In this article the authors study quantum gravity in twistor space. Use of twistor space in gauge theories, mainly provoked by [1], has been prolific in the computation of scattering amplitudes and has unveiled many mathematical properties of gauge theories such as analyticity, integrability and connection to Grassmannian manifolds. Recent developments include the result that quantum anomalies in self-dual Yang-Mills theory on twistor space cancel for certain gauge groups with the existence of axion-like auxiliary fields [2]. This article can be understood as generalization of this result to self-dual quantum gravity or, more precisely, holomorphic Poission-BF theory on twistor space.

In section 2 the authors define the holomorphic Poission-BF theory and discuss how it gives rise to non-linear gravitons. In the following sections the authors compute anomaly polynomials in the holomorphic Poission-BF theory and show all anomalies (gravitational, gauge, and mixed ones) cancel by adjusting couplings to axion-like fields. The authors indicate that when the cancellation occurs all four-point amplitudes with external gravitons and/or gluons in the theory vanish. This implies that all $n \geq 4$-pt amplitudes vanish and integrability is restored in the theory. The authors also comment on relations to other relevant studies including theories of $\mathcal{N} = 2$ strings (as 4-dimensional self-dual gravity) [3, 4] and 4-dimensional Chern-Simons theory [5, 6].

References

[1] E. Witten, Commun. Math. Phys. **252**, 189-258 (2004) doi:10.1007/s00220-004-1187-3 [arXiv:hep-th/0312171 [hep-th]].

[2] K. J. Costello, [arXiv:2111.08879 [hep-th]].

[3] H. Ooguri and C. Vafa, Nucl. Phys. B **361**, 469-518 (1991) doi:10.1016/0550-3213(91)90270-8

[4] H. Ooguri and C. Vafa, Mod. Phys. Lett. A **5**, 1389-1398 (1990) doi:10.1142/S021773239000158X

[5] K. Costello and M. Yamazaki, [arXiv:1908.02289 [hep-th]].

[6] R. Bittleston and D. Skinner, JHEP **02**, 227 (2023) doi:10.1007/JHEP02(2023)227 [arXiv:2011.04638 [hep-th]].