SUMMARY OF THE ROUND TABLE ON EXPERIMENTAL PROSPECTS FOR NEUTRINO OSCILLATION SEARCHES

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ABSTRACT

The Round Table discussion showed that the prospects for future advances in understanding neutrino oscillations are excellent. Many imaginative ideas for new experiments which will clarify the existing evidence for oscillations were presented.

1. Summary

We have had a Round Table discussion with contributions from the panel members, as well as participants in this Neutrino Telescopes Symposium, which makes two things very clear: (1) The phenomenon of neutrino oscillations is far from being understood; and (2) many years of hard, but exciting, physics lie ahead of us in order to resolve the outstanding issues.

1.1. LSND

Perhaps the first issue we would like to see resolved is that of the LSND signal. If this signal is real what of the solar neutrino problem? Will we need to bring in the unpleasant sterile neutrino? The Karmen experiment so far does not see this signal, but it may be too short on sensitivity to provide a conclusive check on LSND. However, two new proposals, MINIBooNE/BooNE at Fermilab and I216 at CERN, described here by Dore and Palladino, promise to resolve this definitively within a few years. We need at least one, preferably both, of these experiments to be done.

1.2. Atmospheric Neutrinos

Perhaps the strongest evidence for the existence of neutrino oscillations comes from the recent atmospheric neutrino results reported by Superkamiokande and Soudan 2, supported by the older Kamiokande and IMB data as well as new results on upgoing muons from Superkamiokande, MACRO and a reanalysis of IMB (though we note that BAKSAN, in a new analysis,does not see this effect). Where do we go from here? Whereas the water Čerenkov Superkamiokande accumulates large statistics, it does not have a particularly good resolution for pointing in the neutrino direction and therefore does not determine L well on an event by event basis. On the other hand Soudan2, a 1 kton iron calorimeter, has rather good pointing for its"high resolution" events, but suffers from low statistics. We have heard impressive proposals for new atmospheric neutrino experiments. Declais described to us a proposal for an iron calorimeter detector at Gran Sasso that would have resolution like Soudan 2 and mass comparable to Superkamiokande. This should narrow down the range of the oscillation parameters considerably. From A. Rubbia we heard the proposal for a 30 kton ICARUS detector at Gran Sasso. Such a detector would have still better resolution and also a Superkamiokande mass. Learned described to us the NEUTRINO EYE proposal, a supermassive water Čerenkov detector ($\sim$ 1 Megaton) with "eye-glasses", based on the AQUARICH proposal of Ypsilantis et.al. NEUTRINO EYE and AQUARICH would make it possible to extend the Δm^2 region of accessibility down to a few times $10^{-4} eV^2$. The ICARUS and water Čerenkov detectors would also have the capability of observing astrophysical neutrinos. Interesting new phenomena in atmospheric neutrinos that might be observed in these new detectors are discussed in Mikheyev's contribution.

1.3. Long Baseline Experiments

But further confirmation of the atmospheric neutrino effect by more atmospheric neutrino experiments is not satisfying enough. We want independent confirmation in controlled accelerator experiments. This is the aim of the long baseline experiments. There are two approaches - the disappearance and the appearance experiments. The disappearance experiment is typified by the NUMI/MINOS proposal described by Bernstein. The baseline is 730 km. and the reach is down to Δm^2 a few times $10^{-3} eV^2$. This is now an approved experiment at Fermilab with the beginning of construction imminent, and data taking scheduled to begin in early 2003. A similar experiment in the proposed higher resolution 30 kton ICARUS detector in the proposed NGS beam (CERN-Gran Sasso) was described by A. Rubbia. But for now all eyes are on the 250 km baseline K2K experiment in Japan described by Sobel. Although K2K does not have the reach of MINOS, it should easily see the disappearance effect if Δm^2 is in the range $10^{-2} eV^2$. First results may be available even before the new millenium!

The appearance experiments proposed are based on the nuclear emulsion type of detector described by Niwa in his talk, and assume that the atmospheric effect is due to $\nu_\mu \rightarrow \nu_\tau$ oscillations. Ereditato described in detail the OPERA proposal for an experiment in the NGS beam. There is a similar proposal by the MINOS group for such a detector at the Soudan mine in the NUMI beam. These experiments would prove conclusively the $\nu_\mu \rightarrow \nu_\tau$ mode of oscillation if Δm^2 is in the suggested Superkamiokande range. How well they could determine oscillation parameters is still not clear. We were told by Niwa that new advances in emulsion production methods bring down the costs of these 1 kton detectors to reasonable figures.

A detailed comparison of the NUMI and NGS beams was presented by Palladino. The indications are that the NUMI beam is somewhat better, perhaps a factor of two in event rate, particularly at low energies, where Superkamiokande indicates the oscillation effects will be at a maximum. But the NGS beam is also capable of allowing the proposed experiments to achieve a good sensitivity.

Given the high cost of constructing new neutrino beams, the question is raised whether the world neutrino community should support two of them, or build one (the already underway and somewhat superior NUMI beam) and combine forces to build the best possible detectors. At the same time the Gran Sasso laboratory could concentrate on the new massive atmospheric and astrophysical neutrino detectors.

1.4. Solar and Reactor Neutrinos

The oscillation interpretation of the solar neutrino problem has become more enigmatic and therefore more exciting with the latest reports from Superkamiokande. Only a few months ago we all believed that the favored solution was that of the MSW low mixing angle. Now we are told the data favor the MSW large mixing angle solution or the vacuum oscillation solution. This suddenly makes the KAMLAND and BOREXINO experiments, which propose to simultaneously detect neutrinos from many reactors, of unusual interest. We have the chance to test the solar neutrino effect in a terrestrial experiment! Suzuki described these experiments in some detail and showed how they could reach the Δm^2 range of $10^{-(4-5)} eV^2$ suggested for the MSW large mixing angle solution. He also discussed the prospects for observing the small angle and vacuum oscillation regions in these detectors using the solar Be^7 neutrinos. Even before then we may hope to have confirmation from SNO that the solar neutrino problem is indeed explained by oscillations. In the farther future we look forward to the crucial observations on the solar pp spectrum which could be achieved by experiments such as HELLAZ and HERON.

1.5. Muon Colliders-the Longer Term Future

For the longer term future we heard about the incredibly intense neutrino beams that could be produced by the proposed muon colliders. Palladino described in detail the properties of a proposed European muon collider and Cline told us the status of the work in progress in the United States. That at least one such machine will be built is looking very promising. The neutrino experiments that these machines will make possible at near distances will indeed be impressive. As John Learned pointed out, there will be many important neutrino questions still to be answered. Can we see CP violation? Can we improve direct mass measurements? And shall we be turning to the phenomena associated wuth astrophysical neutrinos?

2. Conclusion

The frequency of neutrino workshops has undergone a dramatic increase in the last few years. If all of the proposals discussed in this Round Table on experimental prospects, or a good part of them, come to fruition, then we may expect to see a dramatic decrease coming about somewhere in the neighborhood of 2015 - but don't count on it!

3. Acknowledgements

Among the many neutrino workshops Neutrino Telescopes has always been among the most stimulating - for its content, its magnificent setting, and the wonderful hospitality. We are truly grateful to Milla Baldo Ceolin and her staff for that.