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Probing of charmonium and exotics in hadron and heavy ion collisions

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The spectroscopy of higher lying charmonium states together with exotic mesons with masses above the $2\,m(D)$ open charm threshold has been full of surprises and remains poorly understood [1]. It is a good testing tool for the theories of strong interactions, including: QCD in both the perturbative and non-perturbative regimes, LQCD, potential models and phenomenological models. The experiments with antiproton-proton annihilation, proton-proton and proton-nuclei collisions are well suited for a comprehensive spectroscopy program, in particular, the spectros-copy of chamonuim and exotics states. The currently most compelling theoretical descriptions of the mysterious XYZ mesons attrib-ute them to hybrid structure with a tightly bound diquark [2] or tetraquark core [3 - 5] that strongly couples to S-wave molecular like structures. In this picture, the production of a XYZ states in high energy hadron collisions and its decays into light hadron plus char-monum final states proceed via the core component of the meson, while decays to pairs of open-charmed mesons proceed via the component. These ideas have been applied with some success to the XYZ states [2], where a detailed calcu-lation finds a core component that is only above 5% of the time with the component (mostly) accounting for the rest. In this picture these states are compose of three rather disparate components: a small charmonium-like core with rrms < 1 fm, a larger component with rrms $\approx$ 1.5 fm and a dominant component with a huge, rrms ≈ 9 fm spa-tial extent. In the hybrid scheme, XYZ mesons are produced in high energy proton-nuclei collisions via its compact (rrms < 1 fm) charmonium-like structure and this rapidity mixes in a time ($t \sim \hbar/\delta M$) into a huge and fragile, mostly , molecular-like structure. δM is the difference between the XYZ mass and that of the nearest mass pole core state, which we take to be that of the $\chi c1(2P)$ pure charmonium state which is expected to lie about 20 $\sim$ 30 MeV above m(X(3872)) [6, 7]. In this case, the mixing time, cτmix 5 $\sim$ 10 fm, is much shorter than the lifetime of X(3872) which is $\chi\tau X(3872) > 150$ fm [8]. The near threshold production experiments in $\sqrt{s}_{pN} \sim 8$ GeV energy range with proton-proton and proton-nuclei collisions with$\sqrt{s}_{pN}$ up to 26 GeV and luminosity up to $10^{32} cm^{-2} s^{-1}$ planned at NICA may be well suited to test this picture for the X(3872) and other exotic XYZ mesons [9]. Their current experimental status together with hidden charm tetraquark candidates and present simulations what we might expect from A-dependence of XYZ mesons in proton-proton and proton-nuclei collisions are summarized.

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Primary author(s) : Prof. BARABANOV, Mikhail (JINR); Prof. VODOPYANOV, Alexander (JINR)

Presenter(s) : Prof. BARABANOV, Mikhail (JINR)

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