The static three-quark potential from one gauge configuration

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The static three-quark potential is one of the typical quantity in QCD, which can be used to describe a baryon as a bound state of three quarks. However, the determination of its functional form is not straightforward since the functional form is of course dependent on how the color flux tube is formed among the three quarks, which is not known a priori due to nonperturbative nature of the QCD vacuum. Practically the several functional forms from different flux-tube shapes were proposed in previous works [1, 2, 3, 4]. The precise lattice data with less statistical and systematic errors are clearly required.

In this report, we present a part of our results of the static three-quark potential in SU(3) lattice gauge theory at zero temperature extracted from the Polyakov loop correlation function (PLCF) by employing the multilevel algorithm [5]. We carried out simulations using the standard Wilson gauge action in SU(3) lattice gauge theory at $\beta = 6.00$ on the 24^4 lattice. The PLCF is an ideal three-quark source since they are free from the systematic effect due to the spatial Wilson lines. The multilevel algorithm, a powerful noise reduction method, reduces the statistical noise thoroughly. The three-quark potential V_{3q} is extracted from the expectation value of the PLCF by

$$V_{3q}(\vec{x}_1, \vec{x}_2, \vec{x}_3) = -\frac{1}{T} \ln \langle \mathrm{Tr}P(\vec{x}_1)\mathrm{Tr}P(\vec{x}_2)\mathrm{Tr}P(\vec{x}_3)\rangle + O(\frac{1}{T}e^{-(\Delta E)T}) \ , \tag{1}$$

where $\vec{x}_1$, $\vec{x}_2$, $\vec{x}_3$ correspond to the spatial location of quarks. Note that the contamination from the excited states $O(\frac{1}{T}e^{-(\Delta E)T})$ is negligible at zero temperature as the time extent of the lattice $T = 24$ is large enough.

In Fig. 1, we show the three-quark potential computed from one gauge configuration and compare it with the average from nine independent gauge configurations [6]. We find that the result from one configuration coincides with the average, which means that it is possible to compute the expectation value even from one configuration by tuning the parameters of the multilevel algorithm. Using this method we are currently investigating the three-quark potential of various quark configurations.

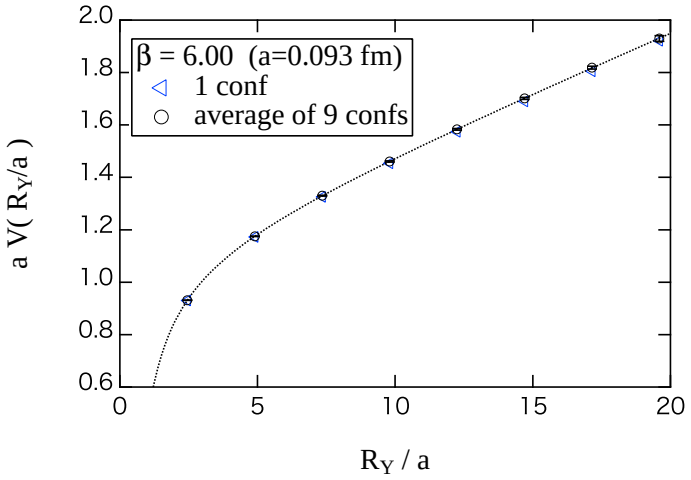

Figure 1: The three-quark potential computed from one gauge configuration, which is compared to the average of the potential from nine independent configurations. Three quarks are put at the vertices of regular triangles.

References

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