

In order to determine the critical dimensions and the most favorable distribution of the small uranium spheres within a large graphite sphere it is essential to have an accurate value for μ and for the capture cross-section of carbon for thermal neutrons.

In order to have an accurate value for μ it will be necessary to have a direct measurement of p for small hydrogen concentrations preferably for $n \approx 3$. In the following we shall indicate in what way an accurate value for p can be obtained:

Let us consider a box filled with a homogeneous mixture of uranium oxide and water and let the box be so large that a neutron which has an energy of less than 1000 volts in the center of the box be slowed down below 1 volt before it reaches the boundary of the box by diffusion. If such a box is then irradiated with neutrons the energy distribution of the neutrons below 1000 volts in the center of the box will be the same as it would be in an infinite space filled with the same uranium water mixture in case of a uniform generation of neutrons throughout the space. If a radio-active indicator like rhodium or indium which has its lowest dominant resonance absorption line below the dominant resonance absorption line of uranium is placed in the center of the box the activity induced in the rhodium indicator by the resonance neutrons of rhodium will be ^{caused} ~~caused~~ only ^{by} (those neutrons which are slowed down below the resonance region of uranium without being captured by uranium at resonance. We shall call this activity the resonance activity of the indicator and designate it if a rhodium indicator is used with $(Rh^* \text{ in } U)$. If, on the other hand, an indicator like, for instance, iodine is used which has its dominant absorption lines above the uranium resonance the resonance activity of this indicator $(I^* \text{ in } U)$ will, at least in the ideal case, not be affected by the resonance absorption of uranium. The ratio of $(Rh^* \text{ in } U)$ and $(I^* \text{ in } U)$ would therefore give some measure of $1 - p$ if the activity of the indicators as measured by an ionization chamber or electron counter gave a ^{real} ~~measure~~ measure of the number of the neutrons which pass through the resonance region of rhodium or iodine. This, of course, is by no means the case. Therefore, a second experiment has to be performed in which the resonance activities of the rhodium and iodine indicators are determined in the center of another box which contains water. ~~(or perhaps even better a mixture of water and graphite having approximately the same water density as the mixture used in the first experiment. We then find~~

(preferably but not necessarily water of the same density as the water contained in the uranium water mixture used in the first experiment) We then find

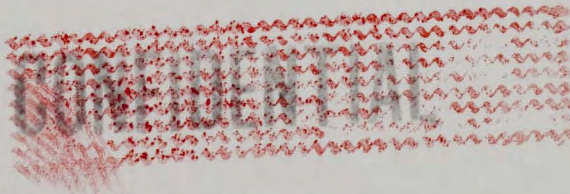
$$1-p = \frac{(R_h^* \text{ in U}) \times (J^* \text{ in H}_2\text{O})}{(R_h^* \text{ in H}_2\text{O}) \times (J^* \text{ in U})}$$

If there are uranium resonance lines of some importance above the lowest resonance lines of iodine then we have

$$1-p < \frac{(R_h^* \text{ in U}) \times (J^* \text{ in H}_2\text{O})}{(R_h^* \text{ in H}_2\text{O}) \times (J^* \text{ in U})}$$

giving a reliable upper limit for $1-p$ and consequently a lower limit for p which used in conjunction with equation No. 38 will give a lower limit for the value of μ .

The upper limit which has been reported for the carbon cross-section by Halban, Frisch, and Koch is already so low that it would be difficult to improve upon it unless a method were used which is specifically designed to measure extremely small capture cross-sections. Such a method will be described in the following:



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~~THE CAPTURE CROSS SECTION OF CARBON~~

~~Since the capture cross section of carbon determines the critical dimensions and the mass of uranium which has to be used in order to reach the point of divergence of the chain reaction it is necessary to measure this value beyond the upper limit which has been reported by Halban, Frisch and Keech. This upper limit is already so low that it would be difficult to improve upon it unless some method is used specifically designed for measuring extremely small capture cross sections. In the following we wish to describe such a method.~~

Let us consider a sphere of carbon and a neutron source in the center of the sphere. The thermal neutron density inside the carbon will then obey equation No. only in this case Q is a function of r of which we must not assume $\frac{dQ}{dr} = 0$. Let the carbon sphere be immersed in a water tank or surrounded by paraffin wax. The thermal neutron density will then have a fairly high value at the surface of the sphere and inside the sphere it will be some function of r, $\rho_1(r)$. If in a second experiment the surface of the sphere in the water is covered by cadmium the thermal neutron density at the surface of the sphere is then reduced to zero and inside the sphere it will be another function of r, $\rho_2(r)$. The difference $\rho(r) = \rho_1 - \rho_2$ obeys the homogeneous equation

$$D(C) \frac{d^2(\rho(r))}{dr^2} - S(C) r \rho = 0$$

which has the solution

$$\rho(r) = C \frac{e^{r/A} - e^{-r/A}}{r}$$

We can thus find A by determining the value of ρ for two values of r, for instance, $r=0$ and $r=r$. It is

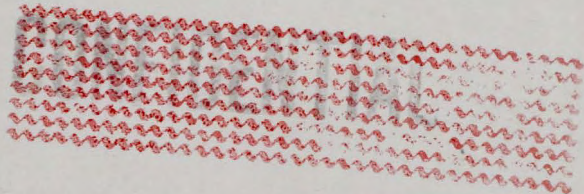
$$\frac{\rho(r)}{\rho(0)} = \frac{e^{r/A} - e^{-r/A}}{2r/A}$$

Or for small values of r/A

$$\frac{\rho(r)}{\rho(0)} \approx 1 + \frac{1}{6} \left(\frac{r}{A}\right)^2$$

Using a sphere of graphite of fifty to seventy centimeters of radius it should be possible to measure the range A with sufficient accuracy. There is a limit to using very large spheres which arises out of the fact that for a very large sphere most of the neutrons emitted in the center of the sphere, will be slowed down to the thermal region within the carbon and the thermal neutron density near the surface of the carbon may become very low. If that

happens, then the difference $\rho = \rho_1 - \rho_2$ will become small and will therefore set a limit to the accuracy of the measurement.



MEASUREMENTS (cont'd)

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