On the Track of Modern Physics

Pauli and neutriNO

Wolfgang Pauli was a scientist with **"NO"** in his mind. Pauli's exclusion principle, that two electrons can't occupy the same quantum state is fundamental for all the chemistry. In 1930, in order to explain a continuous energy distribution of the electrons (and positrons) emitted during β decays, Pauli suggested the existence of a new particle, so small, that " you have **no** chance to find it". It was called neutrino by E. Fermi and discovered only in 1956 by C. Cowan and F. Reines.

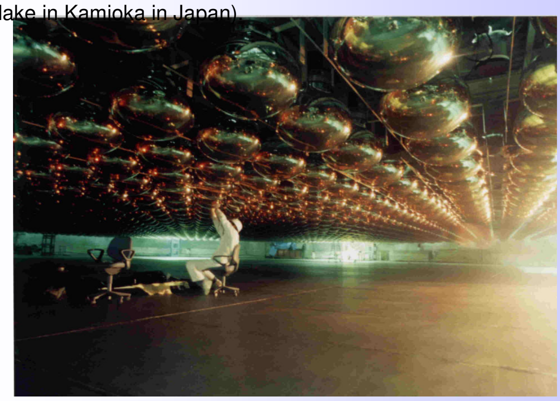
In 1998 some results of the experiment performed in old Kamioka mine (1000 m below the surface) indicated that, possibly, neutrinos have a non-zero mass. And that the three types of neutrinos flying form Sun can change in flight from one to another [1].

The mystery of lacking Solar neutrinos has also been solved [2]. It seemed before that Sun produced too little neutrinos - but now it turns up that these were scientists, who were not able to catch them

20 years old Pauli was looking for a job and had to deliver a lecture. The president, a well know professor, commented that Pauli's calculations are not quite clear for him. Pauli answered that physics is difficult and no everyone has to understand it.
Pauli started again looking for a job...

[A.K. Wróblewski, Uczeni w anegdocie].

Neutrinos are detected by reactions opposite to β decay, like $^{37}Cl \rightarrow {}^{38}Ar$. Because the probability of such a reaction is very small with a quite big background, these experiments need big installations placed deep under the Earth surface (on the photo - a boat ride on the surface of the detector lake in Kamioka in Japan).

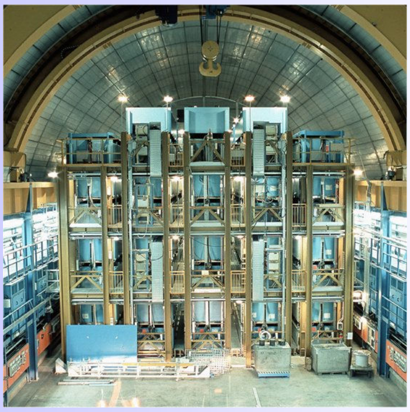


In 2003, experiments from Kamioka laboratory gave another sensational notice [3]: antineutrinos from Japanese reactors dissapear in a mysterious way! The only explanation was that electronic neutrinos change their *flavour* in flight, becoming *muon* neutrinos. So they have mass! The difference in mass between ν_e and ν_μ is very small but measurable: $\Delta m = 6.9 \times 10^{-5}$ eV^2

The 2002 Nobel Prize in Physics
Masatoshi Koshiba
International Center
for ElementaryParticle Physics,
University of Tokyo, Japan
"for pioneering contributions to astrophysics, in particular for the detection of cosmic neutrinos"

Another picturesque installation catching neutrinos is under "Big Stone" – Gran Sasso in Abruzzo, Italy.
This project is to catch in Italy neutrinos produced by proton accelerator in Geneva, Switzerland, and traveling underground without visa.

http://www.regione.abruzzo.it
www.bo.infn.it/ lvd/indexright.html



It was Italian scientist Bruno Pontcorvo, emigrated to the SovietUnion who proposed in 1957 the "inverted" reaction to capture neutrinos $n + \nu \rightarrow p + e$
http://pontecorvo.jinr.ru/photo/57.html

"The Super Nova early warning system"

Neutrinos are light, but also fast. It takes several hours to photons emerge from the depth of supernova star after its sudden lighting, and neutrinos are faster:
we have enough time to switch on telescopes!

http://snews.bnl.gov/

SN 1987A was the last supernova visible in our skies — and the first from which scientists detected neutrinos.

Hubble Heritage Team

http://snews.bnl.gov/frames.news.html

[2] In 2002, a flux of *electron* neutrinos with the intensity of 1.76×10^6 cm^{-2}s^{-1} and a flux of the *heavier neutrinos* with the intensity of 3.41×10^6 cm^{-2}s^{-1} were observed in Sudbury experiment (=another old mine, in Canada), finally in agreement with Solar nuclear-reaction models. Limits on neutrino masses are $\nu_e < 2.8$ eV and the sum 0.05 eV$< \nu_e + \nu_\mu + \nu_\tau < 8.4$ eV (giving not more than 18% of the missing Universe mass).
[3] About 40% of electronic anti-neutrinos from Japanese nuclear power stations dissapear if traveling 150 km underground. It turns-out that other experiments were done too close to reactors and did not show any neutrino oscillations for this reason.

[1] Ashie Y et al. Evidence for an oscillatory signature in atmospheric neutrino oscillations, Physical Review Letters 93 (10): Art. No. 101801 Sep 3 2004 .
[2] Q.R. Ahmad et al. Measurement of the rate of $\nu_e + d \rightarrow p + p + e^-$ interactions produced by ^{8}B solar neutrinos at the Sudbury Neutrino Observatory, Physical Review Letters 87 (7): Art. No. 071301 Aug 13 2001
[3] K. Eguchi, et al. First Results from KamLAND: evidence for Reactor Antineutrino Dissaperance, Physical Review Letters 90 (2): Art. No. 021802 Jan 17 2003
http://www-sk.icrr.u-tokyo.ac.jp/sk/pub/200407/index.html