Theory and computation highlights in November, 2018
(Theory and computation to Drector's Monthly Report to JSABOD)
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Three-particle channels are important in spectroscopy of excited mesons, which is closely related to the JLab science program. A new Theory Center paper [arXiv:1810.01261] explores a variational approach to the finite-volume *N*-body problem. The general formalism for *N* non-relativistic spinless particles interacting with periodic pair-wise potentials yields *N*-body secular equations, the solutions for which depend on the infinite-volume *N*-body wavefunctions. The infinite-volume *N*-body dynamics may be solved by using the standard Faddeev approach, and the variational *N*-body formalism could provide a convenient numerical framework for finding discrete energy spectra in periodic lattice structures.

The Joint Physics Analysis Center (JPAC) at JLab has performed an analysis of the three-pion system with quantum numbers $J^{PC}=1^{++}$, which is produced in the weak decay of τ leptons and dominated by the axial meson $a_1(1260)$ [Phys. Rev. D 98, 096021 (2018)]. They built a model based on approximate three-body unitary with free parameters fixed by fitting to the ALEPH data on $\tau^- \to \pi^-\pi^+\pi^- \nu_\tau$ decay. They then performed the analytic continuation of the amplitude to the complex energy plane, addressed carefully the singularity structures related to the $\pi\pi$ subchannel resonances, and extracted the $a_1(1260)$ pole position.

One challenge in the phenomenological interpretation of data from scattering or production experiments is the determination of the resonance spectrum. In the light baryon sector resonances can be broad and overlapping and are in most cases not directly visible in the cross section data. Testing resonance hypotheses in the light baryon sector could be guided by model selection techniques that introduce penalties for resonances to help determine the minimally needed set of resonances to describe the data. The JPAC at JLab compared several possible penalization schemes, and as an application, they performed a blindfold identification of hyperon resonances in the $KN \to K\Xi$ reaction based on the Least Absolute Shrinkage and Selection Operator (LASSO) in combination with the Bayesian Information Criterion (BIC) and found ten resonances – out of the 21 above-threshold hyperon resonances with spin $J \leq 7/2$ listed by the Particle Data Group [arXiv:1810.00075].

The last few years have seen the development of chiral two-nucleon interactions that are local in configuration space and therefore well suited for use in quantum Monte Carlo calculations of light-nuclei spectra and neutron-matter properties. The Theory Center staff uses chiral effective field theory to derive nuclear interactions and electromagnetic currents for magnetic form factors and photo- and electro-disintegration cross sections [arXiv:1809.10180].. The currents are characterized by three low-energy constants, which are constrained by reproducing the magnetic moments of the deuteron and trinucleons. The calculated magnetic form factors of A=2 and 3 nuclei and deuteron threshold electrodisintegration at backward angles are in excellent agreement with experimental data at low values of momentum transfer, where chiral effective field theory is expected to be valid.