Yang-Mills theory constructed from Cho-Faddeev-Niemi decomposition (I)[1]

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We give a new way of looking at the Cho-Faddeev-Niemi (CFN) decomposition[2] of the Yang-Mills (YM) theory to answer how the enlarged local gauge symmetry respected by the CFN variables is restricted to obtain another YM theory with the same local and global gauge symmetries as the original YM theory.[1] This may shed new light on the fundamental issue of discrepancy between two theories for independent degrees of freedom and a role of the Maximal Abelian (MA) gauge in the YM theory.

First, we introduce the color unit vecotr $\boldsymbol{n}(x)$ in the $SU(2)$ YM theory independently of the original gauge field $\mathscr{A}_\mu(x)$. The gauge transformation of $\boldsymbol{n}(x)$ is nothing but the map from S^2 to S^2 at each spacetime point. Therefore the gauge symmetry of the YM theory is enlarged from $SU(2)$ to $SU(2) \times [SU(2)/U(1)]$ by introducing $\boldsymbol{n}(x)$. Here, performing the change of the variables (CFN decomposition):

$$\mathscr{A}_\mu = c_\mu \boldsymbol{n} + g^{-1}\partial_\mu \boldsymbol{n} \times \boldsymbol{n} + \mathbb{X}_\mu,$$

we obtain the CFN-YM theory.

Next, we adopt the new MA gauge condition, which is obtained by minimumizing the functional $\frac{1}{2}\int d^4x \mathbb{X}_\mu \cdot \mathbb{X}^\mu$. The new MA gauge partially fixes the gauge symmetry of CFN-YM theory, to leave residual $SU(2)$ symmetry unbroken.

As a byproduct, this consideration presents new insight into the meaning of gauge invariance and the observables, e.g., a gauge-invariant mass term and a vacuum condensates of mass dimension two. See [3] for BRST formulation and [4] for lattice simulation.

References

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[1] This talk is based on [1] in collaboration with K.-I. Kondo and T. Murakami.