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The Status of the Nuclear Shell Model

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For 70 years, the nuclear shell model has provided the conceptual and computational framework for most of low-energy nuclear structure. In particular, since the 1980s large-scale shell model calculations have achieved remarkable success in reproducing and (sometimes) predicting experimental data. However, these calculations are inevitably phenomenological in nature, with parameters fit to the data they hope to describe. Efforts to derive shell model parameters based on the underlying interaction between nucleons date back to the 1960s, but have been beset by persistent difficulties. Such a derivation is desirable both for a more reliable extrapolation beyond the range of existing data, and for applications to searches for physics beyond the standard model, where parameters cannot be fixed by experiment.

In the past decade, the formulation of the nuclear force in an effective field theory framework and many-body techniques based on renormalization group ideas have combined with increased computational power to enable substantial progress on this decades-old problem. I will summarize recent advances which allow for a parameter-free connection of the shell model to the underlying interaction, paving the way for robust predictions with quantified theoretical uncertainties.

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