MEASUREMENT AND RESONANCE ANALYSIS OF NEUTRON TRANSMISSIONS THROUGH FOUR SAMPLES OF ^{238}U *

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Accurate total and partial cross sections for ^{238}U are important for nuclear reactor design. In the resolved resonance region, energies below 4.0 keV, these cross sections are described in terms of individual resonance parameters of which the neutron widths in the 1.5 to 4.0 keV region from various workers appear discrepant.[1-5] In order to determine these widths, we have measured (0.880 to 100.0 keV) and analyzed (0.880 to 4.000 keV) neutron transmissions through 0.076, 0.254, 1.080, and 3.620-cm-thick, enriched ^{238}U samples.

The measurements were performed in the 150 m station of flight path 6 of ORELA. Neutron "clock" flight times were determined with a EG&G TDC-100 multistop clock which measured the time interval between a start pulse from a gamma-flash detector in the ORELA target room and a stop pulse formed with the usual coincidence procedure from the fast and slow outputs of a RCA-4522 phototube whose face was optically coupled to a 12.7 mm-thick Li-glass scintillator used as a neutron detector. A ^{10}B time-overlap filter and a Pb γ-flash filter were fixed in the flux at 5 m. Additional background-determination filters and ^{238}U samples were alternated in and out of the beam at 40 m. The 20-day measurement consisted of 30-minute cycles, each of which contained an open beam followed by transmissions through the four ^{238}U samples with these

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configurations repeated again with an Al-Mn-S filter in the beam. These ten flight-time spectra were constructed in 52250 channel arrays on a SEL computer disk. After determining an absolute energy scale accurate to 2 x 10^{-4}, deadtime correcting the spectra, and subtracting background, ^{238}U transmissions without the Al-Mn-S filter in the flux, ^{238}U transmissions with the Al-Mn-S filter, and the various transmissions of the Al-Mn-S filter were all calculated. The latter two transmission sets were used to verify internal consistency.

The former set of four transmissions were simultaneously least-squares shape fitted with the computer code SIOB[6] which contains both Doppler and resolution broadening and employs the multilevel Breit-Wigner formalism. An asymmetric resolution function, based on a skewed time distribution expected for the moderated neutrons and Monte Carlo calculations of the expected neutron diffusion in the Li-glass disk, was required in order to obtain reasonable fits. The exact equations and procedures used to fit these data are given in Ref. 7. In particular, the data was divided into 15 energy regions, each fitted separately by varying the resonance energies and neutron widths with fixed radiation widths. Approximately 200 eV of levels above and below the fitted region were explicitly contained in the cross section with levels beyond accounted for with picket fence terms. The variable effective radius was required to both normalize the four transmissions and supply the potential-resonance interference.

Figure 1 shows a simultaneous fit to the four transmissions with an effective radius of .9631 ± .0006 x 10^{-12} cm where the five large s-wave resonances at 3693.19 ± .03, 3716.80 ± .05, 3734.21 ± .04, 3765.11 ± .05, and 3781.96 ± .03 eV have neutron widths of .425 ± .009, .111 ± .005, .225 ± .007, .109 ± .005, and .488 ± .009 eV, respectively. In addition to the above errors which are three times the SIOB statistical standard deviations, there are estimated overall systematic uncertainties of 0.02% and .05% in the energy scale and effective radius respectively and from 3.0 to 5.0% for the neutron widths. The effective radius increased somewhat monotonically from .949 to .973 x 10^{-12} cm with energy from 1.0 to 4.0 keV.

Our neutron widths are compared in a consistent manner with those from Carraro and Kolar,[2] Rahn et al.,[3] Nakajima et al.,[4] and Poortmans et al.[5] in Fig. 2 where s-wave strength functions for 0.5 keV intervals are shown. Below 0.880 keV the ORELA strength functions are from our previous 42 m neutron widths[7] whose sum in the overlap region from 0.880 to 1.087 keV is 2.3% smaller than the 150 m values. Figure 2 shows reasonable agreement below 1.5 keV on average between the various measurements except for the Garg et al.[1] results (not shown) which are consistently much smaller. Above 2.5 keV the systematic discrepancies are obvious; however, the various measurements and in particular the most recent measurements[5,7] seem to require a large s-wave strength function, whereas ENDF/B-IV was based on the smaller neutron widths of Rahn et al,[3]

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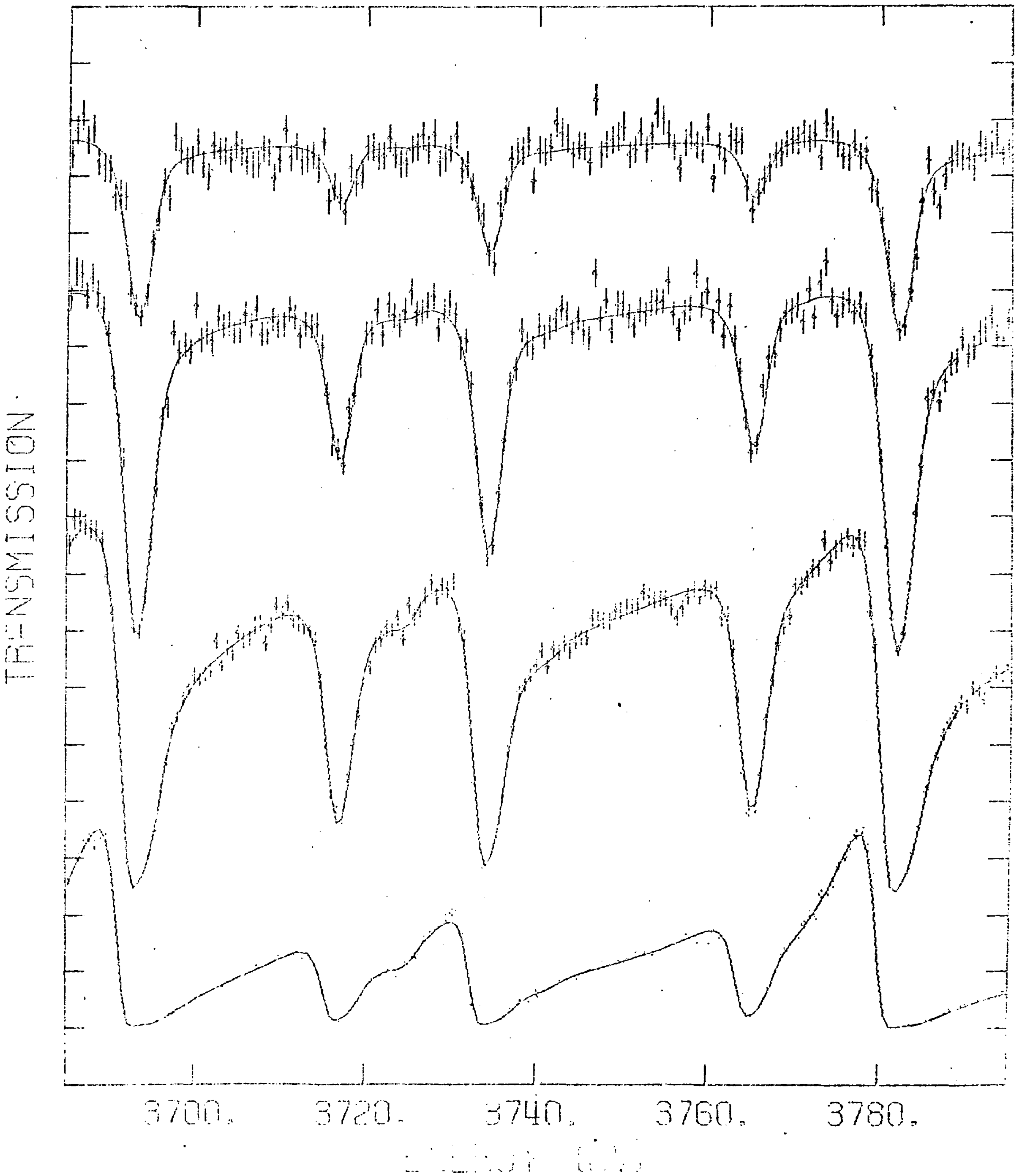
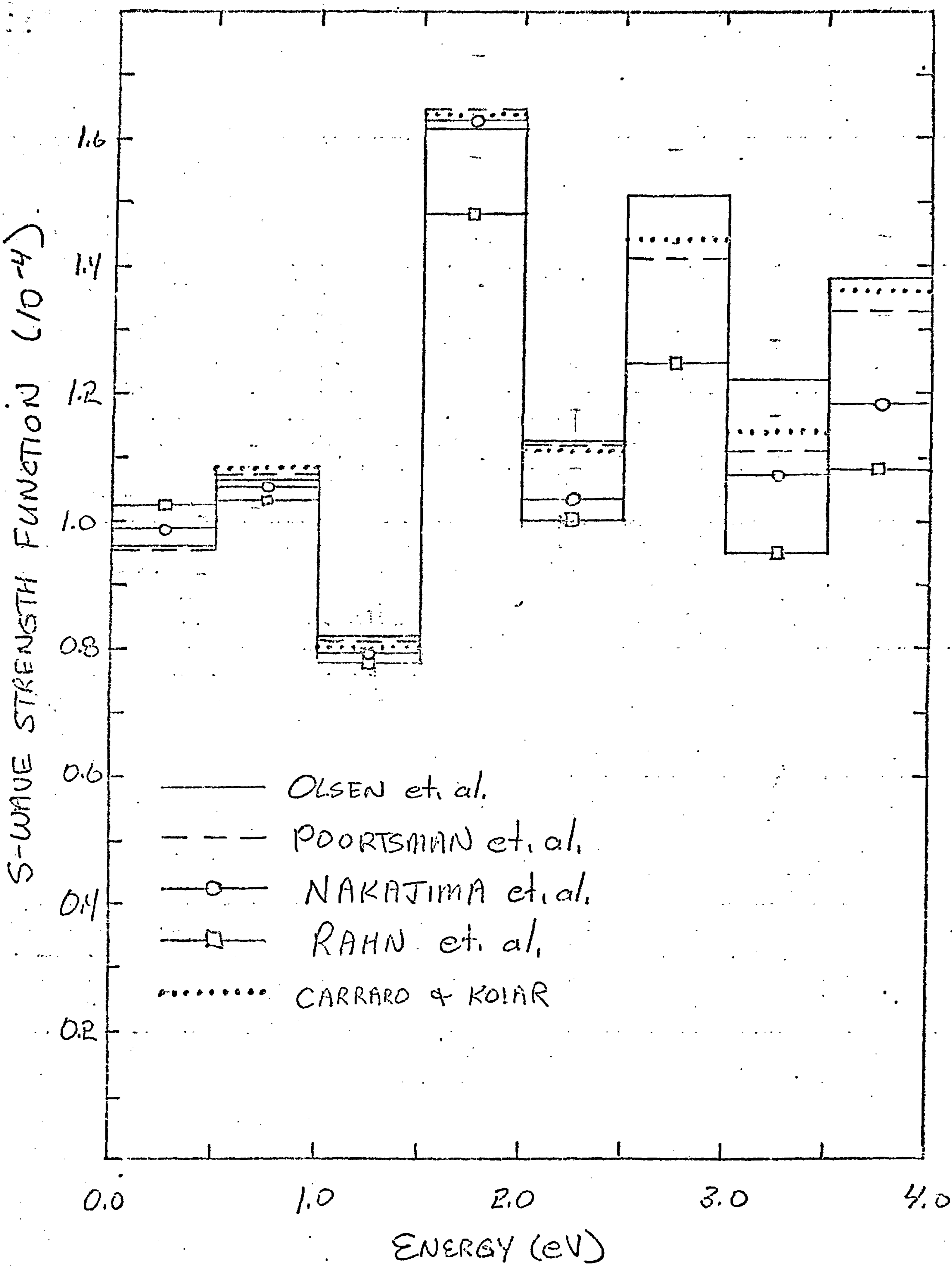
FIGURE CAPTIONS

Fig. 1 Least-squares shape fit to 0.076-, 0.254-, 1.080-, and 3.620-cm thick ^{238}U sample transmissions from a four sample simultaneous search on the energy region from 3650 to 3813 eV. With fixed radiation widths the resonance energies and neutron widths and the effective radius were varied.

Fig. 2 Comparison of neutron widths on average employing local s-wave strength functions calculated for 0.5 keV intervals for a consistent set of levels from various measurements, Ref. 2 to 5 and 7. The estimated systematic uncertainty for the ORELA neutron widths increases from 2.0% at very low energies to 5.0% at 4.0 keV.



TRANSMISSION
3700.
3720.
3740.
3760.
3780.


S-WAVE STRENGTH FUNCTION (/10⁻⁴)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.0
2.0
3.0
4.0
ENERGY (eV)
OLSEN et. al.
POORTSMAN et. al.
NAKAJIMA et. al.
RAHN et. al.
CARRARO & KOLAR