

# Phantom crossing dark energy in Horndeski's theory

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## Abstract

© 2018 American Physical Society. The  $\Lambda$ CDM model is a remarkably successful model which is consistent with the observations of cosmic microwave background radiation (CMB), baryon acoustic oscillation (BAO), and the large scale structure of the Universe. However, the discrepancy in the value of  $H_0$  between the local observations and PLANCK observation of CMB was recently pointed out. One of the ways to ease the discrepancy is to introduce phantom dark energy instead of the cosmological constant. However, phantom dark energy often suffers from instabilities. We will investigate the general solution to overcome the difficulty of phantom dark energy and construct some particular models which have a phantom crossing and can be consistent with the observations.

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## References

- [1] A. G. Riess (Supernova Search Team Collaboration), *Astron. J.* 116, 1009 (1998). ANJOAA 0004-6256 10.1086/300499
- [2] S. Perlmutter (Supernova Cosmology Project Collaboration), *Astrophys. J.* 517, 565 (1999). ASJOAB 1538-4357 10.1086/307221
- [3] E. Komatsu (WMAP Collaboration), *Astrophys. J. Suppl. Ser.* 192, 18 (2011). APJSA2 1538-4365 10.1088/0067-0049/192/2/18
- [4] P. A. R. Ade (Planck Collaboration), *Astron. Astrophys.* 571, A16 (2014). AAEJAF 0004-6361 10.1051/0004-6361/201321591
- [5] P. A. R. Ade (Planck Collaboration), *Astron. Astrophys.* 594, A13 (2016). AAEJAF 0004-6361 10.1051/0004-6361/201525830
- [6] W. J. Percival (SDSS Collaboration), *Mon. Not. R. Astron. Soc.* 401, 2148 (2010). MNRAA4 0035-8711 10.1111/j.1365-2966.2009.15812.x
- [7] C. Blake, *Mon. Not. R. Astron. Soc.* 418, 1707 (2011). MNRAA4 0035-8711 10.1111/j.1365-2966.2011.19592.x
- [8] F. Beutler, C. Blake, M. Colless, D. H. Jones, L. Staveley-Smith, L. Campbell, Q. Parker, W. Saunders, and F. Watson, *Mon. Not. R. Astron. Soc.* 416, 3017 (2011). MNRAA4 0035-8711 10.1111/j.1365-2966.2011.19250.x
- [9] A. J. Cuesta, *Mon. Not. R. Astron. Soc.* 457, 1770 (2016). MNRAA4 0035-8711 10.1093/mnras/stw066
- [10] T. Delubac (BOSS Collaboration), *Astron. Astrophys.* 574, A59 (2015). AAEJAF 0004-6361 10.1051/0004-6361/201423969
- [11] A. G. Riess, L. Macri, S. Casertano, H. Lampeitl, H. C. Ferguson, A. V. Filippenko, S. W. Jha, W. Li, and R. Chornock, *Astrophys. J.* 730, 119 (2011); ASJOAB 1538-4357 10.1088/0004-637X/730/2/119
- [12] A. G. Riess, L. Macri, S. Casertano, H. Lampeitl, H. C. Ferguson, A. V. Filippenko, S. W. Jha, W. Li, R. Chornock, and J. M. Silverman *Astrophys. J.* 732, 129(E) (2011). ASJOAB 1538-4357 10.1088/0004-637X/732/2/129
- [13] A. G. Riess, *Astrophys. J.* 826, 56 (2016). ASJOAB 1538-4357 10.3847/0004-637X/826/1/56
- [14] V. Marra, L. Amendola, I. Sawicki, and W. Valkenburg, *Phys. Rev. Lett.* 110, 241305 (2013). PRLTAO 0031-9007 10.1103/PhysRevLett.110.241305

- [15] E. Di Valentino, A. Melchiorri, and J. Silk, *Phys. Lett. B* 761, 242 (2016). PYLBAJ 0370-2693 10.1016/j.physletb.2016.08.043
- [16] G. B. Zhao, *Nat. Astron.* 1, 627 (2017). 2397-3366 10.1038/s41550-017-0216-z
- [17] P. J. E. Peebles and B. Ratra, *Astrophys. J.* 325, L17 (1988). ASJOAB 1538-4357 10.1086/185100
- [18] B. Ratra and P. J. E. Peebles, *Phys. Rev. D* 37, 3406 (1988). PRVDAQ 0556-2821 10.1103/PhysRevD.37.3406
- [19] T. Chiba, N. Sugiyama, and T. Nakamura, *Mon. Not. R. Astron. Soc.* 289, L5 (1997). MNRAA4 0035-8711 10.1093/mnras/289.2.L5
- [20] I. Zlatev, L. M. Wang, and P. J. Steinhardt, *Phys. Rev. Lett.* 82, 896 (1999). PRLTAO 0031-9007 10.1103/PhysRevLett.82.896
- [21] A. Vikman, *Phys. Rev. D* 71, 023515 (2005). PRVDAQ 1550-7998 10.1103/PhysRevD.71.023515
- [22] G. W. Horndeski, *Int. J. Theor. Phys.* 10, 363 (1974). IJTPBM 0020-7748 10.1007/BF01807638
- [23] A. De Felice and S. Tsujikawa, *Phys. Rev. Lett.* 105, 111301 (2010). PRLTAO 0031-9007 10.1103/PhysRevLett.105.111301
- [24] C. Deffayet, O. Pujolas, I. Sawicki, and A. Vikman, *J. Cosmol. Astropart. Phys.* 10 (2010) 026. JCAPBP 1475-7516 10.1088/1475-7516/2010/10/026
- [25] C. Deffayet, X. Gao, D. A. Steer, and G. Zahariade, *Phys. Rev. D* 84, 064039 (2011). PRVDAQ 1550-7998 10.1103/PhysRevD.84.064039
- [26] T. Kobayashi, M. Yamaguchi, and J. Yokoyama, *Prog. Theor. Phys.* 126, 511 (2011). PTPKAV 0033-068X 10.1143/PTP.126.511
- [27] B. P. Abbott (LIGO Scientific and Virgo Collaborations), *Phys. Rev. Lett.* 119, 161101 (2017). PRLTAO 0031-9007 10.1103/PhysRevLett.119.161101
- [28] B. P. Abbott, *Astrophys. J.* 848, L13 (2017). ASJOAB 1538-4357 10.3847/2041-8213/aa920c
- [29] B. P. Abbott, *Astrophys. J.* 848, L12 (2017). ASJOAB 1538-4357 10.3847/2041-8213/aa91c9
- [30] D. A. Coulter, *Science* 358, 1556 (2017). SCIEAS 0036-8075 10.1126/science.aap9811
- [31] P. Creminelli and F. Vernizzi, *Phys. Rev. Lett.* 119, 251302 (2017). PRLTAO 0031-9007 10.1103/PhysRevLett.119.251302
- [32] J. Sakstein and B. Jain, *Phys. Rev. Lett.* 119, 251303 (2017). PRLTAO 0031-9007 10.1103/PhysRevLett.119.251303
- [33] J. M. Ezquiaga and M. Zumalacregui, *Phys. Rev. Lett.* 119, 251304 (2017). PRLTAO 0031-9007 10.1103/PhysRevLett.119.251304
- [34] T. Baker, E. Bellini, P. G. Ferreira, M. Lagos, J. Noller, and I. Sawicki, *Phys. Rev. Lett.* 119, 251301 (2017). PRLTAO 0031-9007 10.1103/PhysRevLett.119.251301
- [35] S. Arai and A. Nishizawa, *Phys. Rev. D* 97, 104038 (2018). PRVDAQ 2470-0010 10.1103/PhysRevD.97.104038
- [36] D. Langlois, R. Saito, D. Yamauchi, and K. Noui, *Phys. Rev. D* 97, 061501 (2018). PRVDAQ 2470-0010 10.1103/PhysRevD.97.061501
- [37] L. Lombriser and A. Taylor, *J. Cosmol. Astropart. Phys.* 03 (2016) 031. JCAPBP 1475-7516 10.1088/1475-7516/2016/03/031
- [38] L. Lombriser and N. A. Lima, *Phys. Lett. B* 765, 382 (2017). PYLBAJ 0370-2693 10.1016/j.physletb.2016.12.048
- [39] A. De Felice and S. Tsujikawa, *J. Cosmol. Astropart. Phys.* 02 (2012) 007. JCAPBP 1475-7516 10.1088/1475-7516/2012/02/007
- [40] P. J. Mohr, D. B. Newell, and B. N. Taylor, *Rev. Mod. Phys.* 88, 035009 (2016). RMPHAT 0034-6861 10.1103/RevModPhys.88.035009
- [41] V. Sahni, A. Shafieloo, and A. A. Starobinsky, *Astrophys. J.* 793, L40 (2014). ASJOAB 1538-4357 10.1088/2041-8205/793/2/L40
- [42] V. Sahni and Y. Shtanov, *J. Cosmol. Astropart. Phys.* 11 (2003) 014. JCAPBP 1475-7516 10.1088/1475-7516/2003/11/014
- [43] B. Feng, X. L. Wang, and X. M. Zhang, *Phys. Lett. B* 607, 35 (2005). PYLBAJ 0370-2693 10.1016/j.physletb.2004.12.071
- [44] Y. F. Cai, E. N. Saridakis, M. R. Setare, and J. Q. Xia, *Phys. Rep.* 493, 1 (2010). PRPLCM 0370-1573 10.1016/j.physrep.2010.04.001
- [45] S. Das, P. S. Corasaniti, and J. Khoury, *Phys. Rev. D* 73, 083509 (2006). PRVDAQ 1550-7998 10.1103/PhysRevD.73.083509