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# Charmonium-like states and $K^*$ resonances from lattice QCD

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**Abstract.** I presented the first evidence for $X(3872)$ from lattice QCD, the first search for $Z_c^+(3900)$ and the first extraction of $K^*(892)$ strong decay width.

The charmonium-like state $X(3872)$ with $J^{PC} = 1^{++}$ has never been unambigously identified from the lattice, since it was not established in addition to the discrete scattering states like $DD^*$. These should namely appear as energy levels with the same quantum number $J^{PC} = 1^{++}$ and are particularly important as $X(3872)$ lies almost on top of $DD^*$ threshold. In the simulation [1] we established $X(3872)$ with $I = 0$ in addition to all the nearby $DD^*$ and $J/\psi\ \omega$ scattering states for the first time. We found large and negative $DD^*$ scattering length, which agrees with the presence of a very shallow bound state $X(3872)$ in view of the Levinson's theorem. We did not find $X(3872)$ in the $I = 1$ channel in our simulation with exact isospin.

We performed the first lattice QCD search for manifestly exotic $Z_c(3900)$ [2]. During 2013, the experiments BESIII, Belle and CLEOc reported a discovery of $Z_c^+(3900)$ in the decay to $J/\psi\ \pi^+$, while J and P are experimentally unknown. We simulated the most popular channel with $J^{PC} = 1^{+-}$ and $I = 1$, and we did not find a candidate for $Z_c^+(3900)$. Instead, we only found discrete scattering states $D\bar{D}^*$ and $J/\psi\ \pi$, which inevitably have to be present in a dynamical QCD. The possible reasons for not finding $Z_c^+$ may be that its quantum numbers are not $1^{+-}$ or that the employed interpolating fields were not diverse enough. A simulation with additional interpolating fields will be required for a more conclusive result.

The simulation of $K\pi$ scattering in p wave with $I = 1/2$ was aimed at calculating the scattering phase shift [3]. This was determined from each energy level using Luscher's relation, where we simulated scattering system with three choices of total momenta $P = 0,\ \frac{2\pi}{L} e_z,\ \frac{2\pi}{L}(e_x + e_y)$. The Breit Wigner type fit of the resulting phase shift lead the mass and the decay width (or rather the $K^* \to K\pi$) coupling that agrees with the experimental values within the errors. This presents the first lattice determination of the $K^*(892)$ strong decay width.

## References

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2. Sasa Prelovsek and Luka Leskovec, arXiv:1308.2097.
3. Sasa Prelovsek, Luka Leskovec, C.B. Lang and Daniel Mohler, Phys. Rev. D88 (2013) 054508, arXiv:1307.0736.