

**SEARCH FOR HIGHER LYING CHARMONIUM AND EXOTICS IN
EXPERIMENTS USING HIGH QUALITY ANTIPROTON BEAM WITH
MOMENTUM UP TO 15 GeV/c**

M. Barabanov, A. Vodopyanov

Joint institute for Nuclear Research Dubna Russia 141980

Contact email: *barabanov@jinr.ru*

The study of strong interactions and hadronic matter in the process of antiproton-proton annihilation seems to be a perspective nowadays. The research of charmonium, charmed hybrid and tetraquark spectra and their main characteristics (mass, width, branching ratio) in experiments using high quality antiproton beam with momentum up to 15 GeV/c, is promising to understand the dynamics of quark interactions at small distances. Charmonium spectroscopy is a good testing tool for the theories of strong interactions: QCD in perturbative and non-perturbative regimes, LQCD and QCD inspired phenomenological potential models.

Nowadays the scalar 1P_1 , 1D_2 and vector 3P_J , 3D_J charmonium states and higher laying scalar 1S_0 and vector 3S_1 charmonium states are poorly investigated. The domain above $D\bar{D}$ threshold of 3.73 GeV/c² is badly studied. According to the contemporary quark models namely in this domain, the existence of charmed hybrids with exotic ($J^{PC} = 0^{+-}, 1^{+-}, 2^{+-}$) and non-exotic ($J^{PC} = 0^{++}, 1^{++}, 2^{++}, 1^{--}, 1^{--}$) quantum numbers as charged and neutral tetraquarks is expected [1, 2].

The elaborate analysis of spectrum of charmonium, charmed hybrids and tetraquarks with hidden charm was carried out, and the attempts to interpret a great quantity of experimental data above $D\bar{D}$ threshold were considered. Using the combined approach based on the quarkonium potential model and model of confinement on the three-dimensional sphere embedded into four-dimensional Euclidian space, new higher lying states of charmonium, charmed hybrids and tetraquarks are expected to exist in the mass region above $D\bar{D}$ threshold. But much more data on different decay modes are needed for deeper analysis. These data can be derived directly from the experiments with high quality antiproton beam.

Especially attention is given to the new states with the hidden charm (XYZ-particles) discovered recently. Their interpretation is far from been obvious nowadays [2]. The experimental data from different collaborations were carefully studied. Some of these states can be interpreted as higher laying states of charmonium and tetraquarks. This treatment seems to be perspective and needs to be carefully verified in the experiments using antiproton beam with momentum ranging from 1 to 15 GeV/c.

[1] PANDA Collaboration, Physics Performance Report, P.63 (2009);

[2] N.Brambilla *et al.*, European Physical Journal C 71:1534, P.1 (2011).