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Abnormal states with unequal constituent masses

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The Bethe-Salpeter equation for system of two oppositely charged particles not only reproduces the Coulomb spectrum, but, for enough large coupling constant $calC > \frac{\pi}{4}$, predicts additional levels [1,2] not covered by the Schroedinger equation. These relativistic states (called abnormal) are dominated, for more than 90-99 percent, by the exchanged photons [3] (which are scalar in the model [1,2]), while contribution of two massive charged particles themselves is rather small (1-10 percent). These predictions and theoretical clarification of the nature of the abnormal states put on the agenda their experimental detection. Since the carrier of a large (positive) charge is a heavy ion, and the negative charge is provided by electron, the masses of particles, capable of forming the abnormal systems and available in laboratory, are very different. We show that in a system with so different masses the abnormal states still exist. Moreover, the effect of unequal masses is attractive. From the Bethe-Salpeter amplitude we extract the two-body light-front wave function and calculate the balance between contribution to the state vector of two charged constituents and photons. It is weakly sensitive to the mass ratio. The photons still predominate.

[1] G.C. Wick, Phys. Rev. 96, 1124 (1954).
[2] R.E. Cutkosky, Phys. Rev. 96, 1135 (1954).
[3] J. Carbonell, V.A. Karmanov, H. Sazdjian, Eur. Phys. J. C (2021) 81:50.

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