November 7, 2024 11:00 AM (1 hour)

Recent advances in multi-messenger astronomy have provided a key set of constraints on the equation of state (EoS) of QCD at high baryon density, via extraterrestrial observations of dense stellar objects such as neutron stars (NSs). It was suggested that the softening of the EoS at intermediate densities required to comply with the observed tidal deformability, together with the subsequent stiffening at high densities to protect the $2M_\odot$ NSs from their gravitational collapse, may indicate a phase transition at the core. This is often attributed to color deconfinement, although it is rather a heuristic guidance within simplistic approaches that do not account for the microscopic dynamics of underlying QCD.

Whereas the existence of quark matter is an intriguing option, a pure hadronic scenario has been shown to fully reconcile the modern constraints from observation, where the essential ingredients are the lowest nucleon $N(940)$ and its parity partner $N^*(1535)$ interacting with mesons in a chiral-invariant way. The properties of N and N^* can be well captured within the parity doublet model based on the mirror assignment of chirality: The mirror assignment is a more general representation for the nucleons with opposite parity, than the conventional one a la Gell-Mann and Levy, the naive assignment. It is a striking difference that the parity doublet model predicts the N and N^* being degenerate and massive when the chiral symmetry becomes restored, whereas the naive one inevitably leads to massless nucleons. The former, the mirror scenario, emerges in Nature, as confirmed by the recent lattice QCD simulations exhibiting a clear manifestation of parity doubling near the chiral crossover in the baryon spectra.

In this talk, we present novel superfluids of parity-doubled neutrons and discuss their properties in an effective Lagrangian approach. Our mean-field analyses reveal that (1) two vector-type condensates emerge, and (2) the dispersion relation of the gapped neutron leads to a strong spatial anisotropy. Some implications will be advocated.

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Session Classification: 1-day workshop (4th week)