The variation of the fine structure constant: testing the dipole model with thermonuclear supernovae

L. Kraiselburd • S. J. Landau • C. Negrelli • E. García–Berro

Abstract The large-number hypothesis conjectures that fundamental constants may vary. Accordingly, the space-time variation of fundamental constants has been an active subject of research for decades. Recently, using data obtained with large telescopes a phenomenological model in which the fine structure constant might vary spatially has been proposed. We test whether this hypothetical spatial variation of α, which follows a dipole law, is compatible with the data of distant thermonuclear supernovae. Unlike previous works, in our calculations we consider not only the variation of the luminosity distance when a varying α is adopted, but we also take into account the variation of the peak luminosity of Type Ia supernovae resulting from a variation of α. This is done using an empirical relation for the peak bolometric magnitude of thermonuclear supernovae that correctly reproduces the results of detailed numerical simulations. We find that there is no significant difference between the several phenomenological models studied here and the standard one, in which α does not vary spatially. We conclude that the present set of data of Type Ia supernovae is not able to distinguish the standard model from the dipole models, and thus cannot be used to discard nor to confirm the proposed spatial variation of α.

Keywords quasars: absorption lines – cosmology: miscellaneous – stars: white dwarfs – supernovae: general

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1 Introduction

Since the large number hypothesis was first proposed by Dirac (1937) the search for a time variation of fundamental constants has motivated numerous theoretical and experimental works. To this regard it is important to realize that the most commonly accepted cosmological theories rely on the assumption that fundamental constants – like the gravitational constant G, the fine structure constant α, or the proton-to-electron mass ratio $\mu\ldots$ – are indeed truly and genuinely constant. However, the assumption that these constants do not vary with time or location is just a hypothesis, though quite a reasonable an important one, which needs to be observationally corroborated. Actually, several modern grand-unification theories predict that these constants are slowly varying functions of low-mass dynamical scalar fields – see, for instance, Lorén-Aguilar et al. (2003), Uzan (2003) and García-Berro (2007), and references therein. In particular, the ongoing attempts of unifying all fundamental interactions have led to the developement several multidimensional theories, like string-motivated field theories, related brane-world theories, and (related or not) Kaluza-Klein theories, which predict not only an energy dependence of the fundamental constants but also a dependence of their low-energy limits on cosmological times. Thus, should these theories prove to be correct, it is expected that fundamental constants would vary slowly over long timescales, or would vary spatially. Hence, it is natural ask ourselves which are the observational consequences of a spatio-temporal variation of the fundamental constants, and to design new methods to measure, or at least to constrain, such hypothetical variations, as this would allow us to confirm or discard some of the proposed theories.

According to this theoretical framework, in the last decade the issue of the variation of fundamental constants has experienced a renewed interest, and several observational studies have been undertaken to scrutinize their possible variations (Uzan 2003; García-Berro 2007), and to establish constraints on such variations. Generally speaking, the experimental studies can be grouped in two different categories, namely astronomical and local methods. The latter ones include, among other techniques, geophysical methods such as the Oklo natural nuclear reactor that operated about 1.8×10^9 years ago (Petrov et al. 2006; Gould et al. 2006), the analysis of natural long-lived β decayers in geological minerals and meteorites (Olive et al. 2004b), and laboratory measurements which compare clocks with different atomic numbers (Fischer et al. 2004; Peik et al. 2004). The former methods comprise a large variety of methods – see the reviews of Uzan (2003) and García-Berro (2007) for extensive discussions of the many observational techniques. However, the most successful method employed so far to measure hypothetical variations of α and μ is based on the analysis of the spectral lines of high-redshift quasar absorption systems, the so-called many-multiplet method (Webb et al. 1999). This method compares the characteristics of different transitions in the same absorption cloud, and results in a gain of an order of magnitude in sensibility respect to previous methods. As it should be otherwise expected, most of the reported results are consistent with a null variation of fundamental constants. However, using this method Webb et al. (1999) and Murphy et al. (2003b) have reported the results of Keck/HIRES observations which suggest a smaller value of α at high redshift as compared with its local value. Nevertheless, an independent analysis performed with VLT/UVES data gave null results (Srianand et al. 2004). Contrary to the previous results, a recent analysis using VLT/UVES data suggests also a variation in α but in the opposite sense, that is, α appears to be larger in the past (Webb et al. 2011; King et al. 2012). In addition, it has been pointed out (Landau & Simeone 2008; Kraiselburd et al. 2013) that results calculated from the mean value over a large redshift range (or cosmological time-scale) are at variance with those obtained considering smaller intervals. Thus, from the observational point of view, a possible slow variation of fundamental constants with look-back times remains a controversial issue, and the discrepancy between Keck/HIRES and VLT/UVES is yet to be resolved.

Since the Keck/Hires and VLT/UVES observations rely on data from telescopes observing different hemispheres, it has been recently suggested that their respective results can be made consistent if the fine structure constant were spatially varying. Additionally, there is some recent observational evidence which could be interpreted as a hint for deviations from large-scale statistical isotropy. For example, the alignment of low multi-poles in the Cosmic Microwave Background angular power spectrum (Copi et al. 2010), and the large-scale alignment in the QSO optical polarization data (Hutsemékers et al. 2014) may support this explanation. All these observations have boosted the interest in the search for a spatial variation of α. As mentioned, Webb et al. (2011) and King et al. (2012) reported a possible spatial variation of α, and showed that phenomenological models where the variation in α follows a dipole law can be well fitted to the obtained data. This result was later confirmed by Berengut et al. (2012). All these observational works also motivated the theoretical interest in this kind of studies. For instance, Mariano & Perivolaropoulos (2012) studied if the reported spatial variation of α was compatible with the observations of distant Type Ia supernovae (SNIa). They did so employing the Union 2 compilation of luminosity distances (Amanullah et al. 2010; Suzuki et al. 2012). More recently, Yang et al. (2014) searched for a preferred direction using the Union 2.1 sample and found a preferred direction which can be well approximated by a dipole fit. However, none of these studies took into account the dependence of the Chandrasekhar limiting mass on the precise value of α. The only study in which a dependence of the intrinsic properties of Type Ia supernovae has been done is that of Chiba & Kohri (2003). Specifically, they analyzed the effect of changing α on the peak bolometric magnitude of Type Ia supernovae. However, this pioneering analysis only considered the dependence of the mean opacity of the expanding photosphere of Type Ia supernovae on the value of α, and neglected the dependence of the Chandraskhar limiting mass on the precise value of α. In this paper we perform a similar analysis, this time considering as well the dependence of the Chandrasekhar mass on α. Thus, our study complements and expands that of Chiba & Kohri (2003). To compare with observations we employ the standard cosmological model and the Union 2.1 compilation of distant SNIa. Our paper is organized as follows. In Sect. 2 we explain how our models are built. If follows Sect. 3, where we present our results. Lastly, in Sect. 4 we summarize our main findings and we present our conclusions.

2 The luminosity distance relation

In this paper, we use the measured luminosity distance of SNe Ia explosions to test the phenomenological dipole models of King et al. (2012). Thermonuclear supernovae are best suited for this purpose as they are considered good standard candles that can be observed up to very high redshifts.

Actually, SNe Ia are calibrable candles, as its peak luminosity correlates with the decline rate of the light curve. This is because, although the nature of their progenitors and the detailed mechanism of explosion are still the subject of a strong debate, their observational light curves are well understood and their individual intrinsic differences can be accounted for. Hence, observations of distant SNe Ia are now used to constrain cosmological parameters (Perlmutter et al. 1999; Riess et al. 2004), or to discriminate among different alternative cosmological theories. However, their reliability as distance indicators relies on the assumption that there is no mechanism able to produce an evolution of the observed light curves over cosmological distances. The homogeneity of the light curve is essentially due to the homogeneity of the nickel mass produced during the supernova outburst ($M_{\rm Ni} \sim 0.6\,M_\odot$), and this is primarily determined by the value of the Chandrasekhar limiting mass, which depends on α:

$$M_{\rm Ch} \propto \left(\frac{e^2}{\alpha G}\right)^{\frac{3}{2}}, \qquad (1)$$

where all the symbols have their usual meaning. Thus, the nickel mass synthesized during the thermonuclear outburst scales as $\alpha^{-3/2}$. Hence, if α varies so does the nickel mass, and consequently, the peak bolometric luminosity of thermonuclear supernovae and correspondingly the derived distance. Also, the peak luminosity of thermonuclear supernovae depends on the opacity of the expanding photosphere, that also depends on the precise value of α. In the next subsection we calculate how the peak bolometric magnitude scales on α taking into account both dependences.

2.1 The dependence of the peak luminosity on α

The dependence of the peak bolometric magnitude of thermonuclear supernovae on α can be obtained using simple analytical arguments. To do this we follow closely Chiba & Kohri (2003), this time taking all the dependencies on α into account. To start with, we recall that the peak luminosity of SNIa is given by:

$$L_{\rm peak} = M_{\rm Ni}\, q(t_{\rm peak}) \qquad (2)$$

where $M_{\rm Ni} \simeq 0.6\,M_{\rm sun}$, and

$$q(t) = \left[S^{\beta}_{\rm Ni} e^{-t/\tau_{\rm Ni}} + S_{\rm Co}\left(e^{-t/\tau_{\rm Co}} - e^{-t/\tau_{\rm Ni}}\right)\right] f^{\gamma}_{\rm dep}(t) + S^{\beta}_{\rm Co}\left(e^{-t/\tau_{\rm Co}} - e^{-t/\tau_{\rm Ni}}\right) \qquad (3)$$

is the energy deposited by the ^{56}Ni$\rightarrow$^{56}Co$\rightarrow$^{56}Fe decay chain inside the photosphere of the exploding supernova, $\tau_{\rm Ni}$, and $\tau_{\rm Co}$ are the lifetimes of the corresponding decays, and $S^{\gamma}_{\rm Ni}$, $S^{\gamma}_{\rm Co}$ and $S^{\beta}_{\rm Co}$ are the respective energies. In this expression the γ-ray deposition function can be well approximated by (Colgate et al. 1980):

$$f^{\gamma}_{\rm dep} = G(\tau)\left[1 + 2G(\tau)(1 - G(\tau))\left(1 - \frac{3}{4}G(\tau)\right)\right] \qquad (4)$$

and

$$G(\tau) = \frac{\tau}{\tau + 1.6} \qquad (5)$$

being τ the optical depth.

We first compute the time at which the peak luminosity occurs. At this time the diffusion timescale, $t_{\rm diff}$ equals the expansion timescale, $t_{\rm exp}$. Hence, we have $t_{\rm peak} = t_{\rm diff} = t_{\rm exp}$. We now compute approximate expressions for both timescales. The expansion timescale is obtained from the velocity of the ejected material, $t_{\rm diff} = R/v$, where the velocity can be obtained from the energy of the explosion:

$$v = \sqrt{\frac{2E}{M}}. \qquad (6)$$

The diffusion timescale is given by:

$$t_{\rm diff} = \frac{\kappa\rho R^2}{c} \qquad (7)$$

where $\kappa \simeq 0.1$ cm^2 g^{-1} is the opacity. We substitute the value of ρ by its average value:

$$\rho = \frac{3M}{4\pi R^3} \qquad (8)$$

After some algebra we obtain:

$$t_{\rm diff} = \frac{3\kappa}{4\pi c v t_{\rm exp}} \qquad (9)$$

Taking into account that at $t_{\rm peak}$ the diffusion timescale and the expansion timescale are equal, we obtain

$$t_{\rm peak} = \left(\frac{3\kappa}{4\sqrt{2}\pi c}\right)^{1/2}\left(\frac{M^3}{E}\right)^{1/4} \qquad (10)$$

Here, for the sake of simplicity, we will only focus on Chandrasekhar-mass models. Moreover, we will assume that only α varies, and that the values of G and e remain constant. Thus, both M and E are determined by the Chandrasekhar limiting mass, and consequently depend on α. Also, the opacity (mainly determined by electron scattering) depends on the value of α. Thus, we have that a small variation of the fine structure constant, $\delta\alpha$, results in a variation of the time at which the peak luminosity occurs:

$$\frac{\delta t_{\rm peak}}{t_{\rm peak}} = \frac{1}{2}\frac{\delta\kappa}{\kappa} + \frac{3}{4}\frac{\delta M}{M} - \frac{1}{4}\frac{\delta E}{E} \qquad (11)$$

Taking into account the dependence on α of M and E, and assuming that the opacity scales as α^2 (Chiba & Kohri 2003) we finally obtain:

$$\frac{\delta t_{\rm peak}}{t_{\rm peak}} = -\frac{3}{8}\frac{\delta\alpha}{\alpha} \tag{12}$$

We now investigate how τ scales on α:

$$\tau = \kappa\rho R = \frac{3}{4\pi}\kappa\frac{M^2}{Et^2} \tag{13}$$

At peak luminosity:

$$\tau = \sqrt{2}c\left(\frac{M}{E}\right)^{1/2} \tag{14}$$

Consequently:

$$\frac{\delta\tau}{\tau} = \frac{1}{2}\frac{\delta M}{M} - \frac{1}{2}\frac{\delta E}{E} = -\frac{7}{4}\frac{\delta\alpha}{\alpha} \tag{15}$$

Using this result we now study how q depends on α:

$$\frac{\delta q}{q} = -\frac{\delta t_{\rm peak}}{t_{\rm peak}} + \frac{\delta f^{\gamma}_{\rm dep}}{f^{\gamma}_{\rm dep}} = -\frac{\delta t_{\rm peak}}{t_{\rm peak}} + \eta\frac{\delta G}{G} \tag{16}$$

where

$$\eta = 1 + 4G(t_{\rm peak}) - 10.5G(t_{\rm peak})^2 + 6G(t_{\rm peak})^3 \tag{17}$$

and

$$\frac{\delta G}{G} = 1.6\frac{\delta\tau}{\tau} \tag{18}$$

Finally, combining Eqs. (12), (16), (15) and (18) we obtain the following expression for the variation of q at peak luminosity:

$$\frac{\delta L_{\rm peak}}{L_{\rm peak}} = \frac{\delta q(t_{\rm peak})}{q(t_{\rm peak})} = \left(\frac{3}{8} - \frac{7}{4}1.6\eta\right)\frac{\delta\alpha}{\alpha} \tag{19}$$

All in all, it turns out that the peak bolometric magnitude, $\mathcal{M}$, and hence the luminosity distance of distant SNIa are different when a varying α is considered. The correction to $\mathcal{M}$ is given by:

$$\delta\mathcal{M} = -2.5\frac{\delta L_{\rm peak}}{L_{\rm peak}} = -2.5\left(\frac{3}{8} - \frac{7}{4}1.6\eta\right)\frac{\delta\alpha}{\alpha} \tag{20}$$

Note that this expression differs from that of Chiba & Kohri (2003), because in addition to the term that accounts for the variation of the opacity of the expanding photosphere there are terms which account for the variation of the mass of nickel synthesized in the thermonuclear outburst (Gaztañaga et al. 2002). In Fig. 1 we compare our results with those of Chiba & Kohri (2003). As can be seen, in our case the dependence on $\delta\alpha/\alpha$ of $\delta L_{\rm peak}/L_{\rm peak}$ is steeper than that of Chiba & Kohri (2003). This, clearly, is due to the fact that in our case we do not only take into account the dependence of the opacity on α and but also we consider that of the mass of nickel synthesized in the supernova outburst. However, we stress that both our results and those of Chiba & Kohri (2003) agree in the fact that a decrease of the value of α translates into an increase of the luminosity of thermonuclear supernovae. Thus a smaller (larger) value of α makes SNIa brighter (fainter).

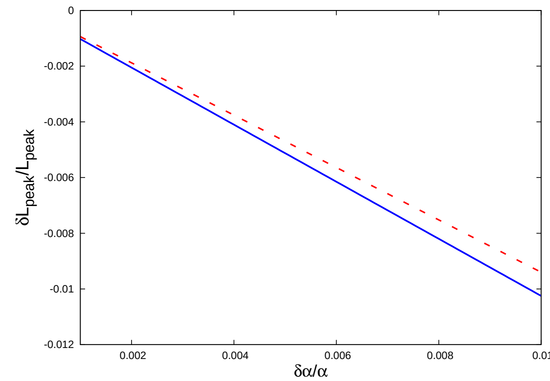

Fig. 1 Peak luminosity of distant Type Ia supernovae as a function of $\delta\alpha/\alpha$. The solid line corresponds to the case in which both the variation of the Chandrasekhar limiting mass and the variation of the opacity of the expanding photosphere are considered, while the dashed line corresponds to that in which only the variation of the opacity is taken into account.

2.2 The variation of α

As mentioned, the data obtained using the Keck and the VLT telescopes during the last years has resulted in a set of values of $\Delta\alpha/\alpha$ for ~ 300 absorption systems covering most of the sky. This extensive set of data was analyzed by Webb et al. (2011) and King et al. (2012) and, taken together, they concluded that there is evidence for an angular variation of α. Moreover, they proposed the following phenomenological model for the variation of α:

$$\frac{\delta\alpha}{\alpha} = A + B\cos\theta, \tag{21}$$

where $\cos\theta = \vec{r}\cdot\vec{D}$, $\vec{D}$ is the direction of the dipole, $\vec{r}$ is the position on the sky, A is a constant (a monopole term) and B is the amplitude of the dipole term. The values of A, B and θ depend somewhat on the data set considered studied (King et al. 2012). We nevertheless emphasize that in all the models of King et al. (2012) α depends on right ascension and declination, and moreover that the direction of the dipole seems to be well established, pointing towards the same approximate direction on the sky. Thus, here, for the sake of conciseness, we will only analyze their best fit model, for which the amplitudes of the monopole and dipole

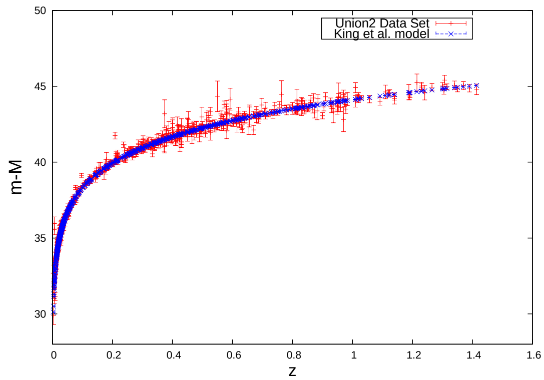

Fig. 2 A comparison of the distance modulus and redshift for the model of King et al. (2012). The observed data from the Union 2.1 compilation and their respective errors are shown in red, while the theoretical predictions are shown using blue symbols. See the online edition of the journal for a color version of this figure.

terms are respectively $A = (-0.177 \pm 0.085) \times 10^{-5}$ and $B = (0.97^{+0.22}_{-0.20}) \times 10^{-5}$, and the dipole term points towards right ascension $17.4^{h} \pm 1.0^{h}$ and declination $-61^{\circ} \pm 10^{\circ}$. In a second step we will consider the effects of a varying α using the results obtained in Sect. 2.1, but leaving A, B and $\vec{D}$ as free parameters, and we will obtain their values using the observed data of Type Ia supernovae.

2.3 Reference cosmological model

We adopt as a reference model to compare with a flat ΛCDM model with the following cosmological parameters. The matter density in units of the critical density is $\Omega_{M} = 0.264$ and we also take $\Omega_{R} = 0$. At last, the Hubble constant is $H_0 = 71.2\,\mathrm{Mpc}^{-1}\,\mathrm{km\,s}^{-1}$. These are the best-fit values presented by the WMAP collaborarion using the 9-year WMAP data of the Cosmic Microwave Background (Bennett et al. 2013), the temperature power spectrum for high l from the Atacama Cosmology Telescope (Das et al. 2014) and South Pole Telescope (Reichardt et al. 2012), the position of the Baryon Acoustic Oscillations peak (Anderson et al. 2014, 2013; Padmanabhan et al. 2012; Blake et al. 2011), and the three year sample of the Supernovae Legacy Survey (Guy et al. 2010; Conley et al. 2011; Sullivan et al. 2011).

3 Results

In this section we show the results of comparing the data of the Union 2.1 compilation of SNe Ia with the phenomenological model of King et al. (2012). To this end, in Fig. 2 we compare the relation between the distance modulus and the redshift for the theoretical model and the observational data of the Union 2.1 compilation. As can be seen, the theoretical model matches very well the observated luminosity distance-redshift relationship. We now check whether there is an angular dependence of the value of the fine structure constant. Fig. 3 shows the distance modulus as a function of the right ascension (left panel) and declination (right panel) of the absorption systems, for the model of King et al. (2012) considered here (blue points) and the observational data (red points). Again, overall all the phenomenological model seems to explain well most of the observed supernovae, although there are some differences for each individual SNIa, depending on its respective position in the sky. Moreover, it can be seen that there is no obvious correlation between the value of the distance modulus and the position in the sky.

Since the amount of available observational data is sufficiently large, it is crucial to further quantify the degree of agreement between the observed data and the theoretical models. To do so we use a χ^2 test. The χ^2 estimator is constructed using the following expression:

$$\chi^2 = \sum \frac{[(m(z,\theta) - M_0)_{\rm P} - (m - M_0)_{\rm R}]^2}{\sigma_{\rm O}^2} \qquad (22)$$

In this equation $(m(z,\theta) - M_0)_{\rm P}$ is computed considering the hypothetical variation of α according to the phenomenological model of King et al. (2012) and considering the results of Sect. 2.1, whereas $(m - M_0)_{\rm R}$ and $\sigma_{\rm O}$ are the observational data and the observational errors of the distance modulus taken both from the Union 2.1 compilation. We obtain that the reduced χ^2 – that is the value of χ^2 divided by the number of degrees of freedom, ν – for the phenomenological model proposed by King et al. (2012) is $\chi^2/\nu = 1.74591$, while for the case in which no variation of α is considered we obtain $\chi^2/\nu = 1.74589$. Thus, the differences are not statistically significant. We note that when the complete data set of the Union 2.1 compilation (713 data points) is used, the reduced value of χ^2 is slightly larger than expected in both cases. This is due to the fact that although the vast majority of the data fit very well with our standard model, there are some supernovae that do not. This issue has been discussed previously in the literature (Gopal Vishwakarma & Narlikar 2010), and thus we will not discuss it in detail here. Instead, we refer to the previously mentioned work for an extensive discussion of the problem, and we simply discard the 17 conflictive data points that Gopal Vishwakarma & Narlikar (2010) recommend to do not use. When this procedure is adopted we obtain $\chi^2/\nu = 1.03494$ and $\chi^2/\nu = 1.03493$, respectively.

It is nevertheless interesting to go one step beyond and adopt the inverse procedure. That is, check whether or not there is a preferred direction in the raw observational data. Hence, in a second step we consider A, B and $\vec{D}$ as free parameters, and obtain the resulting values using the observational data of the Union 2.1 compilation, this time employing the luminosity distance computed according to the results of Sect. 2.1. We will do so using the complete

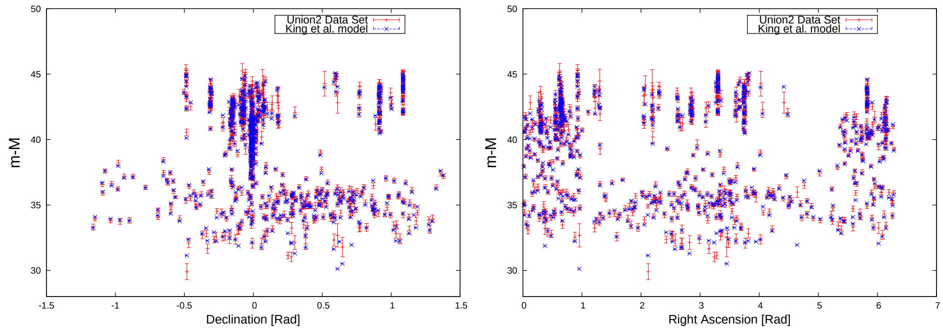

Fig. 3 A comparison of the distance modulus and right ascension (left panel) and declination (right panel), for the model of King et al. (2012). Again, the observed data and the theoretical ones are shown using red and blue symbols.

Model	A	B	R.A. (hr)	δ (°)	χ^2/ν
1	$(1.141 \pm 0.297) \times 10^{-2}$	$(2.182 \pm 0.718) \times 10^{-2}$	23.013 ± 2.052	(65.911 ± 10.512)	1.681
2	$(7.811 \pm 2.821) \times 10^{-3}$	$(2.122 \pm 0.785) \times 10^{-2}$	1.313 ± 4.268	(75.719 ± 10.052)	1.001

Table 1 Parameters of the dipole for the different models obtained from the statistical analysis.

Union 2.1 data set (model 1) and the reduced data set, in which only 696 data points are considered (model 2). The results of this exercise are shown in Table 1. As it happened when considering the models of King et al. (2012), the values of χ^2 for model 1 is larger than expected while we find a reasonable value when only 696 data points are included in the statistical analysis. Moreover, it follows from Table 1 that the values of A, B and $\vec{D}$ are considerably different for the two sets of data studied here. In particular, the amplitude of the monopole term (A) is significantly larger when the complete Union 2.1 dataset is employed, and moreover for both datasets we obtain values that are considerably larger than that obtained by King et al. (2012) employing the many multiplet method, and that of Yang et al. (2014) using Type Ia supernovae, but disregarding the effects of a varying α. However, we remark that given the large uncertainties in the determination of A our results are compatible with a null result for model 2, which is obtained using the more reliable data. Also the direction of the dipole term is different in both cases, although their respective amplitudes are similar. Moreover, the direction of the dipole when the correct dependence on α is considered is at variance with the results of King et al. (2012) for distant quasars and Yang et al. (2014) for SNIa.

4 Discussion and conclusion

In this paper we have studied whether the recently reported space-time variation of the fine structure constant (King et al. 2012) can be confirmed or discarded using the Union 2.1 compilation of luminosity distances of SNIa. To do so we have derived from simple physical arguments a scaling law for the peak bolometric magnitude of distant SNIa. Our results show that the currently available data does not allow to either confirm nor discard the phenomenological models of King et al. (2012) and Webb et al. (2011). The ultimate reason for this is that the magnitudes of the reported variations of α result in modest variations of the peak bolometric magnitudes of distant SNIa, and thus the differences in the positions of the SNIa of the Union 2.1 compilation are too small when compared with the leading terms intervening in the calculation of the luminosity distances of Type Ia supernova. To this regard, it is worth mentioning that Yang et al. (2014) have found that the SNIa data can be better explained when a dipole model pointing towards ($b = -14.3° \pm 10.1°$, $l = 307.1° \pm 16.2°$) – a direction close to that found by King et al. (2012). However, in their calculations they did not include the effects of a possible variation of α, and instead assumed that all the fundamental constants were indeed truly constant. Our approach goes one step beyond and we included it. In a second step we used the Union 2.1 compilation to check whether or not there exists a variation of α, and we have found that the monopole term cannot be determined with accuracy given the still large uncertainties, and that for the dipole term the direction is at odds with that found in previous studies. Thus, the analysis performed here shows that if such a preferred direction in the SNIa data of the Union 2.1 catalog exists, its origin cannot likely be due to an eventual variation of α. In summary, we conclude that the actually available SNIa data cannot be used to distinguish between a standard cosmological model in which α is strictly constant and a model where α has a space-time variation.

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