Gluonic Fusion in Exclusive Nearthreshold Meson-Production in Proton-Proton Collisions

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Meson production with electromagnetic and hadronic probes is actually under intensive investigation in modern electron and hadron factories. Particularly, the exclusive meson production at the corresponding threshold in proton-proton collisions is a major part of the experimental program at COSY, WASA, IUCF and TRIUMF.

The major goal of such investigations is to test the short-range dynamics in the nucleon-nucleon (and in the nuclear) system: the momentum transfer at threshold for the η and the production of heavier mesons is beyond 700 MeV/c, equivalently to scales below a $1/2$ fm in coordinate space. To account for the efficient sharing of such large momenta among the interacting hadrons, — the critical piece in any microscopic approach, — the most current models involve, in the framework of effective degrees of freedom meson, exchange currents and the excitation of baryon resonances.

In this note we approach exclusive meson-production in a quark-gluon exchange model: with baryons represented as quark-scalar diquarks and mesons as pure quark-antiquark states, momentum sharing is provided by multiple gluon exchange (accompanied by quark exchange to account for color-singlet hadrons). Guided by findings from meson-exchange models we decompose the full production amplitude into a single hard collision term, accompanied by soft initial (ISI) and final state (FSI) interactions:

$$M_{pp\to pp\lambda} = M_{FSI} M_\lambda M_{ISI}\ ;$$

the hard-scattering amplitude M_λ for a meson λ with the leading gluon-exchange terms is given schematically in the figure enclosed.

Within our basically non-relativistic approach (the hadronic wave functions for constituent quarks are delineated from resonating group calculations), we address and investigate in detail different aspects of the production mechanism (the parameterization of the gluon exchange and the $q\bar{q}$ pair creation potential, finite range and non-local corrections, parameter sensitivities, etc.). Beyond that, various topics are of even more general importance, to name only a unifying description of meson-production with $m_\lambda \leq 1$ GeV, the validity of the OZI rule for the production of the vector mesons $\omega(783)$ and $\phi(1020)$ or the interplay of effective hadronic degrees of freedom via the excitation of baryon resonances from colour-neutral O^+ (Pomeron) 2-gluon exchange (Fig. c).

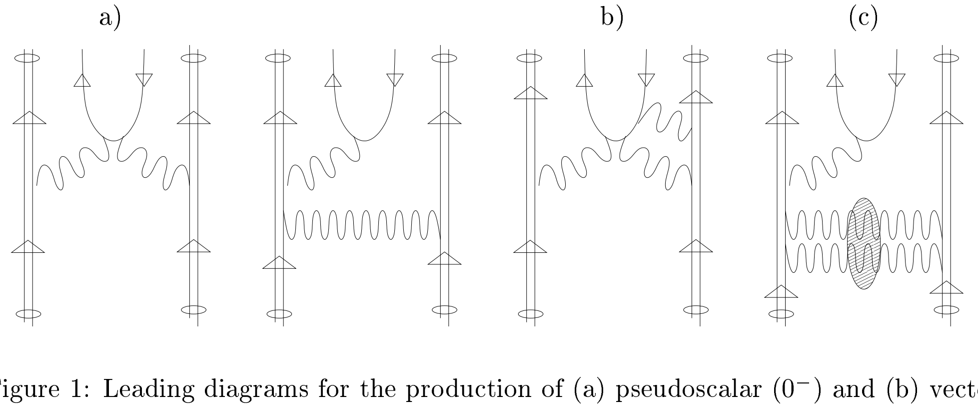

Figure 1: Leading diagrams for the production of (a) pseudoscalar (0^-) and (b) vector mesons (1^-). (c) N^* excitation via soft pomeron exchange (not shown are the one-nucleon term and the quark-exchange).