The Sigma Meson in Lattice QCD

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In the effective models such as the linear σ model and the Nambu Jona-Lasinio model, the π and σ mesons play important roles equally for the chiral symmetry breaking of QCD in the low-energy region. From experimental analyses side, the existence of light σ meson was unreliable a several year ago. However, by recent $\pi - \pi$ scattering phase shift analyses, the $I = 0$ and $J^{PC} = 0^{++}$ meson, $f_0(400 - 1200)$ or σ, appeared bellow 1 GeV mass region in Particle Data Group[1]. Especially, Igi and Hikasa constructed a general model-independent framework to describe the $\pi\pi$ elastic scattering below 1 GeV region and investigated the existence of σ meson [2].

At the present moment, there is no conclusive work about the property of σ meson. Hence the lattice QCD calculation including non-pertubative and relativistic aspects is important task on understanding the property of σ meson. The σ meson masses which are obtained by consideration of the dynamical quark effects are extremely lower than the quenched results. Our intention in this work is to conclude whether the σ meson exists below 1 GeV region and is identified with the iso-singlet scalar meson "$f_0(400 - 1200)$ or σ" in the PDG.

We investigated the property of σ meson whose operator is $\frac{1}{\sqrt{2}}(\bar{u}u + \bar{d}d)$. In the σ meson propagator the contribution of disconnected diagram is the same order of connected diagram; Quenched approximation is not reliable for the investigation of the σ meson. The evaluation of the disconnected diagram was done by using Z_2 noise method. A statistical error of σ propagator which comes from the disconnected diagram mainly is large in the present stage. As preliminary results[3], we obtain the following properties of σ propagator: (1) Both the connected and disconnected parts equally contribute to the σ propagator. (2) σ meson could have mass of the same order of the ρ meson.

It is necessary to generate much more gauge configurations and improve the statistical precision of the estimation of σ propagator. Furthermore we must investigate the mixing state of the σ meson and glueball if we obtain the result that σ meson mass is greater than 1 GeV region.

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References

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