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Contributions to uncovering hidden symmetries and structures in S-matrix of
gauge and gravity theories

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As one of the leading experts in the world on the S-matrix for gauge and gravity theories, Prof. Yu-tin Huang initiated, with amazing insight and endeavor, a series of surprising developments that have revolutionized our understanding about scattering amplitudes in field theories and gauge theories in various dimensions.

Scattering amplitudes are fundamental observables in field theories, usually obtained by calculating and summing up thousands of different Feynman diagrams from Lagrangians: even a calculation of a single diagram is very difficult and involved. Each diagram does not respect the underlying symmetries such as the gauge or gravitational symmetries. But surprisingly, a summation of thousands of diagrams miraculously make the final result of scattering amplitudes invariant under these symmetries. It suggests that there must exist a clever method to obtain the scattering amplitudes. The recent development of S-matrix theories bypasses the complicated calculations of Feynman diagrams and the scattering amplitudes are calculated in a much more clever, simple and systematic way. Yu-tin Huang has produced very deep and influential papers on the subject and summarized the recent developments in the famous textbook (written with H. Elvang), "Scattering Amplitudes in Gauge Theories and Gravity", published in 2015 from Cambridge University Press. The book is now the standard reference on this topic and has influenced many researchers.

Yu-tin Huang revealed hidden structures and relations between the scattering amplitudes of gauge theories and gravity theories. It was conjectured that the gravity theory amplitudes are written as a double copy of the gauge theory amplitudes. The first paper [1] showed this *double copy structure* beyond the tree-level approximations by proving the duality relation of color and kinematic factors. The realization led tremendous progress for loop level computations of quantum gravity amplitudes at the ultra-violet energy scale.

The second paper [2] established the presence of dual-superconformal symmetry for three-dimensional $N = 6$ theories to all orders in perturbation theory. Unlike the case of four-dimensional $N = 4$ super Yang-Mills theory, this symmetry was not expected from the dual string picture, and hence the establishment of its presence was an important field theoretical accomplishment. The result revealed hidden structures in the $d=3$ gauge theories and led to high-multiplicity and higher loop computations of the Chern-Simons gauge theories.

Prof. Huang's papers are of very high quality and have revealed various hidden structures of gauge theories and gravity theories. Yu-tin Huang deserves the Nishina Asia Award.

References

- [1] Zvi Bern, Tristan Dennen, Yu-tin Huang, Michael Keirmaier, "Gravity as the Square of Gauge Theory", **Physical Review, D82 (2010) 065003**

- [2] Dongmin Gang, Yu-tin Huang, Eunkyung Koh, Sangmin Lee, Arthur Lipstein, "Tree-level Recursion Relation and Dual Superconformal Theory of ABJM", **JHEP 1103 (2011) 116**