BACKGROUND INDUCED D-D FUSION

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Following the recent publications (1,2) regarding room temperature D-D fusion, spectrum measurements of neutrons emitted from a deuterium loaded palladium thin sheets took place at the Department of Nuclear Engineering, Ben-Gurion University. Various quantities (0.2 gr - 20 gr) of palladium foils loaded with deuterium were measured during April - June 1989. The deuterium loading was done by heating the palladium foils in a quartz capsule to 900°C for 4 hours under vacuum and then cooling down under 3 atm of deuterium gas. (The samples preparation was done at the Hebrew University, Jerusalem).

D-D fusion events were detected by measuring the 2.5 MeV neutrons emitted from the reaction. The neutron spectrometer was composed of a 2" x 2" NE213 liquid scintillator attached to an RCA 8575 photomultiplier tube, an n-γ pulse shape analyzer-ORTEC 460-485, ORTEC Research Amplifier 450, multichannel analyzer ORTEC 918A and IBM PCAT. The proton recoil spectra obtained from the detector were unfolded back to the neutron spectra by the FORIST unfolding code (3). The system is described in detail in Ref. 4.

Because of the good n-γ discrimination of the system (of the order of $1:10^5$) and the fact that we were measuring neutron spectra and could observe the 2.5 MeV neutrons specifically, we did not shield the system in the first few experiments. We obtained considerable 2.5 MeV neutron peaks: of the order of 10^{-3} n/sec with a few gr D-Pd samples. In later experiments we added shielding to the neutron detector and moved to lower background laboratories. We have noticed that the 2.5 MeV neutron yield from the sample depends on the background level. When the samples were sent to very low level laboratories for inspection, no neutrons were measured above background.

The dependence on the background brought us to increase the background artificially. This was done by placing neutron sources at the vicinity of the sample. In most experiments this was done with a 0.1 Ci AmBe neutron source which emits neutrons of energies 3.2 MeV and 4.75 MeV mainly (higher energy neutrons were ignored). In one measurement we used a Cf^{252} spontaneous fission neutron source.

The results of the measurement of 20 gr palladium loaded with deuterium, under "natural" laboratory background is shown in Fig. 1. The 2.5 MeV neutron peak is clearly seen. The total number of counts under the peak is of the order of 10^{-2} n/sec. Interesting results were obtained when the sample was irradiated with neutrons from an AmBe source, it is shown in Fig. 2. The peak at ~1.5 MeV is due to room (or sample) scattered neutrons. There are two peaks to be noticed, the one at ~3 MeV and the other at ~4 MeV. These two peaks are due to recoiled deuterons caused by the 3.2 MeV and 4.75 MeV neutrons from the AmBe source. Most of the deuterons are recoiled forward with energy ~90% of the incoming neutron energy. The experimental setup was such that the neutron source - sample line was at 90° to the sample-detector line. From the kinematics of the $D(d,n)^3He$ reaction it is seen that the neutrons emitted at 90° due to deuterons of energy 3 MeV or less are of energy ~3 MeV. By similar arguments, the peak at ~4 MeV is due to deuterons recoiled by the 4.75 MeV source neutrons. The experiments were repeated several times with different source to sample distances. The neutron spectra in all cases have the same shape as the one shown in Fig. 2 but the intensity showed the $1/r^2$ dependence.

The spectra shown in Figs. 1 and 2 are background subtracted. The background was measured in every case with the same set-up as the foreground, the same materials present but the palladium was not loaded with deuterium (hence much less deuterium atoms). A series of background measurements was done with hydrogen loaded palladium instead of deuterium. The neutron scattering cross-section of hydrogen is about 10 times higher than that of deuterium, therefore the background was higher than the foreground (with no D-D fusion neutrons peaks). After background subtraction we obtained spectra with the D-D neutron peaks as in Fig. 2 but most of the spectrum is negative. This is shown in Fig. 3.

To learn the role of the metal in deuterium loaded metal fusion, we repeated the experiments with deuterium gas at 120 atm in a lecture (small) bottle with natural background and with the AmBe source. The results were very similar to the D-Pd measurements shown in Figs. 1 and 2. At 120 atm. the number of deuterium atoms seen by the detector is more than with 20 gr of deuterium loaded palladium of ratio 0.6. It seems that the metal has no role in the D-D fusion although it is possible that some deuterium diffused into the metal bottle wall and caused the effect.

We repeated the measurement with a ^{252}Cf spontaneous fission source and the deuterium gas. A hump appeared on the source scattered neutron spectrum in the range 2.5 - 3 MeV, as shown in Fig. 4.

A general phenomenon in all our results is that integrating under the peak in the neutron spectra, considering the number of neutrons in the "background" and the reaction cross-sections (d recoil and d-d fusion), we obtained 100-1000 times more neutrons than we should. It is possible that the recoiled deuterons hit many other deuterons and increase the number of d-d fusion reactions considerably. This effect must be studied carefully.

References

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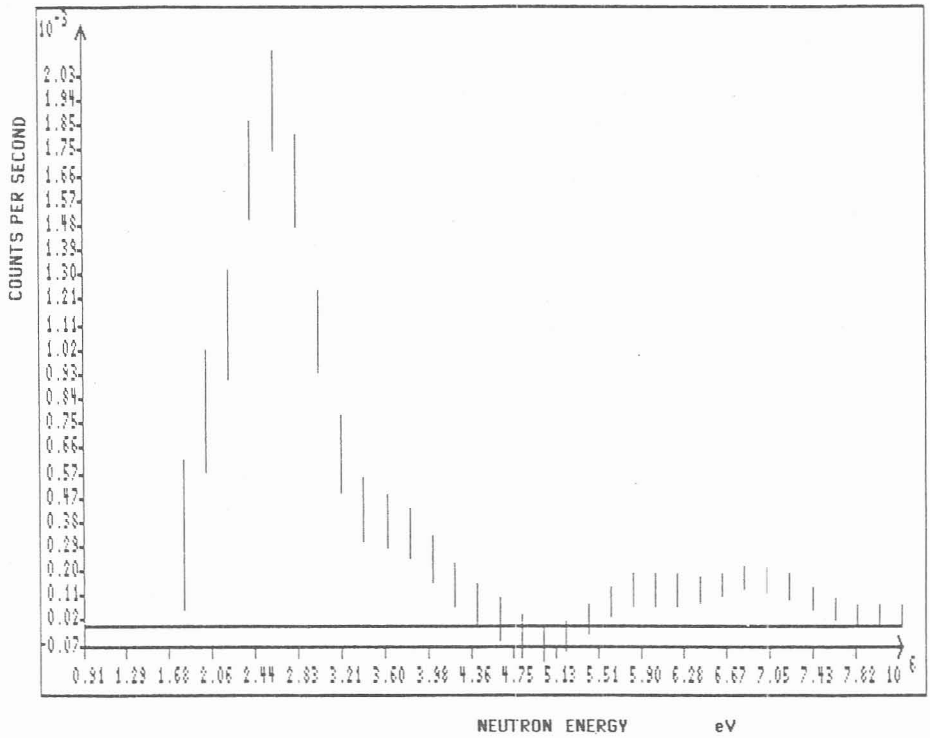

Fig. 1 Neutron Spectrum Emitted From A 20gr D-Pd Sample With Natural Background.

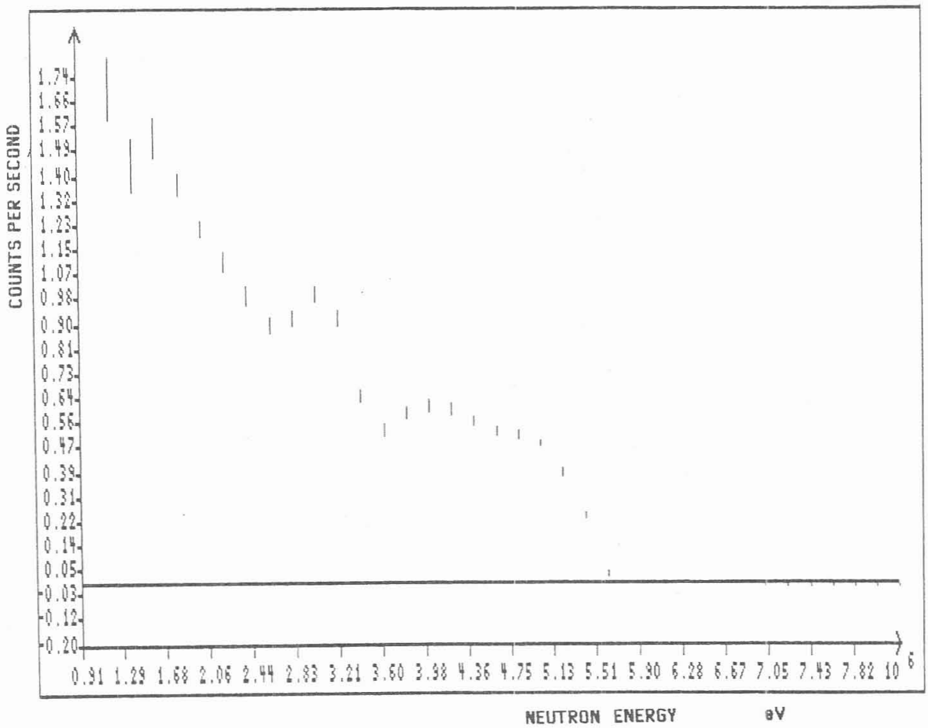

Fig. 2. Neutron Spectrum Emitted From A 20gr D-Pd Sample With An AmBe Neutron Background.

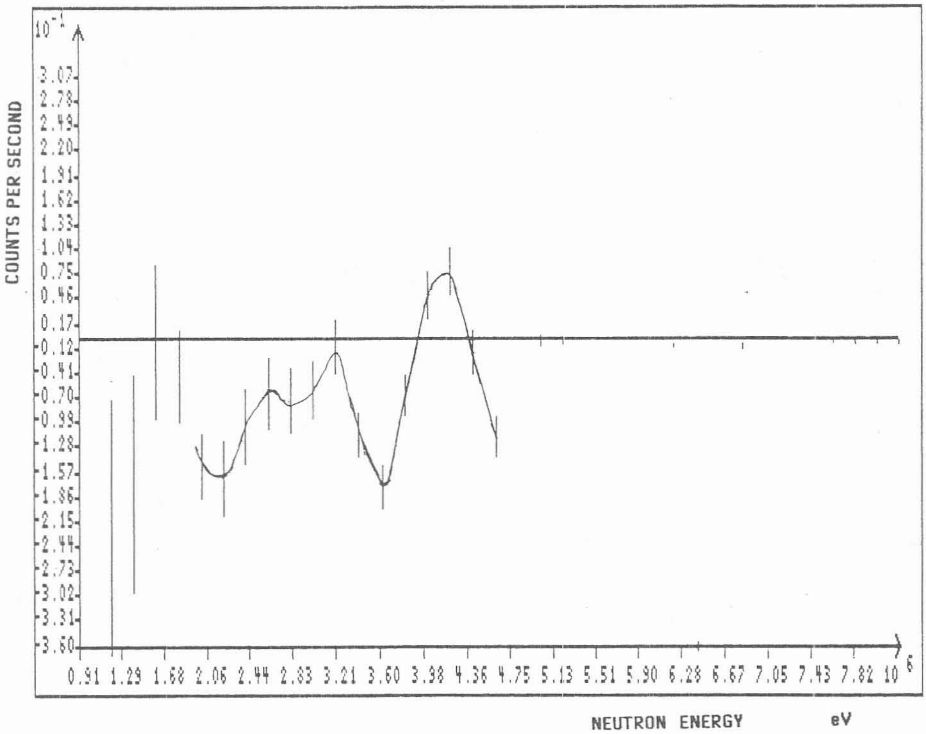

Fig. 3. Neutron Spectrum As In Figure 2 With H-Pd Background Subtracted.

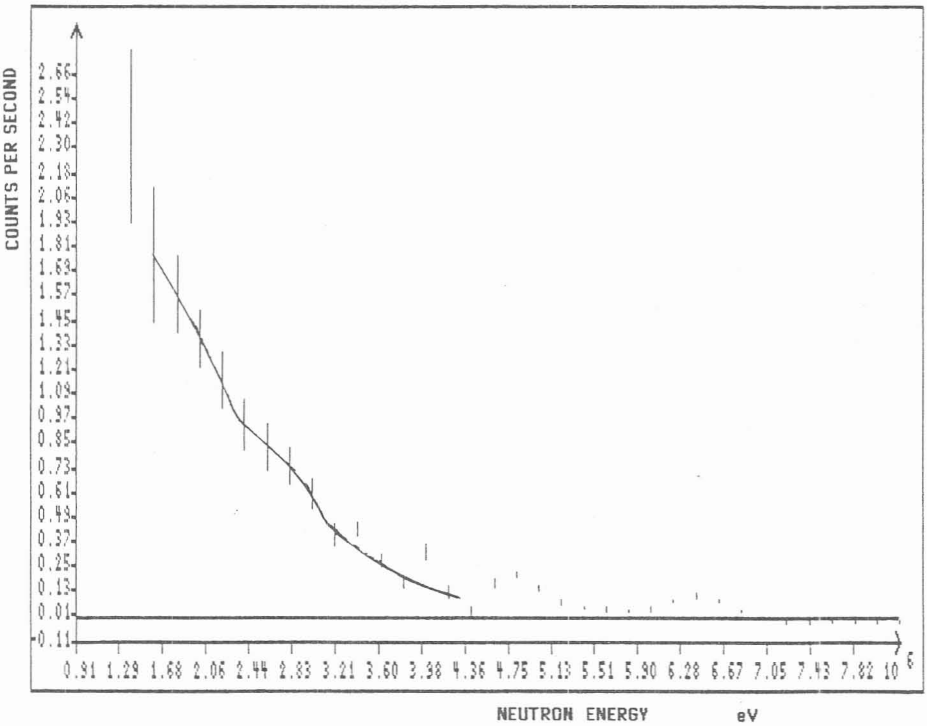

Fig. 4. Neutron Spectrum Emitted From Deuterium Gas Under 120atm With A Cf-252 Neutron Source Background.