CF6 Charge

J. Beatty, A. Nelson, A. Olinto

- Interactions Beyond Laboratory Energies
- The Matter of the Cosmological Asymmetry
- Cosmic Particles as Probes of Fundamental Symmetries and New Particles
- Neutrino Physics from Astrophysics
- Exploring the Basic Nature of Space and Time

Physics of Interactions beyond Laboratory Energies

Observations of cosmic rays with energies above 100 EeV allow the study of hadronic interactions at center of mass energies beyond 100 TeV. High energy neutrinos produced in the interactions of ultrahigh energy cosmic rays with cosmic backgrounds or in the environments where particle acceleration is taking place also give an opportunity to probe neutrino interactions at energies well above laboratory experiments. Interpretation of these data is complicated by the uncertainty in the composition of the highest energy cosmic rays, as well as their low flux. Extracting the underlying particle physics from these data requires a comprehensive approach spanning astrophysics as well as particle and nuclear physics.

Survey what we may expect to learn about particle physics beyond LHC energies from observations of high energy cosmic rays, photons, and neutrinos. Survey ongoing, planed, and proposed experiments of ultrahigh energy cosmic rays such as Auger, Telescope Array, and JEM-EUSO, very high to ultrahigh energy neutrinos such as IceCube, ANTARES, ANITA, ARA, ARIANNA, and KM3NeT, and high to very high energy gamma-rays such as Fermi, VERITAS, MAGIC,HESS, HAWC, and CTA.

The Matter of the Cosmological Asymmetry

The cosmological asymmetry between baryons and anti baryons is one of the strongest pieces of evidence for physics beyond the standard model. There are diverse theoretical proposals for new physics at a range of energy scales, most of which include new sources of CP violation, and either additional baryon or lepton number violation. There are plausible theories with implications for experiments at all three frontiers. Leptogenesis theories predict new CP violation in the neutrino sector. Grand Unified theories predict proton decay. Electroweak baryogenesis models predict a cosmological phase transition which leaves traces in gravitational wave and CMB experiments, and new collider physics at or below a TeV.

Survey what we may expect to learn about the origin of matter from searches at ongoing, planned and proposed facilities such as the LHC, ILC, CLIC, muon collider, B-factories, neutrino experiments, gravitational wave experiments and CMB experiments.

Cosmic Particles as Probes of Fundamental Symmetries and New particles.

The propagation and detection of cosmic rays, gamma-rays, and neutrinos also involve well-understood interactions at extreme relativistic boosts, a large range of energies, and access to possible rare production sites. This offers an opportunity to test Lorentz invariance and other fundamental symmetries as well as to probe rare particles that may be present at very low abundances, such as strangelets and anti-nuclei.

Survey what constraints can be placed on Lorentz invariance violation and violation of other fundamental symmetries and conservation laws through observations of high energy cosmic rays, photons, and neutrinos, and ongoing searches for exotic particles in cosmic rays. Survey ongoing, planed, and proposed experiments such as cosmic ray observatories AMS, CALET, Auger, Telescope Array, and JEM-EUSO, very high to ultrahigh energy neutrinos such as IceCube, ANTARES, ARA, ARIANNA, ANITA, and KM3NeT, and high to very high energy gamma-rays such as Fermi, VERITAS, MAGIC,HESS, HAWC, and CTA.

Neutrino Physics from Astrophysics

Cosmological and astrophysical studies of neutrino interactions allow physics probes of wide range of neutrino number of flavors, masses, and mixing angles not accessible to laboratory experiments. These include solar neutrinos, supernova neutrinos, Big Bang nucleosynthesis and CMB constraints on neutrino parameters.

Survey what we may expect to learn about neutrinos umber of flavors, masses, and mixing angles through cosmic neutrinos from theory and ongoing, planned and proposed studies, solar neutrino experiments, supernova neutrino experiments, BBN constraints, CMB constraints. Examples of relevant experiments include Borexino, Super-Kamiokande, SNO+, LENA, and Hyper Kamiokande.

Exploring the basic nature of space and time

Space and time may be quantized at the Planck scale. Effects from this extremely high energy realm may be studied through gravitational waves from the early universe and holographic noise.

Survey what we may expect to learn about the GUT and Planck energy scale with gravitational waves and holographic noise. Survey the theory and ongoing, planned, and proposed gravitational wave and holographic noise experiments. Examples of relevant experiments include the Holometer, LIGO, LISA, and CMB probes of early universe gravitational wave (covered in Dark Energy and CMB.

- Breakout session to refine charge, discuss needed mini-white papers, and plan way forward.