

NF04: Neutrinos from Natural Sources

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NF04 Scope

Our scope:

- The physics that is accessible with neutrinos from natural sources
 - Solar neutrinos
 - Geoneutrinos
 - Supernova neutrinos (including diffuse supernova neutrinos)
 - Atmospheric neutrinos
 - Extragalactic/high energy neutrinos
 - Early universe neutrinos
- The experiments that can address it, including benefits of different technology

Not our scope, but some overlap / synergy:

- Detector technology (NF10)
- Development of the theory (NF08, TF11)
- Cross section measurements (NF06)
- Experimental anomalies (NF02)
- Reactor neutrinos (NF09)
- BSM (NF04)
- Cosmic probes of fundamental physics (CF07)

NF04 Strategy

- Organize report based on 6 sub-group areas, and the relevant LOIs received
 - Solar: 26
 - Geo: 9
 - Supernova: 28
 - Atmospheric: 16
 - Extragalactic/high energy: 23
 - Early universe: 3
- For each topic:
 - Theory overview and open questions
 - Current status of the field
 - Prospects for future measurements
- Benefit from a number of recent review articles
- Appreciate notification of planned white papers
- Balance of sections driven by LOIs / WPs received, to reflect community interest

Solar neutrinos

Included:

- Overview of open questions
- Overview of current state of the art
- Most detail on experimental prospects, broken down by technology

Not included:

- Nuclear xsec measurements (NF06)
- Detector developments (NF10)

4	Solar Neutrinos - Gabriel	3
4.1	Motivation	3
4.2	Current understanding	3
4.3	Water Cherenkov detectors	5
4.3.1	Super Kamiokande	5
4.3.2	Hyper Kamiokande	5
4.4	Liquid scintillator detectors	5
4.4.1	SNO+	5
4.4.2	JUNO	6
4.4.3	LiquidO	6
4.5	Hybrid optical detectors	6
4.5.1	Slow fluors	7
4.5.2	THEIA	7
4.5.3	Jinping	7
4.6	Noble liquid and solid state detectors	8
4.6.1	Nuclear recoil detectors	8
4.6.2	Liquid xenon	8
4.6.3	Liquid argon TPCs	9
4.6.4	Selena	9
4.7	Other concepts	9
4.7.1	High energy solar neutrinos	9
4.7.2	Neutrino detector spacecraft	10

Geoneutrinos

Included:

- Overview of open questions
- Overview of current state of the art
- Most detail on experimental prospects, broken down by technology

Not included:

- Detector developments (NF10)

7	Geoneutrinos - Gabriel	<u>13</u>
7.1	Motivation	<u>13</u>
7.2	Current understanding: Borexino and KamLAND	<u>13</u>
7.3	Prospects for future measurements	<u>14</u>
7.3.1	SNO+	<u>14</u>
7.3.2	JUNO	<u>15</u>
7.3.3	Ocean Bottom Detector (OBD)	<u>15</u>
7.3.4	THEIA	<u>15</u>
7.3.5	Jinping	<u>15</u>
7.3.6	LiquidO	<u>16</u>
7.3.7	Coherent neutrino-nucleus scattering	<u>16</u>
7.3.8	⁶ Li-doped scintillator	<u>16</u>

Supernova neutrinos

- Current understanding
 - Neutrinos as probes of the stellar collapse and multi-messenger detection prospects
 - Neutrino flavor mixing in supernovae
 - DSNB modeling
 - Overview on existing detectors
- Future prospects
 - Improved modeling of flavor mixing, supernova physics, robust predictions of detectable features
 - Improved modeling of BSM scenarios
 - Pinning down DSNB uncertainties
 - New detectors will give more opportunities to disentangle flavors (electron neutrinos, detectors sensitive to NC reactions)
 - Pushing the detection horizon to Andromeda and potential first measurements of the DSNB
 - Emphasis on the complementarity of technologies and messengers - we want to capitalize on this rare event

Atmospheric neutrinos

- Current understanding:
 - Status of neutrino oscillations
 - Three flavor oscillation: parameters sensitive to atmospheric neutrinos.
 - Sterile neutrino search
 - Atmospheric neutrino flux measurements
 - Experiments : mainly from Super-K, IceCube, ANTARES
- Future prospects:
 - Atmospheric neutrino flux prediction (including related beam experiments)
 - Future sensitivity for neutrino oscillation parameters
 - Other topics, tau-neutrino cc cross section, exotic scenario
 - Experiments : mainly from Super-K, Hyper-K, IceCube, DUNE, CEvNS

High energy astrophysical neutrinos

- Current understanding:
 - **What are the sources?** Generally what environments produce these neutrinos, and then discussion on first identified candidate sources
 - **What experiments measure this?** IceCube and the near future prospects: KM3NeT, Baikal-GVD, P-ONE. For radio, ANITA, ARA, ARIANNA and near future RNO-G.
 - **What knowledge have we gained in particle physics and astro?** Cross sections, Glashow, astro environments
- Future prospects (mainly using the whitepaper “HE and UHE neutrinos” edited by Ackermann, Bustamante, Lu, Otte, Reno, and Wissel):
 - **optical, radio, radar detectors:** in-ice, balloon, satellite, lunar, earth-skimming, RET
 - **new reaches for particle physics and astro:** opportunities for observing new physics, dark matter, W-boson production

Early universe

- Current understanding
 - Cosmic neutrino background (CnuB)
 - Exploring neutrino properties through cosmological data (neutrino masses, N_{eff})
 - New Physics scenarios
- Future prospects
 - Measurement of absolute neutrino mass through CMB-Stage 4 surveys
 - Improved modeling of neutrino mixing and BSM scenarios
 - Detection of CnuB with PTOLEMY

Plans moving forward

- Will release initial draft of our topical group report ahead of the neutrino frontier meeting
- Plan for time at the NF meeting (March 16-18) to get feedback from the community
- Coordination with other topical groups where there is overlap

Back up

NF04 Topics

This topical group covers neutrino detection from all natural sources, including the Earth and astrophysical sources, as well as modeling of neutrino physics in these sources. Specific topics include (LOIs received):

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https://snowmass21.org/neutrino/natural_sources/start