Reply to "Comment on 'Nonidentical protons' "

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We reply to the Comment by Arrington, which concerns the proton radius extracted from the elastic electron-proton scattering data by using the assumption of nonidentical protons. We agree that the extracted radius should be 0.853 fm. We briefly point out the corresponding consequence in the result of our original paper.

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In the preceding paper [1] Arrington comments on the extracted proton radius by using the assumption of nonidentical protons [2]. There are two issues addressed in the Comment. Below is our response.

(1) We agree that the radius obtained before averaging the proton sizes is already consistent with the muonic hydrogen. This was achieved by using a dipole form factor and the obtained χ^2/N is 10.5. As can be seen in the lower panel of Fig. 3 of Ref. [2] the assumption of nonidentical protons reduces the χ^2/N to 4.5 and slightly decreases the radius. The reason that the χ^2/N cannot be further reduced has been discussed in Ref. [3].

(2) With the second issue we also agree that the extracted radius in the case of nonidentical protons should be 0.853 fm, instead of 0.833 fm, which is caused by a mistake. We have found the source of this mistake, i.e., when we calculated the radius by using Eq. (7) of Ref. [2], we used the original dipole form factor $(1 + Q^2/\Lambda_1^2)^{-2}$, instead of the averaged one, i.e., Eq. (5) of Ref. [2]. By using Eq. (5) in Eq. (7) it is found that the extracted radius is 0.853 fm. This can be also directly calculated from the slope of the form factor, where for the averaged form factor we obtain $dG_{E,p}(Q^2)/dQ^2|_{Q^2=0} = -3.119\ \mathrm{GeV}^{-2}$. As a consequence of this mistake, the numerical values of charge radius in the horizontal axes of Figs. 3 and 4 of Ref. [2] increase by about 0.02 fm, whereas the shapes of the curves stay almost the same. The effect of this mistake on the calculation of neutron star radius and mass is trivial, because in this case we only need to see the effect of nucleon radius variation on the neutron star radius and mass.

As a conclusion, the proton radius extracted from the nonidentical protons assumption should be 0.853 fm, instead of 0.833 fm. This result is still smaller than the standard CODATA value [4], i.e., $r_E = 0.8768(69)$ fm, but larger than the the new muonic hydrogen atom measurement, i.e., $r_E = 0.84184(67)$ fm [5].

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