Finessing the Exponential Scaling with N Problem for Manybody Systems\textsuperscript{1} DEBORAH WATSON, MARTIN DUNN, University of Oklahoma — The resources required for an exact solution of the general quantum mechanical $N$-body problem are widely believed to scale exponentially with $N$, typically doubling for every particle added. With current numerical resources, this problem “hits a wall” around $N = 10$ (within a factor of 2). We have formulated a perturbation method for the general $N$-boson problem that uses symmetry to rearrange this exponential wall so the problem scales as $N^0$. This is achieved by using a perturbation expansion that is invariant under the $N!$ operations of the symmetric group $S_N$, allowing group theory and graphical techniques to be used to solve the problem exactly and analytically at each order for arbitrary interactions and for arbitrary $N$, i.e. the problem scales as $N^0$ at each order. This approach also shifts the work from numerical effort for a single $N$ to analytic work valid for all $N$. The exponential complexity reappears in an exponential wall that scales with the order of the series. We have investigated the growth of complexity as a function of order by enumerating the graphs that correspond to the basis tensors at each order. This formulation opens up the possibility of exact analytical calculations for very large $N$ systems through low order.

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Deborah Watson
University of Oklahoma

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