Laboratori Nazionali del Gran Sasso

New results on geo-neutrinos from Borexino at Gran Sasso Laboratory of INFN

Borexino at the underground INFN Gran Sasso Laboratory, Italy, in the spotlight for a new geo-neutrino measurement.

Borexino is a liquid scintillator detector mainly built for solar neutrino searches. Due to its high level of radiopurity, a worldwide record, Borexino can also detect rare events such as electron-antineutrinos from the interior of the Earth, namely geo-neutrinos.

Geo-neutrinos are electron anti-neutrinos produced in beta decays of long-lived radioactive elements (^{40}K, ^{238}U and ^{232}Th) in the Earth. Electron anti-neutrinos are detected by searching for their interactions on protons in massive organic liquid scintillators. These neutrinos have already been observed in underground laboratories by Borexino at Gran Sasso, Italy, and KamLAND in the Kamioka mine, Japan.

By measuring the geo-neutrino flux on surface the contribution of radioactive elements to the Earth's heat budget can be explored. The radiogenic heat is of high interest to help understanding a number of geophysical processes such as mantle convection and plate tectonics

Today the Borexino International Collaboration has released results from a new measurement with 2.4 times higher exposure with respect to 2010, corresponding to 1352.60 live days and about 187 tons of liquid scintillator after all selection criteria have been applied (3.7×10^{31} proton×year).

In the data collected, 46 electron anti-neutrino candidates have been selected with about 30% of geo-neutrinos contribution. Together with geo-neutrinos Borexino has detected electron anti-neutrinos from nuclear power plants from all over the World. These latter neutrinos give a signal of about 31 events well in agreement with what expected from 446 nuclear cores operating in the period of interest, from December 2007 to August 2012, and with our present knowledge of the parameters of neutrino oscillations. In Borexino the total expected background for electron anti-neutrinos is determined to be of about 0.7 events. The very small background is due to the high level of radiopurity reached in the Borexino liquid scintillator.

For the present measurement the null geo-neutrino hypothesis has a probability of 6×10^{-6}.

Geo-neutrinos detection offers a unique tool to probe the uranium and thorium abundances within the mantle. By considering the contribution from the local (around the Gran Sasso region) and the rest of the crust to the geo-neutrino signal, the signal due to the radioactivity of uranium and thorium in the mantle can be extracted. The present results from Borexino together with the measurement by KamLAND give an indication for the signal from the mantle, $S_{mantle} = 14.1\pm8.1$ TNU (1 TNU = 1 event/year/10^{32} protons).

The new results from Borexino mark a breakthrough for the Earth Sciences and in particular for the comprehension of the origin and thermal evolution of the Earth. The good agreement of the Th/U ratio between geoneutrino signals and the chondritic value has fundamental implications on the cosmochemical models and on the planetary formation processes in the early Solar System.

The origin of the terrestrial heat is a missing piece of knowledge for the full comprehension of mantle convection which drives plate tectonics and thus earthquakes. For the first time two independent geo-neutrino detectors (Borexino and KamLAND) placed in different sites around the planet (Italy and Japan) give the same constraints on radiogenic heat power of the Earth due to the decays of U and Th. The multisite probing of the Earth's interior with geoneutrinos is now a reality which can unveil new constrains on radioactivity content of the mantle, Bulk Silicate Earth models and geo-reactors.

Prof. Giampaolo Bellini (INFN and University of Milan), the former Borexino spokesperson, said: "These new Borexino results confirm the strong potentiality of the geoneutrinos as unique probes: through geoneutrinos we have the important chance to understand the Earth thermal power and what happens below the crust. But not only. The comparison between the relative abundance of the radioactive elements within the Earth and the chondritic ratio can enlighten on the structure of the Solar planets.

Borexino experiment will continue to accumulate data opening further possible achievements. We hope that also the Kamland experiment will release new data and that other experiments can reach such sensitivity and radiopurity levels to allow the study of the geoneutrinos also in different geological sites of the Earth".

Further reading:

[1] G. Bellini et al, (Borexino Collaboration), Phys. Lett. B 687 (2010) 299.

[2] A. Gando et al. (KamLAND Collaboration), Nature Geoscience 4 (2011) 647.

[3] G. Fiorentini et al., Phys. Rev. D 86 (2012) 033004.

[4] S.T. Dye et al., Earth Moon Planets 99 (2006) 241.

[5] G. Bellini et al, (Borexino Collaboration), Physical Review Letters 108, 051302 (2012)

[6] G. Bellini et al, (Borexino Collaboration), Physical Review Letters 107, 141302 (2011)

Dissemination of the results

1. Gemma Testera at Neutrino Telescope, Venice March 12th, 2013

2. Yury Suvorov at Gran Sasso Laboratory, March 13th , 2013

3. Sandra Zavatarelli at Neutrino Geoscience, Takayama, Japan March 21st, 2013

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