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Charming physics using matter-antimatter annihilations

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The strong interaction remains one of the most fascinating topic in modern subatomic physics. Quantum ChromoDynamics (QCD) is successfully reproducing the physics phenomena at distances much shorter than the size of the nucleon. Here, perturbation theory can be used yielding results of high precision and predictive power. However, at larger distance scales, however, perturbative methods cannot be applied anymore, although spectacular phenomena, such as the generation of hadron masses and quark confinement, occur. Studies using charmed hadrons and gluon-rich matter have the potential to connect the perturbative and the non-perturbative QCD region. The annihilation of matter with antimatter in the mass regime of charmonium is an ideal environment to discover new states or transitions that could reveal the secrets of the strong interaction. Hadronic and electromagnetic transitions between charmonium states and their decays have been measured with a world-record in precision at experiments exploiting electron-positron colliders such as BESIII in Beijing, China. Moreover, unconventional narrow charmonium-rich states have recently been discovered at various facilities in an energy regime above the open-charm threshold. Thereby, possibly a new era in charmonium spectroscopy is initiated. The PANDA experiment at the research facility FAIR near Darmstadt, Germany, will exploit the annihilation of cooled anti-protons with protons to perform charmonium spectroscopy with a decisive precision. I will present the most promising results that have recently been obtained in the field of charmonium spectroscopy with emphasis on BESIII together with the future perspectives of PANDA.

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