choice of T there exists a λ for which the fit between calculated and measured PMC is best. The change $\Delta\lambda$ of the molecular field constant on doping proves to be independent of the assumed value of T in the range $5 \leq T \leq 15$°K. We obtained $\Delta\lambda = 1.0$ for the present crystal surfaces. The extra electrons introduced on doping are known to have a certain mobility,[3] and this is why they are an effective link between bulk and surface. That the mobile electrons produce the extra molecular field in the surface is directly seen from their high P in Fig. 1.

The paramagnetic sheet is an effective barrier for photoelectrons from inside the bulk as long as M_s is low, because it is known that spin-disorder scattering is very effective in EuO. When M_s builds up in an external magnetic field, the sheet becomes transparent. This corroborates the deviation of calculated and measured PMC's at higher H shown in Fig. 2. We believe that the thickness of the sheet observed at low M_s can be as small as a few atomic layers. The existence of the paramagnetic sheet at an estimated $T \sim 10°$ K, far below T_C, is surprising. Apart from the reasons already discussed in the literature,[1] an increase of the lattice constant in the surface may be important, which is known to reduce the ferromagnetic part of the exchange in the europium chalcogenides.[7] Further experiments should include the measurement of the T dependences, which will allow a complete molecular field analysis.

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Multiple-Reaction Correction to the Capture Cross Section*

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The multiple-reaction correction of Halpern, Drake, *et al.* to neutron radiative cross-section measurements is shown to be important also below 14 MeV, with the consequence that previously measured uncorrected (or unrestricted to first-chance capture only) (n,γ) cross sections above the first level are in error, being from about 1% to a factor of more than 10 too high.

Some time ago Drake, Whetstone, and Halpern[1] found their 14-MeV (p,γ) photon-spectrum–derived cross sections to be below 1 mb in contrast to previously measured (n,γ) cross sections which ran from 1 mb near magic to as much as 17 mb away from magic above $A = 40$. Cvelbar, Hudoklin, and Potokar[2] reported that their 14-MeV (n,γ) measurements, made by integrating the γ spectrum, up to $A = 138$, gave cross sections from 0.3 to 1.2 mb, again factors of 1.5 to 12 lower than expected. Drake, Bergqvist, and McDaniels[3] continued the (n,γ) cross-section measurements to higher A by measuring direct transitions to bound states with a ^{208}Pb(n,γ) standard and found 14-MeV cross sections to be nearly constant at 0.9 to 1 mb, again very low.

TABLE I. Magnitude of multiple-reaction correction (in percent of true cross section).

Neutron energy (MeV)	W, % $\sigma_{n,\gamma}$	^{238}U, % $\sigma_{n,\gamma}$	^{93}Nb, % $\sigma_{n,\gamma}$	^{235}U, % $\sigma_{n,f}$
0.2	1.8	3	...	1.2
0.5	6	4	...	1.7
1	14	7	3	2.3
2	35	21	28	2.9
5	130	110	97	3.5
10	440	800	230	2.1
14.1	820	2600	400	0.8

Several suggestions for the discrepancies have been put forward,[1-3] but the proposal of Halpern as quoted in Ref. 3, namely that previous measurements may have included (n, n'), (n, pn'), $(n, 2n')$, etc., followed by (n', γ), appears to be correct. Indeed Kantele and Valkonen[4] have carefully extrapolated their 14.5-MeV activation measurements to zero-thickness targets in order to exclude multiple-reaction effects and thereby get cross sections of the same magnitude as the spectrum measurements of Drake, Bergqvist, and McDaniels[3] and Cvelbar, Hudoklin, and Potokar.[2]

It is the purpose of this Letter to emphasize that this Halpern-Drake multiple-reaction correction is also of importance below 14 MeV, and to give a few examples. The correction begins for energies above the first level of the target and consists of the subtraction from the direct primary reaction of reactions caused by secondary neutrons resulting from (n, n'), $(n, 2n')$, (n, pn'), etc. The reason the correction can be very large for high-energy neutron capture is that inelastic scattering is large compared to capture, capture decreases rapidly with energy, and inelastic scattering degrades neutrons into a higher capture cross-section energy region. The effect is greatly enhanced at higher energies when $(n, 2n)$, etc., reactions occur, for then more neutrons are emitted with even greater energy loss below the primary neutron energy. Of course, multiple-reaction corrections should be checked in every experiment, but they are of lesser importance for reactions other than neutron radiative capture. We offer below simple estimates of the magnitude of the correction for a few isotopes.

Because the correction is a multiple-interaction effect, the smaller the sample, the smaller the effect. A brief survey shows that capture samples in the range from about 0.01 cm[5] to 10 cm[6] thickness are not unusual. Since each experiment would require analysis appropriate to its own configuration, we have the freedom of demonstrating the importance of the correction for a simple configuration. We take a neutron beam normally incident on a very wide slab sample of 0.1275 cm thickness.[7] We are also justified in using simple analysis which is, however, adequate to establish the magnitude of the correction. Accordingly, we take all secondary neutrons to be isotropic and we calculate the secondary escape probability using the theory of Case, de Hoffmann, and Placzek[8] and integrating over slab thickness. For low-energy inelastic scattering we use the actual level scattering,[9] summing the results; for higher energy we use simple evaporation theory for the secondary neutrons[10] and normalize to actual experimental measurements.[11] For simplicity we omit $(n, \gamma n')$ corrections to $(n, n'\gamma)$.[12] Interpolation of radiative capture cross sections at high energy is by power law between corrected experimental numbers.[3,13] Simple multiple elastic-scattering corrections,[14] which amount to less than 16%, are included.

The multiple-reaction correction is given in Table I as a percent of the estimated true cross section for four samples all of thickness 0.1275 cm. In Table II we give an example of the dependence of the correction on sample thickness. $\sigma_{n,f}$ for ^{235}U includes all neutron-induced fission

TABLE II. Multiple-reaction correction versus sample thickness. ^{238}U capture cross section, $E_n = 4$ MeV (in percent of true cross section).

Thickness (cm)	Correction (%)
0.032	19.0
0.064	36.0
0.1275	68.0
0.255	130.0

processes, e.g., $\sigma_{n,n'f}$, etc.

It is clear that multiple reactions can also occur in other parts of the apparatus than the sample itself. It is further clear that the correction occurs in the measurement of reactions other than (n,γ), for example, (n,f) which we exhibit for ^{235}U, etc.; however, for identical configurations we expect neutron capture to yield the largest relative correction.

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