# Fine-structure constant is constant!

*John Hartnett*

On 1 April 2004, *SpaceDaily.com* carried the news headline 'Quasar Studies Keep Fundamental Physical Constant—Constant'.[1] It was no April fool's joke.

There has been much ado about the constancy (or otherwise) of the fine-structure constant, and it has been discussed in creationist[2] as well as secular publications.[3–5] There has also been much conjecture that any variation in the value of the constant would imply that the speed of light had been greater in the past.[6–8] This, in itself, was an interesting admission by the secular scientific world, because this possibility had first been suggested by creationists.[9] The theorist who developed these new variable speed-of-light (VSL) theories suggested that they may be an alternative to inflation cosmology.[10] However, the implications were analyzed and were not found to offer any solution to the question of how we see distant starlight in a young universe.[11]

It now seems that the previous result (that there has been a significant change in the fine-structure constant, of around 1 part in 100,000) has been overturned by observations of higher quality. The *SpaceDaily* article went on to say:

> 'Previous astronomical measurements of the fine structure constant—the dimensionless number that determines the strength of interactions between charged particles and electromagnetic fields—suggested that this particular constant is increasing very slightly with time. If confirmed, this would have very profound implications for our understanding of fundamental physics.
>
> 'New studies, conducted using the UVES spectrograph on Kueyen, one of the 8.2-m telescopes of ESO's Very Large Telescope array at Paranal (Chile), secured new data with unprecedented quality.
>
> 'These data, combined with a very careful analysis, have provided the strongest astronomical constraints to date on the possible variation of the fine structure constant. They show that, contrary to previous claims, no evidence exist [sic.] for assuming a time variation of this fundamental constant.'

If a drift in the value of the fine-structure constant ($\alpha = 1/137.03599976(50)$) had been detected, it could have indicated the need for new physics. This, in turn, might have led to a better understanding of how gravitation fits in with particle physics, particularly at the quantum level. (For an explanation of the fine-structure constant, see ref. 11.) The value of this constant tells us something about how electromagnetic forces hold atoms together, and the way light interacts with atoms. At high energies, as the atom is probed more deeply, it has been noted that $\alpha$ gets smaller. Hence, it was thought, it might vary with time and space. Such variation would be allowed, and even predicted, by modern super-string and grand-unification theories.

This news announcement and an earlier *Nature* article[12] were based on recently published papers in *Physical Review Letters* (Srianand *et al.*)[13] and in *Astronomy & Astrophysics* (Chand *et al.*).[14] The *SpaceDaily* article continued:

> 'A team of astronomers, led by Patrick Petitjean (Institut d'Astrophysique de Paris and Observatoire de Paris, France) and Raghunathan Srianand (IUCAA, Pune, India) very carefully studied a homogeneous sample of 50 absorption systems observed with UVES and Kueyen along 18 distant quasars [*sic*] lines of sight.
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> 'They recorded the spectra of quasars over a total of 34 nights to achieve the highest possible spectral resolution and the best signal-to-noise ratio. Sophisticated automatic procedures specially designed for this programme were applied.
>
> 'Interestingly, this result is supported by another—less extensive—analysis, also conducted with the UVES spectrometer on the VLT … Even though those observations were only concerned with one of the brightest known quasar [*sic*] HE 0515–4414, this independent study lends further support to the hypothesis of no variation of alpha.'

The latter was also reported in *Astronomy & Astrophysics* (Quast *et al.*).[15] This last paper presented evidence, from Fe II absorption systems at a redshift of $z = 1.15$, that the average fractional variation of $\alpha$, $\Delta\alpha/\alpha$, is equal to zero, at a 91% significance level, or

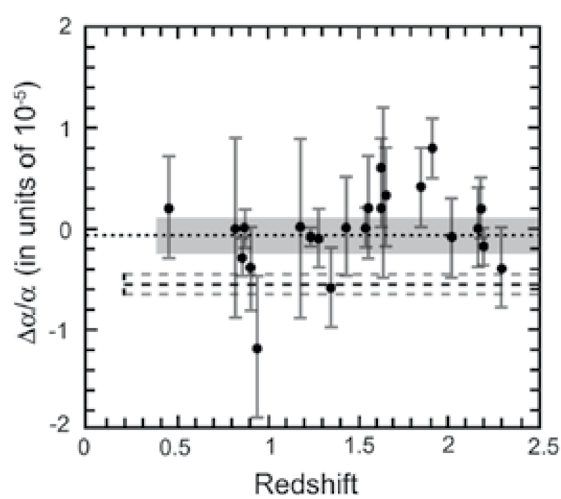


***Figure 1.*** *Reproduced from fig. 3 of ref. 13. The measured values of $\Delta\alpha/\alpha$ from the Srianand* et al. *sample are plotted against the absorption redshifts of Mg II systems. Each point is the best-fit value obtained for individual systems. The horizontal, long, dashed lines show the weighted mean and 1 $\sigma$ range measured by Murphy* et al.*[5] The shadowed region marks the weighted mean and its 3 $\sigma$ error obtained from the Srianand* et al. *study.*

$\Delta\alpha/\alpha = (0.1 \pm 1.7) \times 10^{-6}$. The much larger variation ($\Delta\alpha/\alpha = (-5.7 \pm 1.0) \times 10^{-6}$) for the previous study presented by Murphy *et al.*,[5] from a sample of 143 complex metal systems using the same many-multiplet (MM) analysis, has a significance level of only 12%.

An MM analysis performed by Srianand *et al.*, on a new, very high-quality sample of 23 systems with Mg II absorption lines, measured over the redshift range of $0.4 \leq z \leq 2.3$, confirms the latest results of small variation, with $\Delta\alpha/\alpha = (-0.6 \pm 0.6) \times 10^{-6}$. (For a detailed explanation of the methods used, see ref. 16.) The variations of the fine-structure constant are constrained tightly about zero, irrespective of the distances of the quasar sources.

Figure 3 of Srianand *et al.*[13] is reproduced here (figure 1) and strongly supports the news headlines. The horizontal dashed lines are the previous results (weighted mean and $1\sigma$ range presented by Murphy *et al.*). The filled circles are the new results of Srianand *et al.* Clearly most of these new measurements are inconsistent with the range of the previous (Murphy *et al.*) data.

Recent research on the Oklo natural uranium reactor (Gabon, Africa) claims a historical variation in $\Delta\alpha/\alpha \geq 4.5 \times 10^{-8}$ with 6 $\sigma$ confidence.[17] This earth-based calculation involves certain model dependent assumptions and remains controversial. Recently reported astrophysical observations have consistently indicated an invariant $\alpha$.[18,19]

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