Shown in Fig. 2 (d) are the real and the imaginary parts of the D function versus the proton kinetic energy.

In Figs. 2 (c,d), the real and the imaginary parts of the D functions vanish at $s = s_p$. These are signatures of the primitives, along with crossing the levels $\delta(s) = 0$ with negative slopes on Figs. 2 (a,b).

The values of b and M_α are close to those obtained in Refs. [5, 6].

Benjamins and van Dijk [13] used the hybrid Lee model with one compound state in each channel to describe the nucleon-nucleon S-wave phase shifts below $T_{lab} = 500$ MeV and to reproduce parameters related to the deuteron and the virtual ${}^1S_0$ state. The model does not have explicit CDD poles and primitives. However, it can be reformulated in terms of the QCB model with one CDD pole and two compound states that correspond to the primitive and a high-mass resonance [22].

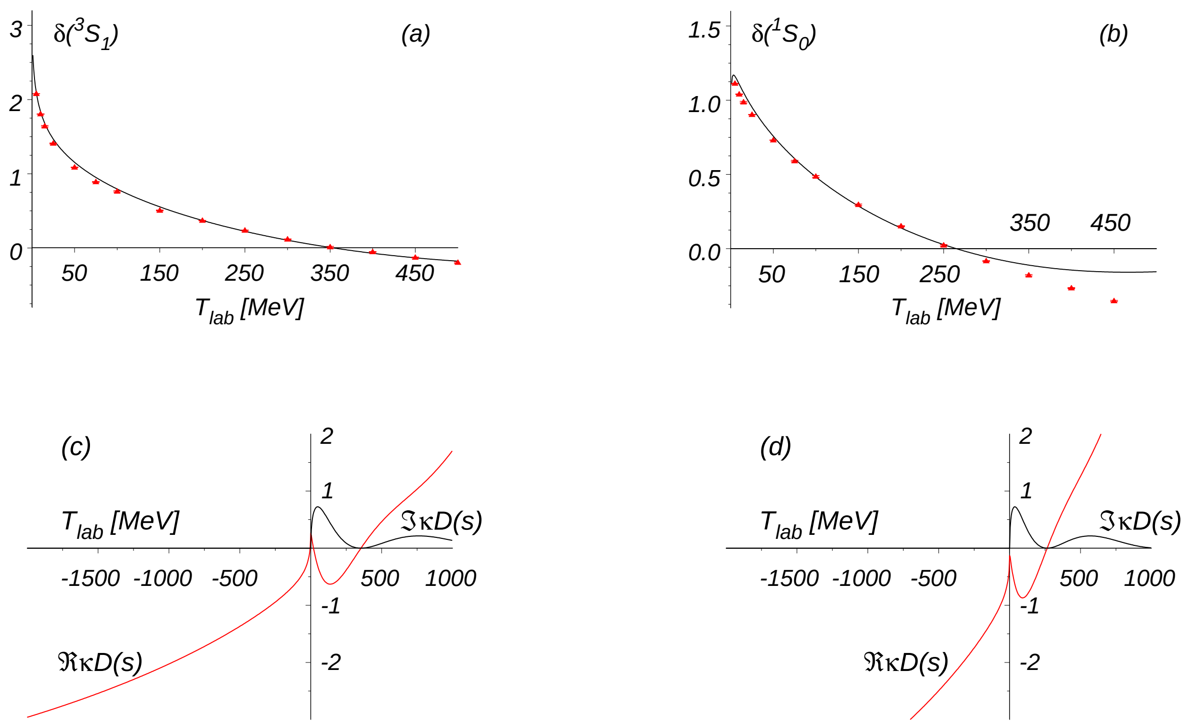

FIG. 2: (Color online) ${}^3S_1$ and ${}^1S_0$ scattering phase shifts in radians (upper panel) and real and imaginary parts of the D functions (lower panel) versus the proton kinetic energy. The solid curves are parametrizations within the relativistic QCB model. The experimental phase shifts [21] are shown by triangles.

Resonances and primitives do not exist as asymptotic states. In Feynman diagrams, propagators of primitives $1/(s - M_\alpha^2)$ are multiplied by form factors $\mathcal{F}(s)$. Such combinations do not have poles at $s = M_\alpha^2$. Primitives thus do not propagate, though they influence the dynamics.

Summarizing, the physical meaning of the CDD poles was revisited. In the general case, the neighboring CDD poles squeeze masses of compound states related to bound states, resonances, or primitives. The primitives are P-matrix poles associated with zeros of the D function on the unitary cut, which do not show up as poles of the S matrix. The Low scattering equation was generalized for amplitudes with primitives. The primitive-type CDD poles occur in systems with repulsion. In the ${}^3S_1$ and ${}^1S_0$ nucleon-nucleon channels, the CDD poles at $M = 3203$ MeV and $M = 2916$ MeV are associated with the primitives at $M_\alpha = 2047$ MeV and $M_\alpha = 2006$ MeV, respectively. The model we used ensures that the D function has the correct analytical properties on the first Riemann sheet of the complex s plane and provides the partial wave amplitudes that satisfy the generalized Low scattering equation.

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