

# हरीश-चन्द्र अनुसंधान संस्थान

(परमाणु ऊर्जा विभाग, भारत सरकार)

छतनाग मार्ग, झुंसी, इलाहाबाद-210 019 (भारत)

## Harish-Chandra Research Institute

(Department of Atomic Energy, Government of India)  
Chhatnag Road, Jhansi, Allahabad-211 019 (INDIA)



ई-मेल E-mail : root@mri.ernet.in

फैक्स Fax : (91)-532-2569576, 2567444

पत्रांक : एच.आर.आई No. HRI/

दिनांक Date Oct 26, 2012

*Prof. Raj Gandhi*

### Recommendation letter for Atri Bhattacharya, post-doctoral fellowship applicant.

I am happy to write in very strong support of Atri Bhattacharya, who will be finishing his Ph.D under my supervision in 2013, and who is applying to your group for a post-doctoral position.

Atri's strong points are his breadth and versatility. He has a solid grounding in particle physics and field theory, based on strong course-work at HRI and independent semester long study projects on the topics of Higgs physics, Leptogenesis, Dark Matter, Current algebras and Anomaly cancellation. In addition, on his own, he has developed very impressive computer skills in C and C++, is familiar with Globes and other packages, and is the person people consult when stuck with any soft-ware issues in their work.

All of this is in addition to his solid knowledge of Neutrino Physics. While much of his work has been on Ultra-High Energy Neutrinos, he is adept at standard low-energy oscillation physics as well. At one point, prior to the  $\theta_{13}$  reactor results, we spent time on studying long baseline oscillations for small and zero  $\theta_{13}$ , and Atri learnt how to use Mark Messier's NuMI flux code and to employ it in conjunction with GLOBES for our calculations. (It was unfortunate that just as we were finishing our work, experiments ruled that  $\theta_{13}$  was large and close to the CHOOZ upper bound.)

Atri's first two papers during his PhD (PLB690, (2010), 42-47 and JCAP 1009(210) 009) study the spectral distortions of diffuse UHE Neutrino fluxes due to physics beyond the standard model as they propagate to earth. We explored the interplay between (i) oscillations, which work to smooth out and reduce spectral differences between flavours, if any, at the source, and (ii) new physics effects during propagation, like Lorentz violation, CP and CPT violation, quantum decoherence the presence of pseudo-Dirac effects and of neutrino decay. We studied how these would modify both the Waxman-Bahcall bound and the spectral nature of diffuse fluxes for various flavors. Also studied were the effects of the mass-hierarchy, the value of the CP phase and the variation over the range of  $\theta_{13}$ . We calculated both the shower and muon-track event in Ice cube for various scenarios.

In two subsequent papers, (**JCAP 1110(2011) 017** and **arXiv 1209.2422**) we have explored the potential of the Glashow resonance (GR) as a discovery tool for UHE neutrinos. The GR cross-sections in the range  $\sim 3\text{-}10$  PeV are very significant. Specifically, at resonance ( $\sim 6$  PeV), the total anti-neutrino-electron cross-section is about 350 times the standard neutrino-nucleon total charged-current cross-section. This makes the GR an important tool for detecting UHE events in this range. We also identified a unique, background free signature of the GR, a single isolated muon un-accompanied by the shown activity.

In another paper (**arXiv: 1109.1832**) which we are about to submit, we re-visited the consequence of CPT invariance and unitarity explored in the Weinberg-Nanopoulos theorem. By systematically expanding the S-matrix order-by order in B(or L) violating couplings, we found a re-formulation of the theorem whereby certain consistent schemes of B (or L) number assignment lead to the presence of both B (or L) conserving and B (or L) violating decay modes of heavy particles. In such schemes, the net CP violation can be non-zero even with graphs to first-order in B (or L) violation, without actually violating the theorem.

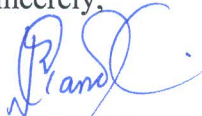
At present Atri, along with two of my other students, is working on a full- fledged atmospheric neutrino code in C++, with full marginalization and chi-squared analysis for a variety of detector choices.

In all of the above work, Atri's contribution has been very significant. He has been a mentor and leader for his juniors and they look up to him for clarity and discussion. He is quiet by nature, thorough in what he does, and tends to speak only after he has understood the physics of any issue under discussion. He is pleasant and easy to interact with. He has played a very helpful role organizing our series of annual conferences, Nu HoRIzons.

Atri would be a very useful addition to any particle physics group. I rate him as one of the best students HRI has had in recent years. The group will miss him once he leaves.

I wish him all success and recommend him very strongly.

Sincerely,



(Raj Gandhi)  
Professor of Physics  
HRI, Allahabad