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Glueball Mass Spectrum and Mass Splitting in $2+1$ Strongly Coupled Lattice Gauge Theories

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Abstract. For a $2+1$ strongly coupled ($\beta = 2/g^2$ small) Wilson action lattice gauge theory with complex character we analyze the mass spectrum of the associated quantum field theory restricted to the subspace generated by the plaquette function and its complex conjugate. It is shown that there is at least one but not more than two isolated masses and each mass admits a representation of the form $m(\beta) = -4\ln\beta + r(\beta)$, where $r(\beta)$ is a gauge group representation dependent function analytic in $\beta^{1/2}$ or β at $\beta = 0$. For the gauge group SU(3) there is mass splitting and the two masses $m_\pm$ are given by

$$m_\pm(\beta) = -4\ln\beta + \ln 16r^4 + \tfrac{1}{2}(2\pm 1)\beta + \left(d_\pm(\beta) \equiv \sum_{n=2}^{\infty} c_n^\pm \beta^n\right),$$

where $r = 3$ is the dimension of the representation and $d_\pm(\beta)$ is analytic at $\beta = 0$. $c_n^\pm$ can be determined from a finite number of the $\beta = 0$ Taylor series coefficients of finite lattice truncated plaquette–plaquette correlation function at a finite number of points.

1. Introduction

In [1] the low lying energy-momentum spectrum of the quantum field theory associated with the $2+1$ strongly coupled lattice gauge theory with Wilson action A' is analyzed. Formally $A' = \beta \sum_p \chi(g_p)$, where χ is the real character of an irreducible representation of a compact gauge group. g_p is the oriented product of group elements around the border of the plaquette P. It is shown that for $\beta > 0$ and small the energy-momentum spectrum in the gauge invariant subspace generated by the time zero plaquette functions $\chi(g_{p_x})$, $x = (x_1 = 0, \mathbf{x}) \in Z^3$ consists of an isolated dispersion curve $\omega(\mathbf{p}) \geqq \omega(\mathbf{0})$, real analytic in $\mathbf{p} \in (-\pi, \pi]^2$, which is identified as a glueball. Furthermore the glueball dispersion curve and mass $m \equiv \omega(\mathbf{0})$ satisfy

$$\lim_{\beta\downarrow 0} \frac{m}{-4\ln\beta} = 1, \qquad \lim_{\beta\downarrow 0} \frac{\omega(\mathbf{p})}{m} = 1,$$

uniformly in $\mathbf{p} \in (-\pi, \pi]^2$.