Comment on "Limits on the Time Variation of the Electromagnetic Fine-Structure Constant in the Low Energy Limit from Absorption Lines in the Spectra of Distant Quasars"

In their Letter [1] (also [2]), Srianand *et al.* analyzed optical spectra of heavy-elements in 23 absorbers along background quasar sight lines, reporting limits on variations in the fine-structure constant, α: $\Delta\alpha/\alpha = (-0.06 \pm 0.06) \times 10^{-5}$. This would contradict previous evidence [e.g., [3,4]] for a smaller α in the absorption clouds compared to the laboratory: $\Delta\alpha/\alpha = (-0.57 \pm 0.11) \times 10^{-5}$ [5]. Here we demonstrate basic flaws in the analysis of [1] using the same data and absorption profile fits.

For each absorber, $\Delta\alpha/\alpha$ is measured using a χ^2 minimization of a multiple-component Voigt profile fit to the absorption profiles of several transitions. The column densities, Doppler widths and redshifts defining the components are varied iteratively until the decrease in χ^2 between iterations falls below a specified tolerance, $\Delta\chi^2_{\rm tol}$. In our approach, we simply add $\Delta\alpha/\alpha$ as an additional free parameter whereas [1] keep it as an external one: for each fixed input value of $\Delta\alpha/\alpha$ the other, free parameters are varied to minimize χ^2. The functional form of χ^2 implies that, in the vicinity of the best-fitting $\Delta\alpha/\alpha$, the "χ^2 curve"—the value of χ^2 as a function of $\Delta\alpha/\alpha$—should be near parabolic and smooth. That is, $\Delta\chi^2_{\rm tol}$ should be $\ll 1$ to ensure that fluctuations on the χ^2 curve are also $\ll 1$. This is crucial for deriving the 1-σ uncertainty in $\Delta\alpha/\alpha$ from the width of the χ^2 curve at $\chi^2_{\rm min} + 1$.

However, none of Srianand *et al.*'s χ^2 curves—Fig. 2 in [1], 14 in [2]—are smooth at the $\ll 1$ level; many fluctuations exceed unity. Two examples are reproduced in Fig. 1. The fluctuations can only be due to failings in the χ^2 minimization: even when [2] fit *simulated* spectra (their Fig. 2) jagged χ^2 curves result, leading to a strongly non-Gaussian distribution of $\Delta\alpha/\alpha$ values and a large range of 1-σ uncertainties (their Fig. 6). Clearly, these basic flaws in the parameter estimation will yield underestimated uncertainties and spurious $\Delta\alpha/\alpha$ values.

To demonstrate these failings, we apply the *same profile fits* to the *same data* but with a robust χ^2 minimization. The spectra were kindly provided by Aracil who confirmed that the wavelength and flux arrays are identical to those in [1]. For each absorber, the best-fitting profile parameters of [2] were treated as first guesses in our χ^2 minimization procedure (detailed in [4]). The relationships between the Doppler widths of corresponding velocity components in different transitions were also the same, as were the relevant atomic data. The relative tolerance for halting the χ^2 minimization was $\Delta\chi^2_{\rm tol}/\chi^2 = 2 \times 10^{-7}$. All absorbers yield smooth χ^2 curves in new our analysis; Fig. 1 shows two examples.

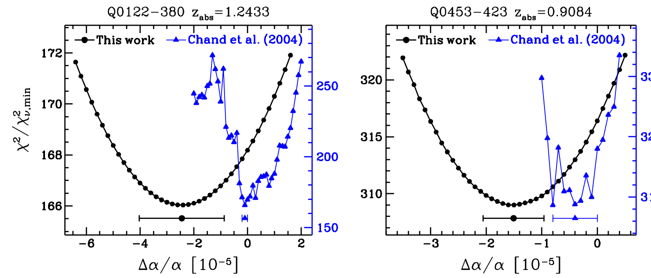

FIG. 1 (color online). Example χ^2 curves from our minimization (circles) and that of [1] (triangles). Fluctuations in the latter indicate failings in the minimization. Points and error bars indicate best-fitting values and 1-σ uncertainties; for our curves $\Delta\alpha/\alpha$ was a free parameter. Note the different vertical scales: left-hand scales for our curves, right-hand scales for [1].

By products of this analysis are revised values of $\Delta\alpha/\alpha$ and 1-σ errors. We find 14 of the 23 $\Delta\alpha/\alpha$ values deviate by $>0.3 \times 10^{-5}$ from those of [1]. Moreover, the errors are almost always larger, typically by a factor of $\sim$3. The formal weighted mean over the 23 absorbers becomes $\Delta\alpha/\alpha = (-0.44 \pm 0.16) \times 10^{-5}$ but the scatter in the values is well beyond that expected from the errors. This probably arises from many sources, including overly simplistic profile fits (see [6]). Allowing for additional, unknown random errors by increasing the error bars to match the scatter (i.e., $\chi^2_\nu = 1$ about the weighted mean), a more conservative result from the data and fits of [1] is $\Delta\alpha/\alpha = (-0.64 \pm 0.36) \times 10^{-5}$—a sixfold larger uncertainty than quoted by [1]. We conclude that the latter offers no stringent test of previous evidence for varying α; this must await a future, extensive statistical approach.

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