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Evidence of glueballs at physical point

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WE perform an exploratory study of glueballs on a RBC/UKQCD gauge ensembles with a large lattice size and with the $N_f = 2 + 1$ dynamical quark masses being tuned at the physical point. The noises of glueball correlation functions are considerably reduced through the cluster-decomposition-error-reduction scheme. The Bethe-Salpeter wave functions are obtained for the salar, the tensor and the pseudoscalar glueballs by using the spatially extended glueball operators defined through the gauge potential $A_\mu(x)$ in the Coulomb gauge. These wave functions show similar features of non-relativistic two-gluon systems, which are used to optimize the signals of the related correlation functions at the early time region, where the ground state masses in each channel can be extracted. By the assumptions that the glueball operators defined in terms gauge potentials couple almost exclusively to pure glueball states, the obtained masses are interpreted to be those of the ground state pure gauge glueballs. For the most interesting scalar channel, the glueball mass is determined to be 1.75(2) GeV, which is in good agreement with the QLQCD predictions and is close to the mass of $f_0(1710)$. Our result shows the existence of glueball states in the presence of dynamical quarks, even though many systematic uncertainties have not yet be well tackled with.

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