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Precision measurement of the ^{7}Be solar neutrino rate and absence of day-night asymmetry in Borexino

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Summary. — Borexino, in data taking since May 2007, is the only experiment capable to perform the measurement of low-energy solar-ν. Borexino has performed the first direct measurement of the ^{7}Be solar-ν rate with accuracy better than 5%. The absence of day-night asymmetry of the ^{7}Be solar-ν rate was measured with a total uncertainty of 1%. Borexino results alone reject the Low Δm^2 (LOW) region of solar-ν oscillation parameters at more than 8.5 σ CL. Combined with the other solar-ν data, Borexino measurements isolate the Large Mixing Angle (LMA)-Mikheyev Smirnov Wolfenstein (MSW) solution of neutrino oscillations without assuming CPT invariance in the neutrino sector.

PACS 26.65.+t – Solar neutrinos.
PACS 14.60.Pq – Neutrino mass and mixing.

1. – Introduction

Thanks to its unprecedented low level of radioactive contamination, Borexino is the only running experiment able to detect solar-ν of energy below 1 MeV. The motivating goal of low-energy solar-ν detection experiments is to directly probe the mechanisms of nuclear energy generation in the Sun and the properties of neutrinos, such as neutrino mixing and oscillations. The main goal of Borexino is the measurement of the 862 keV ^{7}Be solar-ν rate. This measure can be used to probe the transition from vacuum-dominated to matter-enhanced oscillation regimes.

2. – ^{7}Be solar neutrino rate measurements

The Borexino detector [1], in data-taking at the Gran Sasso underground Laboratories (LNGS), is an unsegmented liquid scintillator featuring 300 tonnes of sensitive mass, viewed by 2200 photomultipliers, for the detection of the energy released by the ν-induced electrons recoil. An outermost water shielding is serving as a veto for muons, the only significant residual cosmic background at the 3800 mwe depth of LNGS [2]. The ^{7}Be solar-ν rate is obtained fitting the energy spectrum of the events selected in the fiducial volume. Both the contribution of signal (^{7}Be ν), radioactive (^{85}Kr, ^{210}Bi, ^{210}Po) and

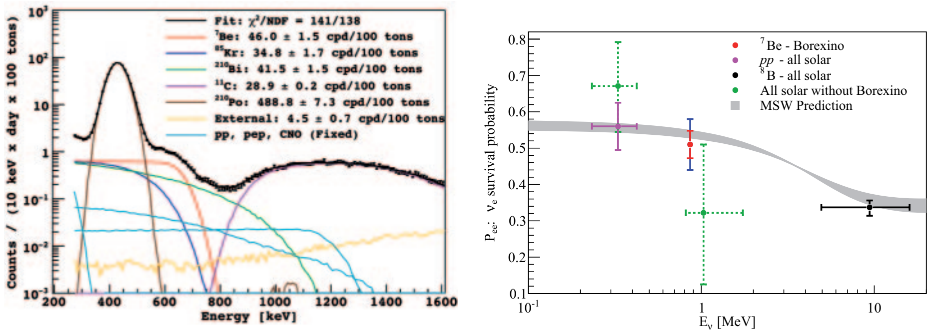

Fig. 1. – *Left*: Energy spectrum after background removal for the ^{7}Be neutrino analysis. Results of fitting procedure are also shown. *Right*: Measurement and predictions for the solar-$\nu_e P_{ee}$.

cosmogenic (^{11}C) backgrounds are included. The events are selected rejecting muons, fast cosmogenic muon daughters, radioactive decay fast coincidences and electronic noise, and requiring the reconstructed event position to be within 3.02 m radius in order to reduce external γ background. The energy spectra are modeled through a Monte Carlo (MC) simulation of all the processes in the detector, including particle energy loss, scintillation and Cherenkov light generation, propagation and detection, and the response of Borexino electronics. The physical models and parameters of the MC have been tuned using detector calibrations data. After the tuning, the energy scale and resolution of events in the analysis fiducial volume are simulated with an accuracy of 1.5%.

Our measurement for the interaction rate of ^{7}Be solar ν is $46 \pm 1.5_{\rm stat} \pm 1.6_{\rm syst}$ c/d/100t [3]. The expected signal for non-oscillating solar ν_e is 74 ± 5 c/d/100 t. The no-oscillation hypotesis is rejected at 4.9σ CL. This result permits a precise determination of P_{ee} for solar ν_e in vacuum and probe the transition between the matter-enhanced and vacuum-dominated oscillation regimes. The meausured value for the day-night asymmetry of the ^{7}Be solar-ν rate is $A_{dn} = 0.001 \pm 0.012_{\rm stat} \pm 0.007_{\rm syst}$ [4]. This result alone rejects the LOW region of neutrino oscillations parameters at more than 8.5σ CL. Combined with the other solar-ν data, Borexino results [3-5] isolate the LMA-MSW solution without including data from the KamLAND $\bar{\nu}_e$ reactor experiment in a combined fit, *i.e.* without relying on the assumption of CPT invariance in the neutrino sector.

3. – Conclusions

The high-precision measurement of the ^{7}Be solar-ν rate probes and validates solar neutrino oscillations in the transition region. Borexino measurements single out the LMA region of neutrino oscillation parameter space at 8.5σ without assuming CPT invariance. The independent determination of the LMA solution obtained by Borexino with solar-ν only is reinforcing the consistency of our understanding of neutrino oscillations.

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