

Theory and computation highlights in December, 2020
(Contribution to the Director's Monthly Report to JSABOD)
January 7, 2021

Theory Center bridged staff and postdoc are highly recognized by the QCD and hadron physics community. Dr. Alexei Prokudin (bridged staff) and Dr. Astrid Hiller Blin (Postdoc) have been elected as 2021 member-at-large and Early-Career/Graduate-Student member of the Executive Committee of the Topical Group of Hadron Physics of the American Physical Society, respectively.

A comprehensive analysis of the γW interference radiative correction to the neutron β -decay matrix element has been performed [arXiv:2012.01580] by Theory Center's Dr. Wally Melnitchouk and collaborators at the University of Manitoba, using a dispersion relations approach. This new approach allows one to compute the γW box amplitude in terms of the isoscalar part of the $F_3^{\gamma W}$ interference structure function. Using the latest available phenomenology from the nucleon elastic, resonance, deep-inelastic, and Regge regions, the improved correction gives a theoretical estimate of the CKM matrix element $|V_{ud}|^2 = 0.94805(26)$, which represents a 4σ violation of unitarity.

The Drell-Yan hadronic tensor for electromagnetic (EM) current has been calculated for the first time in the Sudakov region $s \gg Q^2 \gg q_{\perp}^2$ with $1/Q^2$ accuracy by Theory Center's Dr. Ian Balitsky [arXiv:2012.01588]. It is demonstrated that in the leading order in color N_c the higher-twist quark-quark-gluon TMDs reduce to leading-twist TMDs due to QCD equation of motion. The resulting tensor for unpolarized hadrons is EM gauge-invariant and depends on two leading-twist TMDs: f_1 responsible for total DY cross section, and Boer-Mulders function $h_{\perp 1}$

Theory Center Dr. Dudek and his student completed the first calculation within lattice QCD of excited light meson resonances with $J^{PC} = 1^-, 2^-$ and 3^- [arXiv:2012.00518]. Working with an exact SU(3) flavor symmetry, for the singlet representation of pseudoscalar-vector scattering, they find two 1^- resonances, a lighter broad state and a heavier narrow state, a broad 2^- resonance decaying in both P - and F -waves, and a narrow 3^- state. We present connections to experimental ω^*_J, ϕ^*_J resonances decaying into $\pi\rho, KK^*, \eta\omega$ and other final states. This work has relevance to the GlueX program where excited vector meson resonances are being copiously produced.

Theory Center Dr. Briceno and collaborators derived for the first time an exact analytic representation for scattering amplitudes that couple two-particle systems via a single external current insertion, $2+J \rightarrow 2$. From these amplitudes, they showed how to rigorously define resonance and bound-state form-factors. Furthermore, they explored the consequences of the narrow-width limit of the amplitudes as well as the role of the Ward-Takahashi identity for conserved vector currents. These results hold for any number of two-body channels with no intrinsic spin, and a current with arbitrary Lorentz structure and quantum numbers. This work and the existing finite-volume formalism provide a complete framework for determining this class of amplitudes from lattice QCD.