

## Harnessing $SL(2,Z)$ in Super Yang-Mills and Gravity

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We introduce a new approach to extracting the physical consequences of S-duality for observables of four-dimensional  $N=4$  super Yang-Mills (SYM) theory. The main mathematical tool is the theory of harmonic analysis on the fundamental domain of  $SL(2,Z)$ . Applying this technology leads to strong constraints on the analytic structure of observables in  $N=4$  SYM. We treat a specific set of integrated correlators in some detail, which simplify drastically when expressed in the  $SL(2,Z)$ -invariant eigenbasis. We initiate the study of the statistics of CFT data in the ensemble of  $N=4$  SYM theories. At large  $N$ , this has ramifications for holography. In a sense to be made precise, we show an equivalence between observables in the strongly coupled planar theory, dual to type IIB supergravity on  $AdS_5 \times S^5$ , and their ensemble average over the  $N=4$  SYM conformal manifold.

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