Neutrino

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Lecture-1

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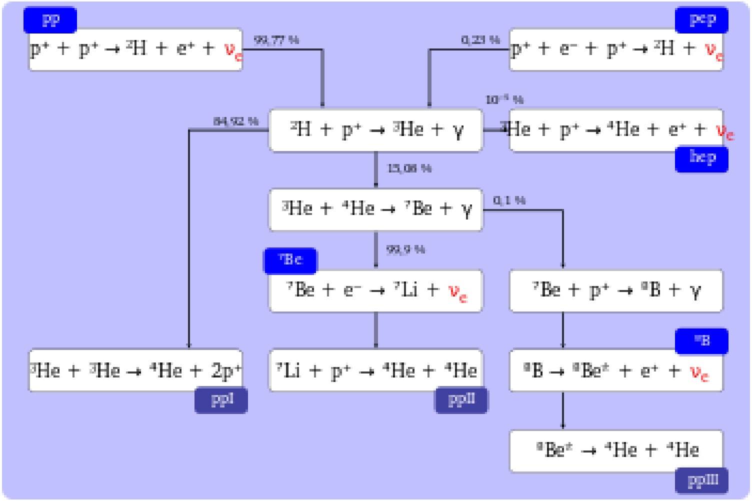
  3. Something might be lacking in our understanding of the neutrino properties.
- All those possibilities have been ruled out and some other ways are to be look out.



pp
$p^+ + p^+ \rightarrow {}^2H + e^+ + \nu_e$
99,77 %
pep
$p^+ + e^- + p^+ \rightarrow {}^2H + \nu_e$
0,23 %
84,92 %
$^2H + p^+ \rightarrow {}^3He + \gamma$
10^{-5} %
$^3He + p^+ \rightarrow {}^4He + e^+ + \nu_e$
hep
15,08 %
$^3He + {}^4He \rightarrow {}^7Be + \gamma$
0,1 %
99,9 %
7Be
$^7Be + e^- \rightarrow {}^7Li + \nu_e$
$^7Be + p^+ \rightarrow {}^8B + \gamma$
8B
$^3He + {}^3He \rightarrow {}^4He + 2p^+$
ppI
$^7Li + p^+ \rightarrow {}^4He + {}^4He$
ppII
$^8B \rightarrow {}^8Be^* + e^+ + \nu_e$
$^8Be^* \rightarrow {}^4He + {}^4He$
ppIII

Table 1. Reactions in the *pp* chain.

Reactions	Name of reaction	Neutrino energy in MeV	Flux in $10^{10}\ \mathrm{cm}^{-2}\,\mathrm{s}^{-1}$
Stage 1: p synthesizes to ^2H			
$p + p \to {}^2H + e^+ + \nu_e$	pp	≤ 0.42	$6.0 \times (1 \pm 0.02)$
$p + e^- + p \to {}^2H + \nu_e$	pep	1.44	$0.014 \times (1 \pm 0.05)$
Stage 2: ^2H synthesizes to ^3He			
$^2H + p \to {}^2He + \gamma$	—	—	—
Stage 3: ^3He synthesizes to ^4He directly			
$^3He + {}^3He \to {}^4He + p + p$	—	—	—
$^3He + p \to {}^4He + e^+ + \nu_e$	Hep	≤ 18.77	8×10^{-7}
Stage 4: Synthesis of ^7Be			
$^3He + {}^4He \to {}^7Be + \gamma$	—	—	—
Stage 5: ^7Be turns into ^4He			
$^7Be + e^- \to {}^7Li + \nu_e$	^7Be	0.861	$0.47 \times (1 \pm 0.15)$
$^7Li + p \to {}^4He + He$	—	—	—

Table 2. The CNO cycle.

Reaction	Neutrino energy in MeV	Flux in $10^{10}\,\mathrm{cm^{-2}\,s^{-1}}$
$^{12}C + p \rightarrow {}^{13}N + \gamma$	—	
$^{13}N \rightarrow {}^{13}C + e^{+} + \nu_e$	≤ 1.2	$0.06(1 \pm 0.50)$
$^{13}C + p \rightarrow {}^{14}N + \gamma$	—	
$^{14}N + p \rightarrow {}^{15}O + \gamma$	—	
$^{15}O \rightarrow {}^{15}N + e^{+} + \nu_e$	≤ 1.73	$0.05(1 \pm 0.58)$
$^{15}N + p \rightarrow {}^{12}C + {}^{4}He$	—	
$^{15}N + p \rightarrow {}^{16}O + \gamma$	—	
$^{16}O + p \rightarrow {}^{17}F + \gamma$	—	
$^{17}F \rightarrow {}^{17}O + e^{+} + \nu_e$	≤ 1.74	$5.2 \times 10^{-4}(1 \pm 0.46)$
$p + {}^{17}O \rightarrow {}^{4}He + {}^{14}N$	—	

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In the next figure the pp and pep chain, CNO cycle and energy distribution of the flux of solar neutrinos from various reactions are shown.

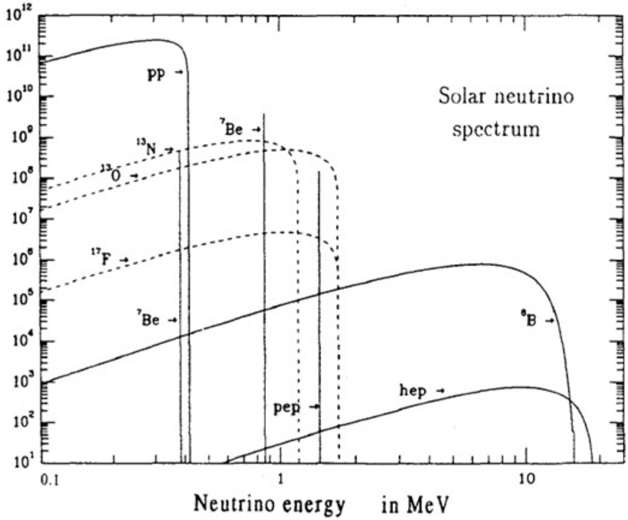

Fig. 1. Energy distribution of the flux of solar neutrinos from various reactions. The fluxes from continuum sources are given in the units of number per cm^2 per second per MeV at the mean earth–sun distance. The line fluxes are in number per cm^2 per second. Solid lines correspond to the pp chain, and dotted lines to the CNO cycle. Adapted from Ref. 5.

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One cannot tell the times of arrival or the energies of the neutrino captured.

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One need how much Y nuclei were supposed to be present primordially in the rock sample.The estimates are not very accurate.

Table 3. Reactions suitable for radiochemical and geochemical detection of solar ν_e's. All reactions are of the form $\nu_e + X \rightarrow e^- + Y$ for suitable nuclei X and Y which are listed.

Initial Nucleus (X)	Final Nucleus (Y)	Threshold (in MeV)	Half life of Y	Capture Rate (in SNU)
^{37}Cl	^{37}Ar	0.814	35 days	7.9 ± 2.6
^{71}Ga	^{71}Ge	0.233	11.4 days	$132\pm^{20}_{17}$
^{7}Li	^{7}Be	0.862	53.4 days	51.8 ± 16
^{127}I	^{127}Xe	0.789	36 days	~ 80
^{81}Br	^{81}Kr	0.470	2×10^5 years	$27.8\pm^{17}_{11}$
^{98}Mo	^{98}Tc	1.68	4×10^6 years	$17.4\pm^{18.5}_{11}$
^{205}Tl	^{205}Pb	0.062	$\sim 10^7$ years	~ 263

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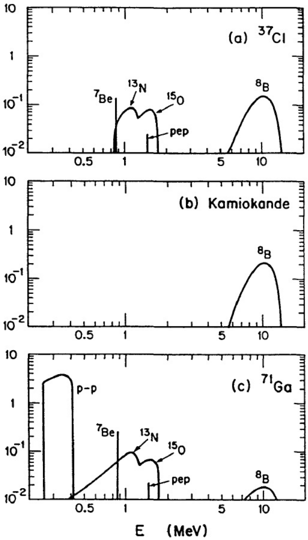

Fig. 2. The energy distribution of neutrinos captured in various detectors. Adapted from Ref. 6. The line sources are given as a fraction of the total signal, and the continuum lines are normalized so that the integrated number is 1.