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Pion and Kaon Condensation from Holographic QCD

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The properties of QCD matter at finite isospin and strangeness densities are investigated employing holographic soft-wall AdS/QCD models. It is confirmed that at high enough isospin densities, charged pions start to condense and the pion superfluid phase appears in the system. It is shown that the chiral condensate and the pion condensate can be transformed to each other and form a 'chiral circle' in the superfluid phase. We derived the Equation of State (EoS) for pionic matter, calculated the normalized trace anomaly Δ and $(\epsilon - 3p)/m_\pi^4$, and analyzed the sound speed and adiabatic index. Additionally, we provided data on the mass-radius relation and the tidal deformability of pion stars. The results indicate that holographic models align well with lattice QCD concerning isospin density, axial-vector condensation, EoS, and trace anomaly, though discrepancies in sound speed and adiabatic index emerge at higher isospin chemical potentials. The holographic models closely match those from the chiral perturbation theory (χPT), suggesting that they can be considered as five-dimensional description of χPT.

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