GeV. The κ exchange contribution is much smaller than the contribution from the K exchange and almost has no effect on the differential cross sections in the full model. The *s* channel contribution is negligible as the other photoproduction process. The *u* channel works at backward angles and leads to a small increase of the differential cross section.

The preliminary CLAS data are helpful to understand the interaction mechanism of the $K^{*0}\Lambda$ photoproduction, such as confirming the dominance of the K exchange and the smallness of nucleon resonance contribution. The precise data at energies around 2 GeV and data at high energies, especially at backward angles will be helpful to clarify the roles of nucleon resonances and the Regge model, respectively.

References

[1] S. I. Nam, A. Hosaka, H. C. Kim, Phys. Rev. D, 71(2005)114012.

[2] J. He, Nucl. Phys. A, 927(2014)24.

[3] J. He, Phys. Rev. C, 89(5)(2014)055204.

[4] J. He, X. R. Chen, Phys. Rev. C, 86(2012)035204.

[5] J. J. Xie, J. Nieves, Phys. Rev. C, 82(2010)045205.

[6] X. Y. Wang, J. He, H. Haberzettl, Phys. Rev. C, 93(4)(2016)045204.

[7] W. Tang, [CLAS Collaboration], Phys. Rev. C, 87(6)(2013)065204.

[8] Y. Oh, H. Kim, Phys. Rev. C, 73(2006)065202.

[9] S. Ozaki, H. Nagahiro, A. Hosaka, Phys. Rev. C, 81(2010)035206.

[10] S. H. Kim, S. I. Nam, Y. Oh, et al., Phys. Rev. D, 84(2011)114023.

[11] S. H. Kim, A. Hosaka, H. C. Kim, Phys. Rev. D, 90(2014)014021.

[12] P. Mattione [CLAS Collaboration], Int. J. Mod. Phys. Conf. Ser., 26(2014)1460101.

1 - 13 Understanding Spin Parities of $P_c(4450)$ and Y(4274) in Hadronic Molecular State Picture*

Yong Gaochan

The hadronic molecular state picture is one of the most popular interpretations of the exotic state in market[1]. It has been widely applied to explain a series of experimentally observed exotic states, which can not be assigned in conventional quark model but is close to the threshold of two hadrons. In the literature, people often focus on the bound state from S-wave interaction and assume P-wave bound state should be difficult to form from hadron-hadron interaction and to observe in experiment. For example, the Y(4274) and the Y(4140) are related to the S-wave $D_s\bar{D}_{s0}(2317)$ and $D_s^{*+}D_s^{*-}$ states, respectively[2,3]. There also exist predictions of hidden-charmed pentaquark from S-wave anticharmed meson and charmed baryon interactions[4,5]. The recent observation of the $P_c(4450)$ and $P_c(4380)$ at LHCb confirmed the existence of the hidden-charmed pentaquark[6]. Surprisingly, different from the predictions in Refs. [4, 5] the hidden-charmed pentaquarks $P_c(4380)$ and $P_c(4450)$ carry opposite parities. Hence, it is difficult to explain both states as hadronic molecular states from the relevant S-wave anticharmed meson and the charmed baryon interactions, *i.e.*, $\bar{D}\Sigma_c^*$, $\bar{D}^*\Sigma_c$, and $\bar{D}^*\Sigma_c^*$ interactions. Such challenge also happens in the case of the Y(4274). The spin parity 1^{++} determined at LHCb[7,8] conflicts with the previous S-wave $D_s\bar{D}_{s0}(2317)$ molecular state interpretation[2,3], which suggests P-wave interaction should be also introduced in this case. In this work we will study the $P_c(4450)$ and Y(4274) in a quasipotential Bethe-Saltpeter equation with a partial wave decomposition on spin parity J^P.

In this work, the $P_c(4450)$ and $P_c(4380)$ are taken as a $5/2^+$ (P- and F-waves) state and a $3/2^-$ (S- and D-waves) state from the $\bar{D}^*\Sigma_c$ interaction, respectively. In the molecular state picture, these states are produced from a generating channel $\bar{D}^*\Sigma_c$, with pseudoscalar (π, η), vector (ρ, ω) and scalar (σ) meson exchanges. These two pentaquarks were observed in the $J/\psi p$ invariant mass spectrum, so we choose it as observation channel. The poles of these two states at $|1-V(z)G(z)|=0$ and the corresponding $J/\psi p$ invariant mass spectrum of $\Lambda_b^0 \to J/\psi K^- p$ decay are presented in Fig. 1.

A pole at $4\,447 \pm 4i$ MeV is found in $5/2^+$-wave $\bar{D}^*\Sigma_c$ interaction. Correspondingly, a narrow peak appears in the $J/\psi p$ mass spectrum near the $\bar{D}^*\Sigma_c$ threshold. The small binding energy and width of this state is due to the relatively weak interaction in P and F waves. Obviously, this state can be identified as the experimentally observed

$P_c(4450)$. In $3/2^-$ wave corresponding to S and D waves, a pole at $4\ 392+46i$ MeV is found, whose peak is rather broad and far from the $\bar{D}^*\Sigma_c$ threshold because of the relatively strong interaction in this partial wave. Hence, the P-wave state is bound more loosely and narrower than the S-wave state, which is consistent with the experimental observations of the $P_c(4450)$ and the $P_c(4380)$[6].

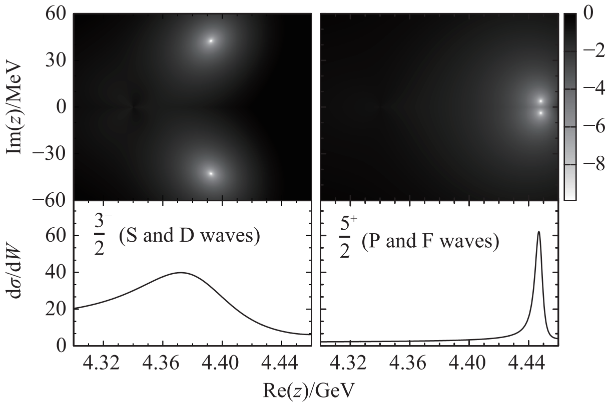

Fig. 1 The $\log|1-V(z)G(z)|$ and the $J/\psi p$ mass spectrum for the $\bar{D}^*\Sigma_c$ interaction coupled with $J/\psi p$ channel.

In Refs. [2, 3], the $D_sD_{s0}(2317)$ interaction has been studied and the Y(4274) is assigned as a S-wave $D_sD_{s0}(2317)$ molcualr state with quantum number $J^{PC}=0^{-+}$, which conflicts with the recent LHCb experiment[7,8]. To reproduce the LHCb spin parity of the Y(4274) we need to introduce the P-wave interaction. Considered that the $D_s\bar{D}_{s0}(2317)$ interaction is mediated by ϕ and η exchanges, it is possibly strong enough to generate a P-wave bound state. A pole at $4\ 275+11i$ MeV is produced from the $D_s\bar{D}_{s0}(2317)$ interaction with 1^{++}, which is presented in Fig. 2. As in the case of the $P_c(4450)$, the 1^{++} (P-wave) state appears near threshold while a 0^{-+} (S-wave) state is far from the threshold of the generating channel. The pole near the threshold at $4\ 275\pm11i$ MeV can be related to the Y(4274) with the spin parity 1^{++} suggested by LHCb. It is interesting to find that the 0^{-+} (S-wave) state is below the J/ψ threshold, which explains why it cannot be observed in experiment.

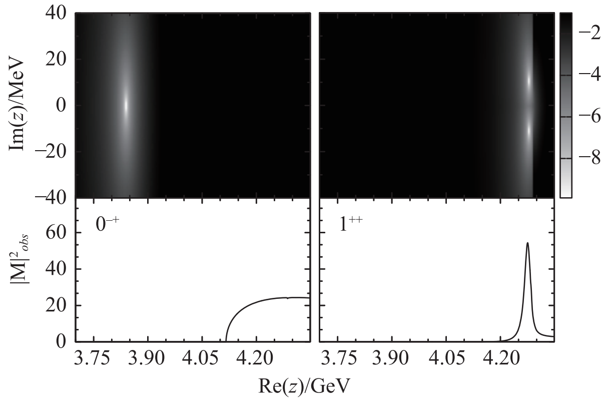

Fig. 2 The $\log|1-V(z)G(z)|$ and the $J/\psi\phi$ mass spectrum for the $D_sD_{s0}(2317)$ interaction coupled with $J/\psi\phi$ channel.

In this work, we study the $\bar{D}^*\Sigma_c$ and $D_s\bar{D}_{s0}(2317)$ interactions and their relation to the experiment observed $P_c(4450)$ and Y(4274) in hadronic molecular state picture. The spin parities of these two states can not be reproduced from only S-wave interactions, so the spin parties which correspond to P wave are considered in this work. A pole near the $\bar{D}^*\Sigma_c$ threshold and a pole near $D_s\bar{D}_{s0}$ threshold can be found with quantum number $5/2^+$ and 1^{++}, respectively. These two poles can be related to the experimentally observed $P_c(4450)$ and Y(4274). The bound states with spin parties which correspond to S wave are also produced as expected. When the P-wave state is produced near the threshold, the S-wave state is far from the threshold.

References

[1] H. X. Chen, W. Chen, X. Liu, et al., Phys. Rept., 639(2016)1.

[2] X. Liu, Z. G. Luo, S. L. Zhu, Phys. Lett. B, 699(2011)341. Erratum: [Phys. Lett. B, 707(2012)577.

[3] J. He, P. L. Lü, Nucl. Phys. A, 919(2013)1.

[4] J. J. Wu, R. Molina, E. Oset, et al., Phys. Rev. Lett., 105(2010)232001.
[5] Z. C. Yang, Z. F. Sun, J. He, et al., Chin. Phys. C, 36(2012)6.
[6] R. Aaij, [LHCb Collaboration], Phys. Rev. Lett., 115(2015)072001.
[7] R. Aaij, [LHCb Collaboration], Phys. Rev. Lett., 118(2017)022003.
[8] R. Aaij, [LHCb Collaboration], Phys. Rev. D, 95(2017)012002.

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1 - 14 Role of Nucleonic Fermi Surface Depletion in Neutron Star Cooling

Dong Jianmin, U. Lombardo, Zhang Hongfei and Zuo Wei

The measurements on the neutron star surface temperature such as Cas A allow us to investigate the thermal evolution of NSs more deeply and hence grasp some crucial information and knowledge on the NS interior as well as some properties of dense nuclear matter[1,2]. The Fermi surface depletion that comes from the nucleonic short-range correlation influences the level density of nucleons around the Fermi surface and controls many properties of Fermion systems related to particle-hole excitations around the Fermi energy. Thus, it affects the inputs of the neutron star cooling.

The Fermi surface depletion of beta-stable nuclear matter is calculated to study its effects on several physical properties that determine the NS thermal evolution[3]. The neutron and proton Z factors measuring the corresponding Fermi surface depletions are calculated within the Brueckner–Hartree–Fock approach, employing the AV18 two-body force supplemented by a microscopic three-body force. The conclusion are summarized as follows: 1) The Fermi surface depletion quenches the peak value of $^3PF_2$ superfluidity by about one order of magnitude, and its effect is extremely strong at high densities. 2) The kinematic conditions giving rise to the threshold for the DU process do not change, and the neutrino emissivity for the DU process is reduced which is in complete contrast to previous expectations. In addition, the neutrino emissivities for the MU processes, the nucleon-nucleon bremsstrahlung processes, the Cooper pair breaking and formation processes are also reduced. 3) The heat capacity of beta-stable neutron star matter is reduced. 4) Based on the above results, it is found that the cooling rates of young neutron stars are significantly slowed, as shown in Fig. 1. The effect of the Fermi surface depletion of nucleons on NS cooling cannot be neglected, when an accurate theoretical study of the cooling is carried out.

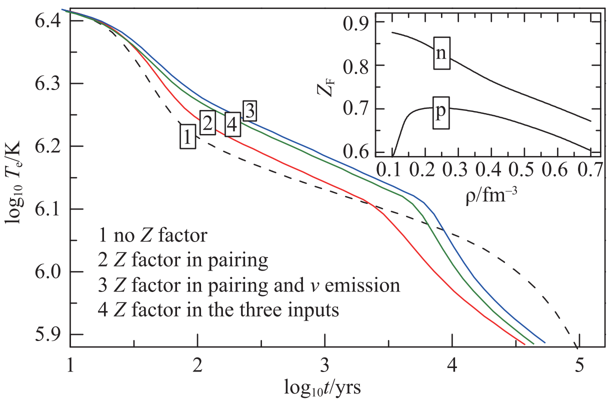

Fig. 1 (color online) Cooling curves of a canonical neutron star.

References

[1] C. O. Heinke, W. C. G. Ho, ApJL, 719(2010)L167.
[2] D. Page, M. Prakash, J. M. Lattimer, et al., Phys. Rev. Lett., 106(2011)081101.
[3] J. M. Dong, U. Lombardo, H. F. Zhang, et al., ApJ, 817(2016)6.