Recent Results and Future Prospects of the South Pole Acoustic Test Setup

R. Nahnhauer for the IceCube Collaboration

Deutsches Elektronen-Synchrotron, (DESY), Platanenallee 6, D-15738 Zeuthen, Germany

Abstract

The South Pole Acoustic Test Setup - SPATS - was built to measure the acoustic properties of Antarctic ice versus depth. Corresponding results are presented for the sound speed, the acoustic attenuation length and the noise level present at the Pole.

Keywords: acoustic neutrino detection, sound speed, acoustic attenuation, noise-level

The feasibility and specific design of an acoustic sensor array as part of a large volume ultra high energy neutrino detector at the South Pole depends strongly on the acoustic properties and the noise condition in the antarctic ice. The South Pole Acoustic Test Setup - "SPATS" has been built to evaluate these parameters. Four strings, co-deployed in IceCube holes down to 400 m - 500 m, carry seven acoustic stations each. The three sensors of each station register artificial sound signals produced by SPATS transmitters or a movable transmitter used in the holes at different depths right after drilling before the water in the hole freezes again. Also acoustic emission from re-freezing bore holes and other anthropogenic sources is received by SPATS.

Using SPATS transmitters and receivers at two neighboring strings with a horizontal distance of 125 m, the sound speed in ice has been measured for pressure and shear waves between 80 m and 500 m depth [1]. Below 200 m it has been found to be constant with values of $v_p = 3878 \pm 12$ m/s and $v_s = 1975.8 \pm 8$ m/s.

The most precise information about sound attenuation is derived from data using a transmitter moving up and down in the water filled IceCube holes at different locations before re-freezing [2]. The averaged results of 47 of such measurements give an attenuation length of 313 ± 57 m. This value is at least an order of magnitude smaller than theoretical estimates suggested. No significant depth or frequency dependency were observed. Further information will come from new data taken using a transmitter at dedicated frequencies.

In contrast to open sea or lake water the acoustic noise in polar ice is stable and gaussian. The absolute noise level is difficult to determine, because an in-situ calibration in the ice at large depth and low temperature has not been possible until now. Using laboratory results, reasonable assumptions lead to a noise floor estimate of less than 20 mPa, including sensor self-noise. Additional measurements during the next Antarctic summer will allow to improve this limit.

Using a threshold trigger and requiring five sensors out of twelve at three or four strings to hear a sound signal from an identifiable source, data from SPATS allowed to derive the presently best neutrino flux limit from an acoustic test array [3]. This preliminary result will be improved using a new readout scheme for the detector.

[1] R. Abbasi, et al., Measurement of sound speed vs depth in South Pole ice for neutrino astronomy, arXiv:09092629, 2009, Astropart. Phys. 33 (2010)277.

[2] R. Abbasi, et al., Measurement of Acoustic Attenuation in South Pole Ice, arXiv:1004.1694,2010, submitted to Astropart. Phys.

[3] J. Berdermann, Acoustic transient event reconstruction and sensitivity studies with the South Pole Acoustic Test Setup, Nucl. Instr. and Meth. A (2010) doi:10.1016/j.nima.2010.11.015