論文の内容の要旨

Bordism Analyses of Symmetries and Anomalies in Quantum Field Theories

(場の量子論の対称性とアノマリーのボルディズムによる解析)

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In this thesis, we study certain topological terms called the Wess-Zumino-Witten (WZW) terms appearing in non-linear sigma models. The WZW terms must be present if the sigma models are realized as low-energy effective descriptions of four-dimensional massless quantum chromodynamics (QCD), as they are responsible for appropriately reproducing the 't Hooft anomalies of global symmetries in the QCD.

This anomaly matching determines the overall coefficient of the WZW terms, but it further reveals that they are not well-defined on arbitrary spacetime manifolds, since they do not obey the required quantization conditions. For the simplest case of the IR non-linear sigma models of SU QCD, it was pointed out earlier that the underlying spacetime manifolds need to be equipped with spin structure allowing spinors to be defined on them, which is indeed natural as the original QCD one started with contain fermions. However, the method used to verify this was rather ad-hoc and was not applicable to QCD with other gauge groups of interest such as SO.

We will explain that the WZW terms should be described in terms of (co)bordism instead of naïve ordinary (co)homology, and show that this description nicely makes sense of those subtleties concerning overall coefficients, not only for SU QCD but also for SO QCD. The solution to the former case has been known as mentioned above, but we newly provide a more sophisticated argument, so to speak, based on (co)bordism with an advantage that it also applies to the latter case which was previously intractable.

Also, SO QCD have another interesting twist concerning the "generalized" global symmetries. It was recently found that $\mathrm{SO}(2n_c)$ QCD with even number of colors have mixed 't Hooft anomaly between ordinary symmetries and "higher-form" symmetries, while it remained unclear how this anomaly is matched in the IR non-linear sigma models. By examining solitonic strings in the sigma models, we find that the WZW terms are also responsible for reproducing this novel anomaly too.