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The effects of parametrization of the dark energy equation of state *

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Abstract We investigate in detail the influence of parametrizations of the dark energy equation of state on reconstructing dark energy geometrical parameters, such as the deceleration parameter $q(z)$ and Om diagnostic. We use a type Ia supernova sample, baryon acoustic oscillation data, cosmic microwave background information along with twelve observational Hubble data points to constrain cosmological parameters. With the joint analysis of these current datasets, we find that the parametrizations of $w(z)$ have little influence on the reconstruction result of $q(z)$ and Om. The same is true for the transition (cosmic deceleration to acceleration) redshift $z_{\rm t}$, for which we find that for different parametrizations of $w(z)$, the best fitted values of $z_{\rm t}$ are very close to each other (about 0.65). All of our results are in good agreement with the ΛCDM model. Furthermore, using the combination of datasets, we do not find any signal of decreasing cosmic acceleration as suggested in some recent papers. The results suggest that the influence of the prior $w(z)$ is not as severe as one may anticipate, and thus we can, to some extent, safely use a reasonable parametrization of $w(z)$ to reconstruct some other dark energy parameters (e.g. $q(z)$, Om) with a combination of datasets.

Key words: cosmology: observations — cosmology: cosmological parameters

1 INTRODUCTION

The observations of type Ia supernovae (SNe Ia) suggest that our universe is experiencing an accelerated expansion epoch (Riess et al. 1998; Perlmutter et al. 1999), which has become the most challenging mystery in cosmology today. Besides SNe Ia, the acceleration was also confirmed by precise measurement of the Cosmic Microwave Background (CMB) anisotropies (Spergel et al. 2003) as well as the baryon acoustic oscillations (BAO) in the Sloan Digital Sky Survey (SDSS) luminous galaxy sample (Eisenstein et al. 2005). This accelerated expansion can be explained by introducing

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the so called dark energy - a hypothetical energy component with a negative pressure (see Peebles & Ratra 2003; Copeland et al. 2006 for reviews).

Various theoretical models of dark energy have been proposed, the simplest being the cosmological constant Λ with constant dark energy density and equation of state $w_{\rm DE} = p/\rho = -1$. This model, the popular ΛCDM model, provides an excellent fit to a wide range of observational data so far. However, there are two well known problems in it. One is the so called "fine tuning" problem, which is that the observed value of Λ is extremely small compared with particle physics expectations (Weinberg 1989). The other is the coincidence problem, i.e. the present energy density of dark energy $\Omega_{\Lambda 0}$ and the present matter density Ω_{m0} are of the same order of magnitude, for no obvious reason. Alternatively, there are other dark energy scalar field models with time varying dark energy density and equation of state, such as quintessence which has $w > -1$ (Caldwell et al. 1998; Zlatev et al. 1999), as well as more exotic "phantom" models with $w < -1$ (Caldwell 2002).

Although most recent studies show that the ΛCDM model is in good agreement with observational data, dynamical dark energy can also explain the data. In order to distinguish between these two different kinds of models from the background evolution, one may need to reconstruct dark energy from observations in parametric or non-parametric ways. This paper will focus on the former. The equation of state of dark energy w is most widely used in the literature nowadays, since any deviation from –1 of w would favor dynamical models. Many parametrizations of $w(z)$ have been proposed so far (Johri & Rath 2007). Although most of them are purely phenomenological, they are necessary steps towards a more complete characterization of dark energy and are routinely employed to analyze data, to optimize survey design and to compare results. Besides, the deceleration parameter $q(z) = -\ddot{a}a/\dot{a}^2$, constructed from the second derivative of the scale factor $a(t)$, is also commonly used to explore the nature of dark energy. Furthermore, the redshift $z_{\rm t}$ at which the universe transits from deceleration to acceleration is also a useful constraint on dark energy dynamics. Recently, a new diagnostic of dark energy was introduced (Sahni et al. 2008), which is called the Om diagnostic. Constructed from the first derivative of luminosity distance and less sensitive to observational errors, and also independent of the value of matter density Ω_{m0}, the Om diagnostic is commonly used to distinguish the cosmological constant model from other dark energy models.

It is well known that fitting data to an assumed functional form would lead to possible biases in the determination of properties of the dark energy and its evolution, especially if the true behavior of the dark energy equation of state differs significantly from the assumed one, and often the results will depend on the chosen parametrization (Li et al. 2007; Sarkar et al. 2008). However, given the same dataset, one can compare the fitting results between different parametrizations and thus check the influence on the results from different parametrizations. This is just what we will investigate.

In this paper, we use four different parametrizations of the dark energy equation of state to constrain the evolution behavior of dark energy and to study their influence on the expansion history of the universe, through the deceleration parameter $q(z)$ and the transition redshift $z_{\rm t}$. Furthermore, we investigate the influence on reconstructing Om using different ansatzs of the dark energy equation of state.

Recently, by analyzing the Constitution SNIa sample together with BAO data and using the Chevallier-Polarski-Linder (CPL) (i.e., parametrization A in our paper) parametrization, Shafieloo et al. (2009) found that there appears to be an increase of Om and a positive value of q at low redshift, which means that the cosmic acceleration may have already passed the peak and now the acceleration is slowing down. However, when including the CMB data, it was found that the result changes dramatically and the behaviors of Om and q become consistent with the ΛCDM model. They argued that this could either be due to the systematics in some datasets or the CPL parametrization which is strained to describe the dark energy behavior at low and high redshift. The same issue was also studied in Gong et al. (2010); Li et al. (2011). By using a different combination of datasets, they also found that the systematics in datasets have a significant effect on the outcomes of the reconstructed cosmic expansion history. In this paper, we will further examine this problem. Different from their work, we study the influence of different parametrizations of $w(z)$ by using the same combination of datasets.

This paper is organized as follows. In Section 2, we summarize the parametrizations of dark energy adopted in this paper. Then, in Section 3, we show the observational data we used and the method to analyze them. In Section 4, the fitting results are given and the influence of different parametrizations of $w(z)$ on constraining the behavior of dark energy is discussed. We give our conclusion in the last section.

2 PARAMETRIZATIONS OF DARK ENERGY

In the framework of a spatially flat Friedmann universe, the expansion history of the universe is given by

$$H^2(z) = H_0^2[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})f(z)], \tag{1}$$

and

$$q = \frac{3w(z)\Omega_x(z)+1}{2}, \tag{2}$$

where $H \equiv \dot{a}/a$ is the Hubble parameter, q is the deceleration parameter, $\Omega_{m0} \equiv \rho_0/\rho_c$ is the current value of the normalized matter density, $\Omega_x(z)$ is the normalized dark energy density as a function of redshift which evolves as $\Omega_x(z) = \Omega_{x0} f(z) H_0^2/H^2$ and

$$f(z) = \exp\left[3\int_0^z \frac{1+w(z')}{1+z'}dz'\right]. \tag{3}$$

The luminosity distance is given by

$$d_L(z) = c(1+z)\int_0^z \frac{dz'}{H(z')}. \tag{4}$$

Next we turn to the parametrizations of $w(z)$. There are many functional forms of $w(z)$ in the literature. In this work, we consider four popular parametrizations. The first is the most widely used CPL parametrization (Chevallier & Polarski 2001; Linder 2003)

$$A : w(z) = w_0 + w_1\frac{z}{1+z}. \tag{5}$$

We call it parametrization A in this paper. In this case, the equation of state becomes $w(z=0) = w_0$ at present time and $w(z \to \infty) = w_0 + w_1$ at earlier time. This simple parameterization is most useful if dark energy is important at late times and insignificant at early times. In addition to its simplicity, this CPL parameterization exhibits interesting properties as discussed in detail by Linder (2008). However, it cannot describe rapid variations in the equation of state. Using this functional form and Equation (3), Equation (1) can be written analytically as

$$H^2(z) = H_0^2\left[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})(1+z)^{3(1+w_0+w_1)}\exp\left(\frac{-3w_1 z}{1+z}\right)\right]. \tag{6}$$

The second parametrization for the dark energy equation of state we would like to consider here is (Jassal et al. 2005)

$$B : w(z) = w_0 + w_1\frac{z}{(1+z)^2}. \tag{7}$$

We call this parametrization B. It can model a dark energy component which has the same equation of state at the present epoch and at high redshift (i.e. $w(0) = w(\infty) = w_0$), with rapid variation at low z. Inserting Equation (7) into Equation (3), Equation (1) then becomes

$$H^2(z) = H_0^2\left[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})(1+z)^{3(1+w_0)}\exp\left(\frac{3w_1 z^2}{2(1+z)^2}\right)\right]. \tag{8}$$

The next parametrization used in this paper is suggested in Barboza & Alcaniz (2008), which is

$$C : w(z) = w_0 + w_1 \frac{z(1+z)}{1+z^2}. \tag{9}$$

Like the CPL one, this parametrization has $w(z=0) = w_0$ and $w(z \to \infty) = w_0 + w_1$. Different from the CPL expression, it is a bounded function of the redshift throughout the entire cosmic evolution, which allows researchers to study the effects of a time varying $w(z)$ from $z \simeq -1$ to the last scattering surface of the CMB at $z \simeq 1100$. We call it parametrization C. In this case, Equation (1) can be expressed as

$$H^2(z) = H_0^2 \left[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})(1+z)^{3(1+w_0)}(1+z^2)^{\frac{3w_1}{2}}\right]. \tag{10}$$

The last parametrization adopted in this paper is the one proposed in Wetterich (2004), which has a functional form

$$D : w(z) = \frac{w_0}{[1 + w_1 \ln(1+z)]^2}. \tag{11}$$

We call it parametrization D. It is easy to see that when the redshift increases, the value of $w(z)$ approaches zero, which can include the possibility that dark energy contributes to the total energy of the universe to some extent at an earlier epoch. In fact, this parametrization is motivated by a wide range of quintessence models to allow for such an early time dark energy. In this condition, Equation (1) can be written as

$$H^2(z) = H_0^2 \left[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})(1+z)^{3+3\bar{w}(z)}\right], \tag{12}$$

where $\bar{w}(z) = w_0/[1 + w_1 \ln(1+z)]$.

Above, we have discussed various parametrizations of the dark energy equation of state used in this paper. Since our purpose is to compare the effects of these different parametrizations on constraining dark energy behavior and expansion history, we use the deceleration parameter $q(z)$ along with the transition redshift z_t and Om diagnostic to incorporate these different parametrizations. Next we reconstruct $q(z)$ for different parametrizations and then give the definition of Om. Combining Equations (2), (3) and (5) we can get $q(z)$ for parametrization A

$$q_A(z) = \frac{1}{2} + \frac{3}{2}\left(w_0 + w_1 \frac{z}{1+z}\right) \times \left[1 + \frac{\Omega_{m0}}{1-\Omega_{m0}}(1+z)^{-3(w_0+w_1)} \exp\left(\frac{3w_1 z}{1+z}\right)\right]^{-1}. \tag{13}$$

Similarly, we get $q(z)$ for other parametrizations. For parametrization B, $q(z)$ can be expressed as

$$q_B(z) = \frac{1}{2} + \frac{3}{2}\left[w_0 + w_1 \frac{z}{(1+z)^2}\right] \times \left[1 + \frac{\Omega_{m0}}{1-\Omega_{m0}}(1+z)^{-3w_0} \exp\left(\frac{3w_1 z^2}{2(1+z)^2}\right)\right]^{-1}. \tag{14}$$

For parametrization C, we have

$$q_C(z) = \frac{1}{2} + \frac{3}{2}\left[w_0 + w_1 \frac{z(1+z)}{1+z^2}\right] \times \left[1 + \frac{\Omega_{m0}}{1-\Omega_{m0}}(1+z)^{-3w_0}(1+z^2)^{-\frac{3w_1}{2}}\right]^{-1}. \tag{15}$$

For parametrization D, $q(z)$ can be written as

$$q_D(z) = \frac{1}{2} + \frac{3}{2}\frac{w_0}{[1 + w_1 \ln(1+z)]^2} \times \left[1 + \frac{\Omega_{m0}}{1-\Omega_{m0}}(1+z)^{-\frac{3w_0}{1+w_1 \ln(1+z)}}\right]^{-1}. \tag{16}$$

The Om diagnostic of dark energy was introduced in Sahni et al. (2008) and is widely used in the literature to distinguish the ΛCDM model from other dark energy models. It is a combination of the Hubble parameter and the redshift and provides a null test of dark energy being a cosmological constant. It only depends on the first derivative of the luminosity distance and is less sensitive to observational errors than $w(z)$. Moreover, it has the advantage of being independent of the value of matter density. Knowing the expansion history of the universe, we can define the Om diagnostic as

$$Om(z) = \frac{E^2(z) - 1}{(1+z)^3 - 1}, \tag{17}$$

where $E^2(z) = H^2(z)/H_0^2$.

The Om diagnostic is very useful in establishing the properties of dark energy at low redshifts. A constant Om indicates the cosmological constant model, while a positive slope of Om is suggestive of phantom ($w < -1$) and a negative slope quintessence ($w > -1$). To reconstruct $Om(z)$, we need to apply the specific models, and also to consider the uncertainties of Ω_{m0}, w_0 and w_1.

3 DATA AND METHOD

In this section, we describe the observational data and analysis method used in this paper. We will fit the models by employing recent observational data including SNIa, BAO, CMB and the Observational Hubble Data (OHD).

For the SNIa data, we use the UNION2 compilation (Amanullah et al. 2010) which totally contains 557 SNe Ia with redshift ranging from 0.511 to 1.12. The χ^2 for SNe Ia is defined as

$$\chi^2_{\rm SN} = \sum_i \frac{[\mu_{\rm obs}(z_i) - \mu_{\rm th}(z_i)]^2}{\sigma_i^2}, \tag{18}$$

where the theoretical distance modulus $\mu_{\rm th}(z) = 5\log_{10}[d_L(z)/{\rm Mpc}] + 25$, σ_i is the total uncertainty in the SNIa data, and the luminosity distance is defined in Equation (4).

The competition between gravitational force and primordial relativistic plasma gives rise to acoustic oscillations which leave their signature in every epoch of the universe. Eisenstein et al. (2005) first found a peak of these baryon acoustic oscillations in the large-scale correlation function at 100 h^{-1} Mpc separation measured from a spectroscopic sample of 46 748 luminous red galaxies from the SDSS. This detection of BAO provided another independent test for constraining the property of dark energy. For the BAO data, we use the SDSS DR7 sample (Percival et al. 2010). The datapoints are

$$\frac{r_{\rm s}(z_{\rm d})}{D_v(0.275)}|_{\rm obs} = 0.1390 \pm 0.0037, \tag{19}$$

and

$$\frac{D_v(0.35)}{D_v(0.2)}|_{\rm obs} = 1.736 \pm 0.065, \tag{20}$$

where $r_{\rm s}(z_{\rm d})$ is the comoving sound horizon at the baryon drag epoch,

$$r_{\rm s}(z) = c\int_z^\infty \frac{c_{\rm s}(z')}{H(z')}dz'. \tag{21}$$

The redshift $z_{\rm d}$ at the baryon drag epoch is fitted with the formula proposed by Eisenstein & Hu (1998)

$$z_{\rm d} = \frac{1291(\Omega_{m0}h^2)^{0.251}}{1 + 0.659(\Omega_{m0}h^2)^{0.828}}[1 + b_1(\Omega_b h^2)^{b_2}], \tag{22}$$

$$b_1 = 0.313(\Omega_{m0}h^2)^{-0.419}[1 + 0.607(\Omega_{m0}h^2)^{0.674}], b_2 = 0.238(\Omega_{m0}h^2)^{0.223}. \tag{23}$$

Here, the sound speed $c_s(z) = 1/\sqrt{3(1+\bar{R}_b/(1+z)}$, with $\bar{R}_b = 31500\Omega_b h^2(T_{\rm CMB}/2.7{\rm K})^{-4}$ and $T_{\rm CMB}$ = 2.726K. The effective distance measure, $D_v(z)$, is given by (Eisenstein et al. 2005)

$$D_v(z) = \left[\frac{d_L^2(z)}{(1+z)^2}\frac{cz}{H(z)}\right]^{1/3}. \quad (24)$$

Thus we can calculate χ^2 statistics for BAO data as

$$\chi^2_{\rm BAO} = \frac{[r_s(z_d)/D_v(0.275) - 0.1390]^2}{0.0037^2} + \frac{[D_v(0.35)/D_v(0.2) - 1.736]^2}{0.065^2}. \quad (25)$$

Since the SNIa and BAO data contain information about the universe at relatively low redshift, we will include the CMB information by implementing the WMAP 7-year data (Komatsu et al. 2011) to probe the entire expansion history up to the last scattering surface. The χ^2 for the CMB data is constructed as

$$\chi^2_{\rm CMB} = X^T C^{-1} X, \quad (26)$$

where

$$X = \begin{pmatrix} l_A - 302.09 \\ R - 1.725 \\ z_* - 1091.3 \end{pmatrix}. \quad (27)$$

Here l_A is the "acoustic scale" defined as

$$l_A = \frac{\pi d_L(z_*)}{(1+z) r_s(z_*)}, \quad (28)$$

where the redshift of decoupling z_* is given by (Hu & Sugiyama 1996)

$$z_* = 1048[1 + 0.00124(\Omega_b h^2)^{-0.738}][1 + g_1(\Omega_{m0}h^2)^{g_2}], \quad (29)$$

$$g_1 = \frac{0.0783(\Omega_b h^2)^{-0.238}}{1 + 39.5(\Omega_b h^2)^{0.763}}, g_2 = \frac{0.560}{1 + 21.1(\Omega_b h^2)^{1.81}}, \quad (30)$$

and the "shift parameter," R is (Bond et al. 1997)

$$R = \frac{\sqrt{\Omega_{m0}}}{c}\int_0^{z_*}\frac{dz}{E(z)}. \quad (31)$$

C^{-1} is the inverse covariance matrix

$$C^{-1} = \begin{pmatrix} 2.305 & 29.698 & -1.333 \\ 29.698 & 6825.270 & -113.180 \\ -1.333 & -113.180 & 3.414 \end{pmatrix}. \quad (32)$$

Determination of the Hubble parameter from observations is one important method used to study the expansion history of the universe, and also the dark energy. The Hubble data at different redshifts are based on differential ages of passive evolving galaxies (Jimenez & Loeb 2002). Recently, twelve Hubble parameter data points were given in Stern et al. (2010). The χ^2 for these OHD is defined as

$$\chi^2_{\rm OHD} = \sum_{i=1}^{12}\frac{[H_{\rm th}(z_i) - H_{\rm obs}(z_i)]^2}{\sigma_i^2}, \quad (33)$$

with z_i ranging from 0 to 1.75.

Finally, the total χ^2 for these four sets of observational data is

$$\chi^2_{\rm total} = \chi^2_{\rm SN} + \chi^2_{\rm BAO} + \chi^2_{\rm CMB} + \chi^2_{\rm OHD}. \quad (34)$$

Given the $\chi^2_{\rm total}$, we can perform a global fitting to determine the cosmological parameters using the Markov Chain Monte Carlo method.

4 RESULTS

In this section, we present our fitting results for different parametrizations of the dark energy equation of state and corresponding $Om(z)$ and $q(z)$ for each parametrization.

Table 1 shows the marginalized results of Ω_{m0}, w_0 and w_1 for each parametrization. It can be seen that for different parametrizations of $w(z)$, the present values of w_0 are very close to each other (all near –1). The only difference is their evolution item w_1, but they do not deviate very far from the concordance ΛCDM model. This can be further shown in Figure 1, where the evolution of w is plotted with a 1σ confidence level. We can see that, although a mildly evolving w is favored, somehow, due to systematic errors, the ΛCDM model remains a good fit to the current data. Furthermore, obviously, the evolution behavior of the equation of state is different for different parametrizations of $w(z)$. Next, we shall see that this "model-dependent" feature changes when reconstructing the deceleration parameter $q(z)$ and Om diagnostic.

Table 1 Marginalized Results with 1σ Errors for Each Parametrization

Parametrization	Ω_{m0}	w_0	w_1	$z_{\rm t}$
A	0.28 ± 0.01	-1.09 ± 0.08	$0.43^{+0.26}_{-0.31}$	0.66 ± 0.03
B	0.28 ± 0.01	-1.03 ± 0.10	$0.95^{+0.92}_{-0.84}$	0.65 ± 0.05
C	0.28 ± 0.01	-1.08 ± 0.07	$0.23^{+0.14}_{-0.17}$	$0.64^{+0.05}_{-0.03}$
D	0.28 ± 0.01	-1.09 ± 0.08	$0.17^{+0.11}_{-0.12}$	$0.66^{+0.04}_{-0.03}$

Figure 2 shows the deceleration parameter $q(z)$ reconstructed for each parametrization (A, B, C and D), from which we can see that different parametrizations give almost the same behavior - a late time acceleration, with a transition from deceleration to acceleration at a redshift $z_{\rm t}$. We calculate $z_{\rm t}$ for each parametrization and show them in Table 1. It is clear that they are almost the same, and consistent with the ΛCDM value ($z_{\rm t} \simeq 0.7$). Note our results are in good agreement with the recent result made by Cunha & Lima (2008), where they directly parameterized $q(z)$ and got $z_{\rm t} = 0.61$ using SNLS supernova data.

Bassett et al. (2004) showed that for the transition redshift, different parametrizations of the dark energy equation of state give widely different values, which vary from $z_{\rm t} = 0.14$ to $z_{\rm t} = 0.59$, all below that of the ΛCDM model. However, they only used supernova data, containing 157 data points, which are more sensitive to systematic errors and parametrizations. Our results show that when using a combination of datasets, with many more data points than a single dataset, the fitting results would be more reliable (less sensitive to systematics and parametrizations), as we can see from the almost model-independent $q(z)$ reconstructed in Figure 2.

Next let us turn to the reconstructed result of the Om diagnostic for different parametrizations of $w(z)$. In Figure 3, we plot Om for each parametrization. Once again, it can be seen that different parametrizations of $w(z)$ have little influence on the evolutionary behavior of Om. We find that ΛCDM is in good agreement with the data (within 1σ), with the phantom model slightly favored (positive slope of Om). Our results are also in good agreement with Sahni et al. (2008).

Finally, our work suggests that for the same combination of datasets (SNIa + CMB + BAO + OHD), different parametrizations of $w(z)$ give almost the same reconstructed results of Om and $q(z)$. Everything is perfectly consistent with ΛCDM, and there is no "cosmic deceleration" feature derived from $q(z)$ and Om as suggested in some recent papers. Thus the parametrizations of $w(z)$ do not lead to severe bias in the reconstructed expansion history $q(z)$, and dark energy diagnostic Om.

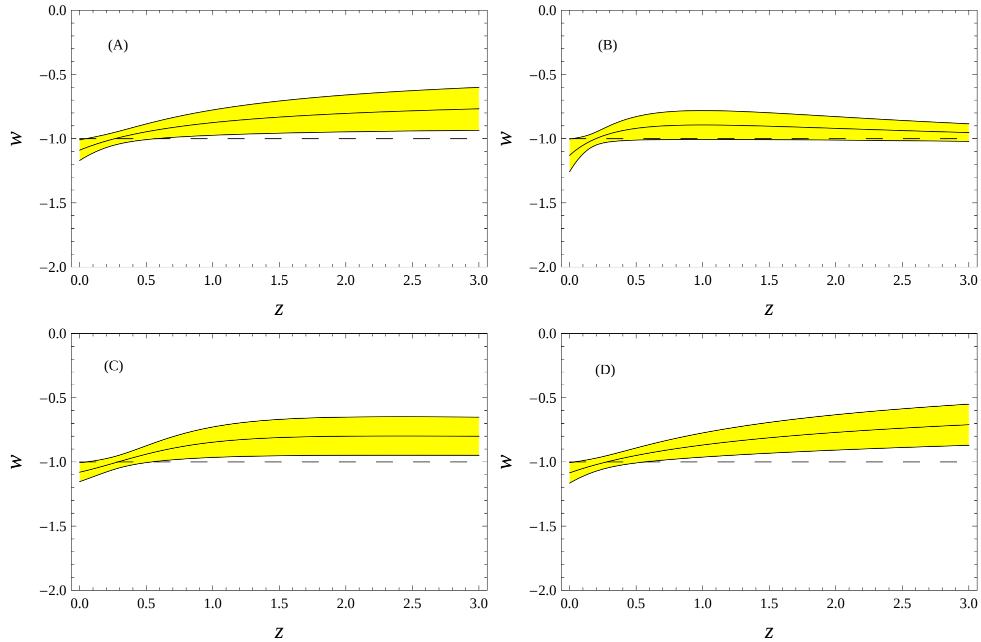

Fig. 1 Equation of state of dark energy w reconstructed for each parametrization (A, B, C and D) using the combination of datasets. The central line represents the best fit (median) and the shaded contour represents the 1σ confidence level around the best fit. The dashed horizontal line represents the cosmological constant.

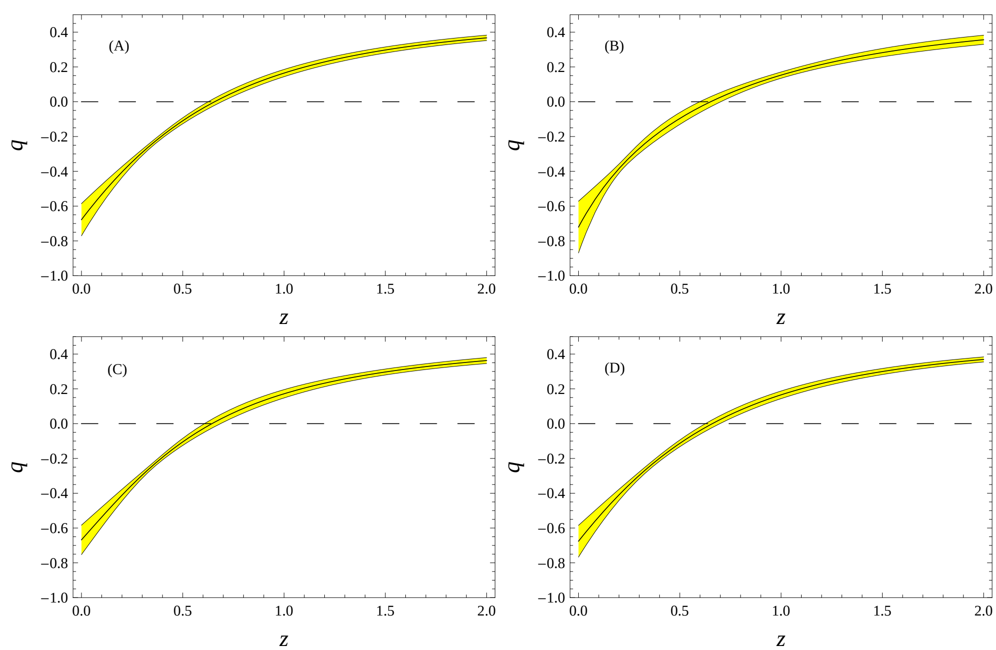

Fig. 2 Deceleration parameter q evolving with redshift for each parametrization (A, B, C and D) using the combination of datasets. The central line represents the best fit (median) and the shaded contour represents the 1σ confidence level.

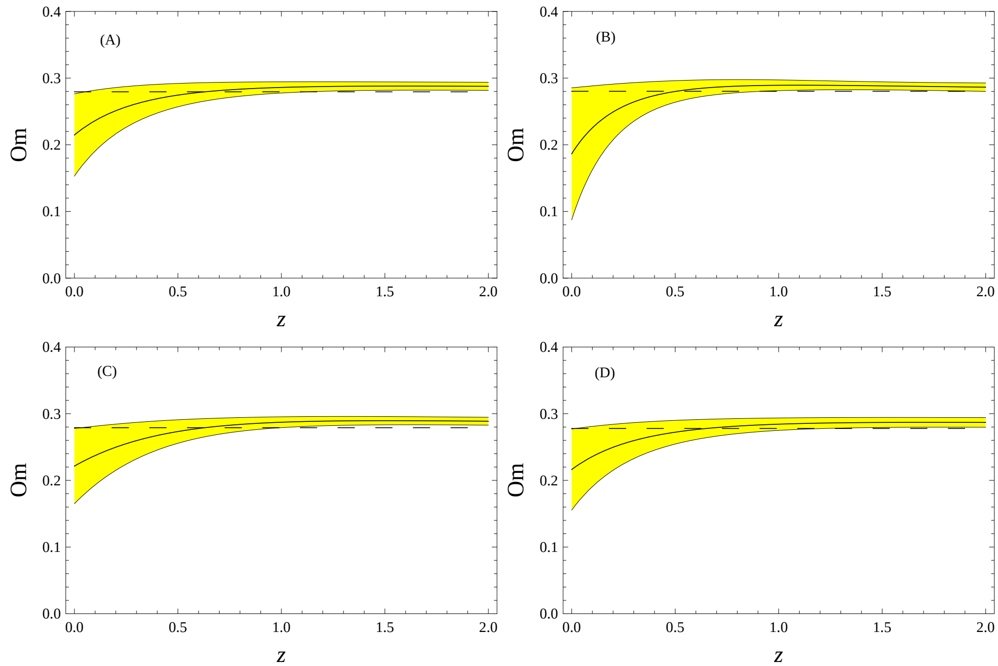

Fig. 3 Om diagnostic reconstructed for each parametrization (A, B, C and D) using the combination of datasets. The central line represents the best fit (median) and the shaded contour represents the 1σ confidence level. The dashed line represents the ΛCDM model.

5 CONCLUSIONS

To summarize, we have examined the influence of parametrizations of the dark energy equation of state on reconstructing other geometrical parameters of dark energy, i.e. $q(z)$ and Om. We have used four parametrizations of $w(z)$ (A, B, C and D denoted in this paper) to reconstruct $q(z)$ and Om. Using the latest combination of datasets (SNIa + CMB + BAO + OHD), we found that, although the fitting results of $w(z)$ depend upon the parametrizations, the reconstructed $q(z)$ and Om are almost parametrization-independent and both in good agreement with the concordance ΛCDM model. Meanwhile, for a different ansatz of $w(z)$, the reconstructed value of the transition redshift $z_{\rm t}$ is almost the same ($\simeq 0.65$), which is also consistent with the value derived from the ΛCDM model ($\simeq 0.7$). Furthermore, our reconstructed results of $q(z)$ and Om for different parametrizations of $w(z)$ suggest that, regardless of the ansatz of $w(z)$, the cosmic expansion is speeding up rather than slowing down. However, with other combinations of datasets, this result would change as shown in Gong et al. (2010), thus we must wait for more reliable data and analysis methods to give the definite answer. Above all, our work suggests that, when studying dark energy behavior using a combination of datasets, the parametrizations of $w(z)$ have little influence on reconstructing other diagnostics of dark energy (e.g. $q(z)$, Om), so we can safely, to some extent, use any of those popular parametrizations to study cosmic expansion history, with a lower price to pay for the prior as anticipated before.

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