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Pion masses in 2-flavor QCD with ¥eta condensation

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We investigate some aspects of 2-flavor QCD with m_u¥not $= m_d$ at low-energy, using the leading order chiral perturbation theory including anomaly effects. While nothing special happens at $m_u = 0$ for the fixed m_d¥not $= 0$, the neutral pion mass becomes zero at two critical values of m_u, between which the neutral pion field
condenses, leading to a spontaneously CP broken phase, the so-called Dashen phase. We also show that the "topological susceptibility" in the ChPT diverges at these two critical points. We briefly discuss a possibility that $m_u = 0$ can be defined by the vanishing the "topological susceptibility. We finally analyze the case of $m_u = m_d = m$ with ¥$theta$ $=$ ¥pi, which is equivalent to $m_u = -m_d = -m$ with ¥$theta$ $= 0$ by the chiral rotation. In this case, the ¥eta condensation occurs at small m, violating the CP symmetry spontaneously. Deep in the ¥eta condensation phase, three pions become Nambu-Goldstone bosons, but they show unorthodox behavior at
small m that $m_{¥}pi^2 = O(m^2)$, which, however, is shown to be consistent with the chiral Ward-Takahashi identities.

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