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Dynamics of Heavy Operator in $N=4$ SYM: Integrated Correlators and AdS Bubbles

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Abstract

We study integrated correlation functions of half-BPS operators in $SU(N)$ $\mathcal{N} = 4$ supersymmetric Yang-Mills theory (SYM) involving two superconformal primary operators in the stress-tensor multiplet and two identical maximal-trace operators of arbitrary R -charge p . Thanks to $\mathcal{N}=4$ SYM electro-magnetic duality these integrated correlators have recently been computed as exact functions of N , p , and of the Yang-Mills complexified coupling τ . Using a combination of tools from $(\mathfrak{sl}(2, \mathbb{Z}))$ spectral theory and resurgence analysis, we study the landscape of large- N and/or large-charge expansions for these correlators. In particular, we find novel non-perturbative effects in the limit where $N \rightarrow \infty$ with p/N^2 fixed. From a holographic point of view this double-scaling regime is deeply connected with a second family of correlators which we analyse. Using the results for the maximal-trace operators, we derive an exact expression for a new integrated correlator involving two coherent-state operators, defined via an exponential generating function of multi-graviton states. At large- N this correlator admits a holographic dual description in terms of a back-reacted geometry known as the AdS bubble. First, we show that the leading supergravity contribution to the integrated correlator agrees with a direct explicit integration of the correlator itself. Secondly, we derive predictions for the integrated version of the Virasoro-Shapiro amplitude evaluated on the AdS bubble background. Lastly, we demonstrate that the large- N non-perturbative contributions to this integrated correlator emerge from giant-magnon configurations in the dual AdS bubble.

