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Probing XYZ meson structure in hadron and heavy ion collisions

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The spectroscopy of charmonium-like mesons with masses above the $2m_D$ open charm threshold has been full of surprises and remains poorly understood. The currently most compelling theoretical descriptions of the mysterious XYZ mesons attribute them to hybrid structure with a tightly bound $c\bar{c}$ diquark or $cq(c\bar{q})\bar{c}$ tetraquark core that strongly couples to S-wave $D\bar{D}$ molecular-like structures. In this picture, production of a XYZ particle in high energy hadron collisions and its decays into light hadron plus charmonium final states proceed via the core component of the meson, while decays to pairs of open charmed mesons proceed via the $D\bar{D}$ component. These ideas have been applied with some success to the $X(3872)$, where a detailed calculation finds a $c\bar{c}$ core component that is only above 5% of the time with the $D\bar{D}$ component accounting for the rest. In this picture, the $X(3872)$ is composed of three rather disparate components: a small charmonium-like $c\bar{c}$ core with $r_{rms} < 1$ fm, a larger D^+D^- component with $r_{rms} \approx 1.5$ fm and a dominant component $D^0\bar{D}^0$ with a huge, $r_{rms} > 9$ fm spatial extent. The experiments with pp and pA collisions ($p \leq 26$ GeV/c and $L \leq 10^{32}$ cm⁻²s⁻¹) are well suited to test this picture for $X(3872)$ and, possibly, other XYZ mesons. In near threshold production experiments ($\sqrt{s_{NN}} \approx 8$ GeV), $X(3872)$ mesons can be produced with typical kinetic energies of a few hundred MeV. In the case of $X(3872)$, its decay length will be greater than 50 fm while the distance scale for the $c\bar{c} \rightarrow D^0\bar{D}^0$ transition would be 2 ~ 3 fm. Since the survival probability of an $r_{rms} \sim 9$ fm "molecular" inside nuclear matter should be very small, $X(3872)$ meson production on a nuclear target with $r_{rms} \sim 5$ fm or more ($A \sim 60$ or larger) should be strongly quenched. Thus, if the hybrid picture is correct, the atomic number dependence of $X(3872)$ production at fixed $\sqrt{s_{NN}}$ should have a dramatically different behavior than that of the ψ' , which is long lived compact charmonium state.

The current experimental status of XYZ mesons together with hidden charm tetraquark candidates and present simulations what we might expect from A-dependence of $X(3872)$ in pp and pA collisions are summarized.

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