

November 29, 2012

Recommendation letter for Daniel Wegman

Dear Colleague:

This is a letter of support for the application of Mr. Daniel Wegman for a postdoctoral position in your group. He is a fifth-year graduate student in high energy theory under my supervision. His area of research is in electroweak extensions of the standard model, both in the gauge and Higgs sectors, with applications to neutrino mixing as well as dark matter. In the past two years, we have completed four papers. Three are published and one is on the arXiv.

(1) Phys. Rev. D 83, 093012 (2011) deals with multi-Higgs realizations of flavor symmetries (such as A_4 , T_7 and $\Delta(27)$) which leave a residual Z_3 symmetry in the charged-lepton sector (lepton flavor triality). Assigning $1, \omega^2, \omega$ to e, μ, τ where $\omega = e^{2\pi i/3}$, this Z_3 symmetry allows the decays $\tau^+ \rightarrow \mu^+ \mu^+ e^-$ and $\tau^+ \rightarrow e^+ e^+ \mu^-$ through exotic scalar particles but no others. If these exotic scalar particles are produced at the LHC, then their decays will also be to different charged leptons, which are excellent signatures. Whereas their direct production cross section is not large, they may be decay products of the standard-model Higgs boson if kinematically allowed. We studied in detail how this may occur at the LHC. With the present information of the observed 126 GeV particle, such low-mass exotic scalars are excluded, but they may still exist with greater masses and be searched for with increased luminosity of the LHC.

(2) Phys. Rev. Lett. 107, 061803 (2011) deals with nonzero θ_{13} in the original A_4 model. In the wake of the first evidence from T2K that θ_{13} is nonzero and rather large, it was shown in this Letter that the original A_4 proposal (Ma, Phys. Rev. D 70, 031901 (2004)) for tribimaximal mixing also discussed how nonzero θ_{13} may occur. This Letter is a detailed study of that proposal. It was pointed out that tribimaximal mixing has always been a theoretical headache, because it requires a vacuum alignment which is only achievable with many extra assumptions involving many new symmetries and particles. It is actually much more natural to have nonzero θ_{13} , with near maximal $\nu_\mu - \nu_\tau$ mixing maintained by A_4 .

(3) Phys. Rev. D 85, 055008 (2012) deals with an unusual candidate for dark matter which is actually a neutral vector gauge boson. It is motivated by a particular realization of E_6 superstring models, known already 25 years ago. The standard model is extended to $SU(3)_C \times SU(2)_L \times SU(2)_N \times U(1)$, where the $X_{1,2,3}$ gauge bosons of $SU(2)_N$ are neutral. They couple to the $SU(2)_N$ doublet $(d, h)_R$, where h has the generalized lepton number $L = -1$ and thus odd R parity. So the gauge bosons $X_{1,2}$ also have odd R and the lighter one, say X_1 , is a dark-matter candidate. The phenomenology of this model at the LHC is very interesting. The process $d + gluon \rightarrow h + X_1$ is available at the LHC, with the signature of one quark jet + missing energy + $l_i^+ l_j^-$. We identified a region of parameter space for such a discovery with perhaps only 10 fb^{-1} of LHC data at 14 TeV.

(4) arXiv:1210.6936 deals with the application of the non-Abelian discrete symmetry D_7 to both quarks and leptons. It shows that the Dirac CP phase of the CKM matrix may be predicted successfully from the knowledge of the other mixing angles and the three quark masses in the *down* sector. It also shows that the neutrino mass matrix may be of the form with two texture zeros conjectured some years ago. This is now very suitable to understand nonzero θ_{13} and we obtain predictions of the Dirac CP phase here as a function of θ_{23} .

From the above, it can be seen that Daniel has learned all the necessary skills to be a successful phenomenologist and practiced at the forefront of research in neutrino physics, dark matter and collider physics. He is versatile in all the analytical tools and programming skills expected of an experienced researcher in this field. To broaden his knowledge, I have sent him to two theory institutes (in Buenos Aires and in Boulder) where he attended lectures on a variety of subjects and interacted with the lecturers and participants. In my discussions with him, he has also demonstrated independence and originality in a number of ideas. He is naturally inquisitive and not afraid to ask questions. I am sure that he will prosper and contribute his share as a postdoctoral researcher at your institute. Please give him your most serious consideration. I recommend him to you very highly.

Best regards,

Ernest Ma, Professor of Physics
University of California, Riverside