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Probing of charmonium and exotic multiquark states in hadron and heavy ion collisions

The spectroscopy of higher lying charmonium states together with exotic mesons with masses above the 2mD 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 ≈ 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 ˜ ħ/δM) 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 χc1(2P) pure charmonium state which is expected to lie about 20 ˜ 30 MeV above MX(3872) [6, 7]. In this case, the mixing time, cτmix 5 ˜ 10 fm, is much shorter than the lifetime of X(3872) which is cτX(3872) > 150 fm [8].
The near threshold production experiments in √s_pN˜8GeV energy range with proton-proton and proton-nuclei collisions with √s_pN up to 26GeV and luminosity up to 10ˆ32cmˆ-2ˆ-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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