Monday, March 24, 2025

Example: Neutrino production during the SN 1987A supernova.

SN 1987A is estimated to have unleashed about 10^{58} neutrinos over a few seconds (i.e. ~2.5 seconds for this problem)

distance of SN1987A = 168,000 light years

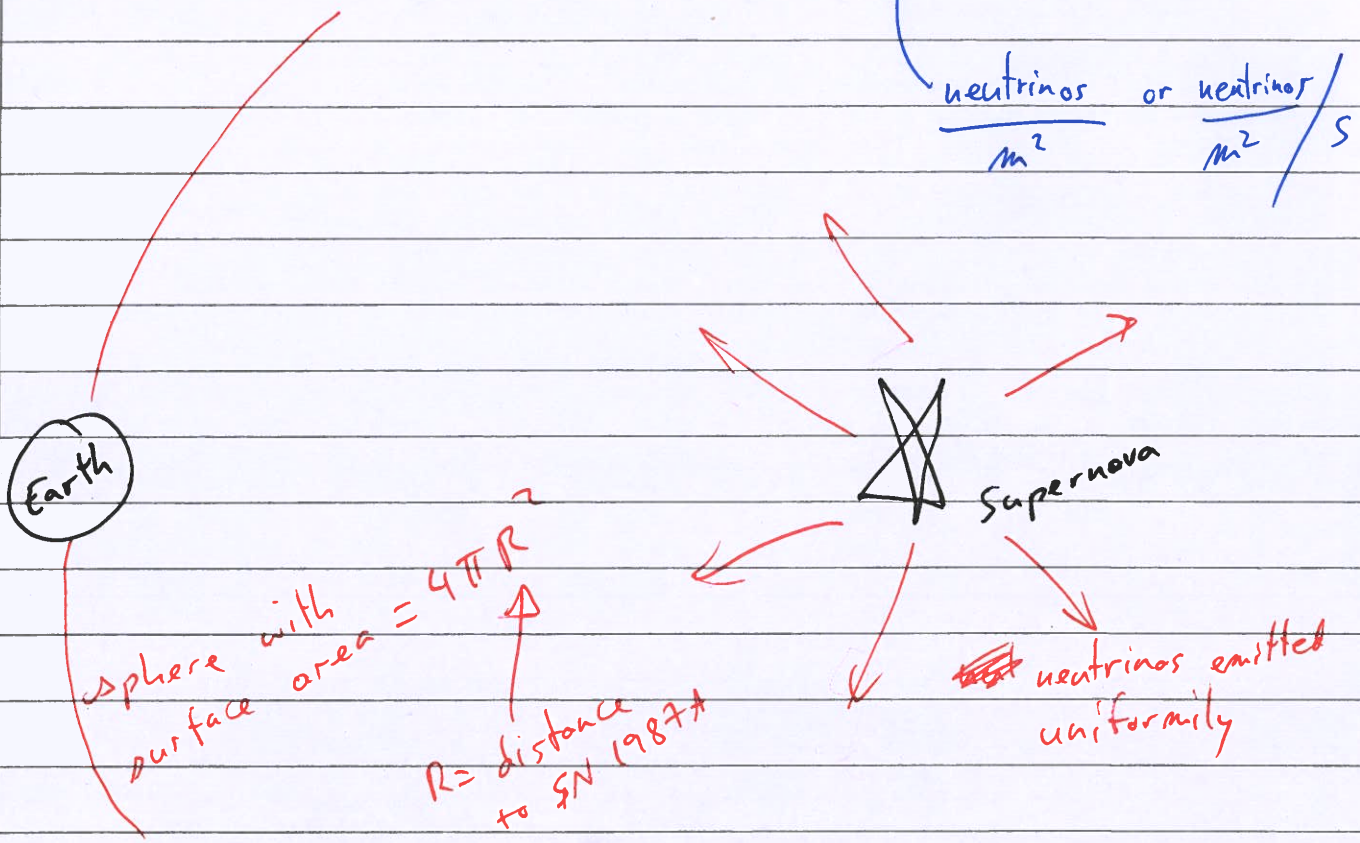
$= (1.68 \times 10^5)(9.46 \times 10^{15})$ m

1 ly $= 9.46 \times 10^{12}$ km $= 9.46 \times 10^{15}$ m

$= 1.59 \times 10^{21}$ m

Question: What was the neutrino flux on Earth from SN 1987A?

neutrinos / m^2 or neutrinos / m^2 / s



$$\text{Area} = 4\left(3.1415926\right)\left(1.59 \times 10^{21}\ m\right)^2$$
$$= 3.174 \times 10^{43}\ m^2$$

$$\text{neutrino flux} = \frac{\#\text{ of neutrinos}}{\text{Area}} = \frac{10^{58}}{3.174 \times 10^{43}} = 3.15 \times 10^{14}$$

$$\simeq 3 \times 10^{14}\ \frac{\text{neutrinos}}{m^2}$$

$$\Rightarrow \boxed{\text{neutrino flux} = 3 \times 10^{14}\ \frac{\text{neutrinos}}{m^2}}$$

$$\text{flux per second} = \frac{\text{neutrino flux}}{\text{pulse duration}} = \frac{3 \times 10^{14}\ \text{neutrinos}/m^2}{2.5\ s}$$

$$= 1.26 \times 10^{14}\ \frac{\text{neutrinos}}{m^2 \cdot s}$$

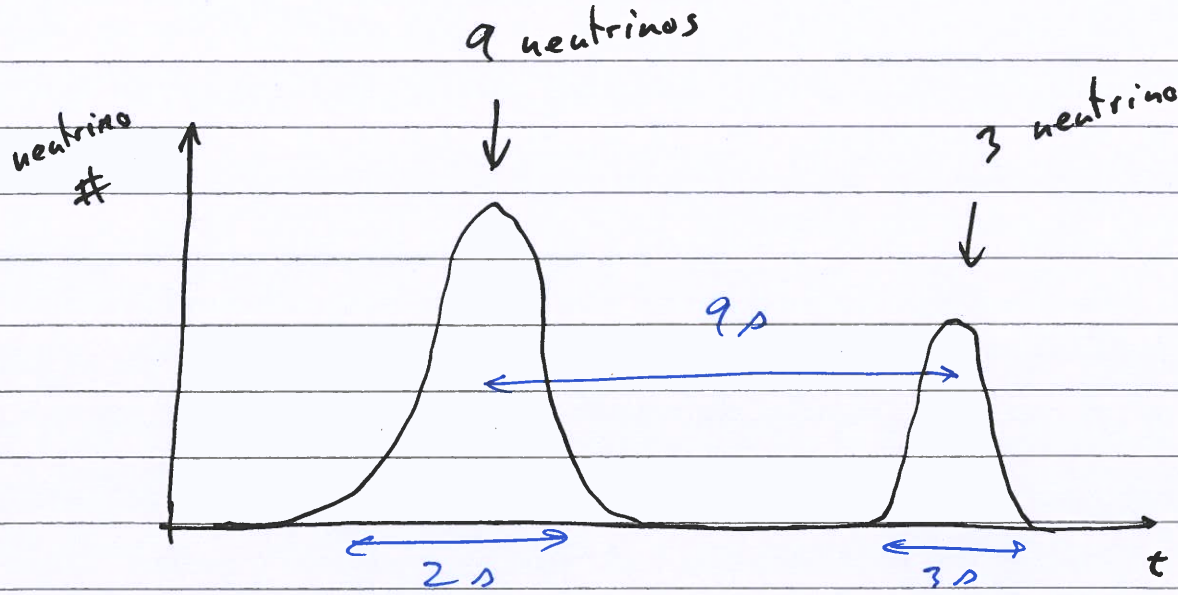
$$\boxed{\text{neutrino flux per second} \simeq 10^{14}\ \frac{\text{neutrinos}}{m^2 \cdot s}}$$

10^{14} = 100 trillion

neutrinos are in the 10-15 MeV range

Note: Solar neutrino flux per second $= 7 \times 10^{16}\ \frac{\text{neutrinos}}{m^2 \cdot s}$

↳ most of the solar neutrinos are in the 100-400 keV range



Kamiokande-II neutrino signal for SN 1987A