Two collider research teams find evidence of new particle Zc(3900)

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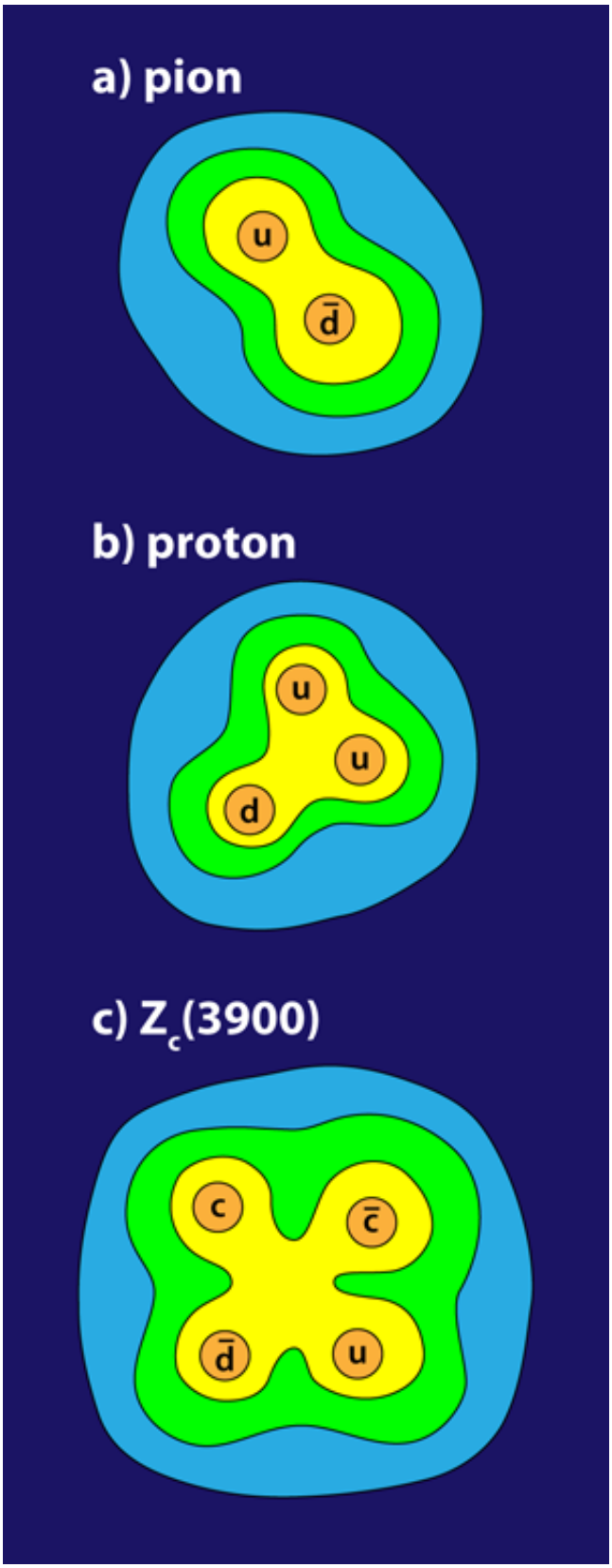

The quark wing of the particle zoo includes (a) quark pairs called mesons, (b)

quark triplets called baryons, and possibly (c) four-quark combinations that may explain the Zc(3900) observations. Credit: (c) APS/Alan Stonebraker, via Physics Viewpoint, DOI: 10.1103/Physics.6.69

(Phys.org) —Two research teams working independently at two different particle accelerators have found evidence of what appears to be a four-quark particle that has come to be called $Z_c(3900)$. Both teams are made up of a large number of researchers affiliated with institutions from around the world and both have published their findings in separate papers in the journal *Physical Review Letters*.

The discovery of what appears to be a new particle has come about at the two sites (the Belle and BESIII experiments in Japan and China, respectively) as a result of research into Y(4260), a particle discovered in 2005. Physicists have been intrigued by Y(4260) as it appears to be made of a charmed quark, an anti-charmed quark and an extra gluon (in addition to the gluons holding the quarks together). In studying the decay of Y(4260)—which is found in the debris after smashing electrons and positrons together in their respective accelerators—both research teams noticed a spike of energy of about 3.9 gigaelectronvolts, which, as it turns out, is approximately four times the weight of a proton. That suggested evidence of a particle with four quarks, something that has never been seen before.

After much more study, both teams concluded that what their data was showing them was something both new and real. Initial indications are that $Z_c(3900)$ is indeed a previously unknown type of matter—a particle with four quarks. Combined, the research teams have found 460 examples of the $Z_c(3900)$ particle giving serious credence to their actual existence. Thus far, the particle appears to have an electric charge and at least one charm and one anti-charm quark. Both teams suspect that it

also has an up and anti-down quark as well, giving it its full complement of four quarks.

Both research teams point out that there might be other explanations for their findings—$Z_c(3900)$ could simply be a pair of two-quark particles bound together, for example. Another possibility is that it's a pair of two-quark particles that are loosely bound, which would mean they are simply interacting for a very short time span.

More research will be conducted by both teams, and of course other physicists around the globe. Studying how $Z_c(3900)$ decays should help determine if what the two teams have found is something truly new, or if it is just already known particles behaving in a novel way.

More information: 1. Observation of a Charged Charmoniumlike Structure in $e^+e^-\to\pi^+\pi^- J/\psi$ at $\sqrt{s}=4.26$ GeV, Phys. Rev. Lett. 110, 252001 (2013) http://prl.aps.org/abstract/PRL/v110/i25/e252001 (free PDF)

Abstract
We study the process $e^+e^-\to\pi^+\pi^- J/\psi$ at a center-of-mass energy of 4.260 GeV using a 525 pb-1 data sample collected with the BESIII detector operating at the Beijing Electron Positron Collider. The Born cross section is measured to be (62.9±1.9±3.7) pb, consistent with the production of the Y(4260). We observe a structure at around 3.9 GeV/c2 in the $\pi^\pm J/\psi$ mass spectrum, which we refer to as the Zc(3900). If interpreted as a new particle, it is unusual in that it carries an electric charge and couples to charmonium. A fit to the $\pi^\pm J/\psi$ invariant mass spectrum, neglecting interference, results in a mass of (3899.0±3.6±4.9) MeV/c2 and a width of (46±10±20) MeV. Its production ratio is measured to be $R=(\sigma(e^+e^-\to\pi^\pm Zc(3900)^\mp\to\pi^+\pi^- J/\psi)/\sigma(e^+e^-\to\pi^+\pi^- J/\psi))=(21.5\pm3.3\pm7.5)\%$. In all measurements the first errors are statistical and the second are systematic.

2. Study of e+e-→π+π-J/ψ and Observation of a Charged Charmoniumlike State at Belle, Phys. Rev. Lett. 110, 252002 (2013) http://prl.aps.org/abstract/PRL/v110/i25/e252002 (free PDF)

Abstract

The cross section for e+e-→π+π-J/ψ between 3.8 and 5.5 GeV is measured with a 967 fb-1 data sample collected by the Belle detector at or near the ϒ(nS) (n=1,2,…,5) resonances. The Y(4260) state is observed, and its resonance parameters are determined. In addition, an excess of π+π-J/ψ production around 4 GeV is observed. This feature can be described by a Breit-Wigner parametrization with properties that are consistent with the Y(4008) state that was previously reported by Belle. In a study of Y(4260)→π+π-J/ψ decays, a structure is observed in the M(π±J/ψ) mass spectrum with 5.2σ significance, with mass M=(3894.5±6.6±4.5) MeV/c2 and width Γ=(63±24±26) MeV/c2, where the errors are statistical and systematic, respectively. This structure can be interpreted as a new charged charmoniumlike state.