

Evidence of a new subatomic particle observed

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A portrait of nucleon-antinucleon bound state. Credit: *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.151901

The BESIII collaboration have reported the observation of an anomalous line shape around ppbar mass threshold in the $J/\psi \rightarrow \gamma 3(\pi^+\pi^-)$ decay, which indicates the existence of a ppbar bound state. The paper was



published online in *Physical Review Letters*.

The proximity in mass to $2m_p$ is suggestive of nucleon-antinucleon bound states, an idea that has a long history. Before the birth of Quark Model, a nucleon-antinucleon bound state was already proposed by Prof. E. Fermi and Prof. C. N. Yang.

There is an accumulation of evidence for anomalous behavior in the proton-antiproton system near the ppbar mass <u>threshold</u>, e.g., $J/\psi \rightarrow \gamma p p a b r$, $J/\psi \rightarrow \gamma \pi^{+}\pi^{-}\eta'$ and the proton's effective form factor determined from $e^{+}e^{-} \rightarrow p p b a r$, exhibiting a narrow peak or a very steep falloff around the ppbar mass threshold, which inspired many speculations and renewed the interests on the nucleon-antinucleon bound state.

X(1840) is a new structure discovered in the $J/\psi \rightarrow \gamma 3(\pi^+\pi^-)$ process in 2013 with subdata sample of BESIII experiment, which is also located near the ppbar mass threshold. A further exploration of line shape of X(1840) is essential to have a better understanding of its nature. Therefore, the BESIII experiment performed an investigation on the $3(\pi^+\pi^-)$ mass spectrum with 10 billion J/ ψ events, which is about 45 times larger than the subdata sample used in the previous measurement.





The anomalous line shape of the resonant structure around ppbar mass threshold in $3(\pi+\pi-)$ mass spectrum. Credit: *Physical Review Letters* (2024). DOI: 10.1103/PhysRevLett.132.151901

An anomalous line shape of X(1840) near the ppbar mass threshold was observed for the first time. After many attempts, it was found that the model with a coherent sum of two Breit-Wigner parameterizations could provide a good description of data, which revealed a new resonance X(1880) with a <u>statistical significance</u> greater than 10 σ , and the mass and width were determined to be 1882.1±1.7±0.7 MeV/c² and 30.7±5.5±2.4 MeV/c, respectively.



The proximity of its mass to the ppbar mass threshold supported the existence of a ppbar bound state. After publication, this result was selected as "Featured in Physics" by *Physical Review Letters*.

More information: M. Ablikim et al, Observation of the Anomalous Shape of X(1840) in $J/\psi \rightarrow \gamma 3(\pi^+\pi^-)$ Indicating a Second Resonance Near pp⁻ Threshold, *Physical Review Letters* (2024). <u>DOI:</u> <u>10.1103/PhysRevLett.132.151901</u>

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