The Physics of Glueballs

Vincent Mathieu
Université de Mons, Belgium
Universidad de Valencia, Spain

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Quantum Chromodynamics (QCD) is the modern theory of the strong interaction. QCD allows the coupling of gluons, the gauge particles of the interaction, which can form an observable states. Glueballs, bound states of gluons, are then a beautiful consequence of the QCD. I review the recent developments on glueballs spectroscopy with a special emphasis on constituent models.

The problematic on the mixing with nearby mesons leads to difficulties in the identification of physical states. The lightest glueball is predicted to be scalar which could be the key in the understanding of the scalar spectrum below 2 GeV. In the other hand, in the pseudoscalar sector, recent data reveal a possible glue content in the $\eta - \eta'$ system.

Beside this implications of glueballs in physical states, the spectrum of pure glue states is an active field of investigation. The pure gauge spectrum of quarkless QCD was investigated by Morningstar and Peardon on a lattice. They identified 15 glueballs below 4 GeV both in $C = +$ and $C = -$. I present a summary of difference methods (bag model, QCD spectral sum rules and AdS/QCD correspondance) used to reproduce the lattice results.

In a constituent picture, the low-lying states are bound states of two gluons with $C = +$. A negative charge conjugation requires at least three gluons. In the usual picture, the gluon is a heavy spin-1 particle since the gauge boson gains a dynamical mass induced by non-perturbative effects. This consideration leads to gluonium pictures for two- and three-gluon glueballs which are extrapolations of meson and baryon systems.

However I show that the naive interpretation do not reproduce the lattice spectrum. This formalism is indeed irrelevant to handle transverse particles such as gluons. The implementation of the helicity formalism for two-gluons glueballs leads to a spectrum in perfect agreement with the lattice results even without the inclusion of short-range spin-splitting potentials.

References

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