Cutting with Occam's razor

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Abstract

We comment positively on the recent article “Seesaw mechanism with Occam's razor” [K. Harigaya, M. Ibe, and T. T. Yanagida, Phys. Rev. D **86**, 013002 (2012)] by Harigaya, Ibe, and Yanagida. In this article, the authors are using the principle of Occam's razor in neutrino physics – a principle that should be applied more often in science in general. At the end, we also discuss the Bayesian method in statistics, in which Occam's razor is naturally built in.

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In July this year, K. Harigaya et al. published an interesting research article [1] in *Physical Review D* in which they used the fundamental principle of Occam’s razor to reduce the number of physical parameters in the so-called seesaw mechanism [2–5] for neutrino mass models. One of the authors is T. Yanagida, who was one of the inventors of the seesaw mechanism that to date gives presumably the best explanation for the smallness of neutrino masses in comparison to the masses of the other particles in the Standard Model of particle physics. It should be mentioned that Occam’s razor has also been discussed in some detail in a recent review [6], although from a different and more general perspective than the one by Harigaya et al.

In the article by Harigaya et al., which was also presented in a plenary talk by Yanagida at the conference “Neutrino 2012” in Kyoto, Japan earlier this year, the authors predict an inverted ordering of the neutrino masses, a value of around 50 meV for the so-called effective Majorana neutrino mass, and a maximal value for the leptonic CP-violating phase that is important for the matter-antimatter asymmetry in the Universe. All three quantities are fundamental parameters in neutrino physics and still unknown, since they have not yet been experimentally determined.

Future neutrino experiments will show if the three predictions are true, but the idea is praiseworthy. The philosophical principle of Occam’s razor is a good principle, since it urges one to select among models making the fewest assumptions and therefore offering the simplest description, and it should be used more often in science, and especially, in modeling of physics.

Nevertheless, when comparing two models, it may not always be completely clear which of the two models that is the simpler one. Normally, the model with least number of free parameters is considered to be the simplest. In statistics, the so-called Bayesian method, in which Occam’s razor is naturally built in, offers a rigorous way to determine which of the two models is to be selected [7]. Using this method, the simpler model will be chosen even if it fits data somewhat worse, and the more complex model will only be preferred if it fits data significantly better. Thus, comparing the Bayesian and frequentist (“traditional”) method of statistics, it could be favorable to use the Bayesian method, since Occam’s razor is generically embodied in this method.

Finally, it should be pointed out that the so-called Occam factor, originating from the volume of parameter space, penalizes models with more parameters [8, 9] and is dependent

on the chosen metric in the parameter space – the prior – which is often the result of a subjective evaluation by an “expert”. Therefore, the model selection can be influenced by the choice of prior. In practice, this is a perspective that makes the usage of the Bayesian method somewhat less appealing. Especially, this is the case when little or nothing is known about the parameter space of the model under consideration.

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