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USE OF THE BORRMANN EFFECT TO PRODUCE
NEARLY MONOENERGETIC X RAYS

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A computer program has been written to calculate (1) the spectral shape and intensity of the anomalous transmission, and (2) experiments performed to measure these quantities for energies in the range from 15 to 55 keV for germanium. The code takes into consideration the effects of collimators, air attenuation, the crystal, and detector efficiency. The collimator essentially determines the full width at half maximum (FWHM) of the transmitted spectra. Figures 3 through 6 show a comparison between the theoretical and measured peak shapes for anomalous transmission at 20, 30, 40 and 50 keV. In each case, the theoretical curve was multiplied by the ratio of the measured-to-theoretical intensity. This shows the excellent ability of the code to predict the peak shape. The measured and calculated FWHM are shown in Table 1. For low energies and thick crystals, the anomalously transmitted x rays

are almost 100% σ -polarized. However, as you go to higher energies the degree of polarization decreases, as can be seen in Table 2 where R_p is the relative anomalous transmission. The measured intensities range from 50 to 95% of that theoretically possible, as shown in Table 3. The crystals were 1.65 mm thick for the 15-, 20-, and 25-keV measurements; 8.58 mm for 30, 35, and 40 keV; 19.48 mm for 45, 50, and 55 keV. The values of $\mu x/\gamma$, where γ is the $\cos \theta$, ranged from 19.7 to 80.4.

There is excellent agreement between the theoretical and measured peak shapes over the entire energy range, and since the crystals are not perfect it is not surprising that the measured intensities are less than what is theoretically possible. Thus, anomalous transmission is a viable method of producing a continuously variable source of monoenergetic x rays.

Fig. 3. Comparison of theoretical and measured peak shapes at 20 keV.

Fig. 5. Comparison of theoretical and measured peak shapes at 40 keV.

Fig. 4. Comparison of theoretical and measured peak shapes at 30 keV.

Fig. 6. Comparison of theoretical and measured peak shapes at 50 keV.

Table 1. Measured and Calculated FWHM for Germanium

E	FWHM	
	Calculated	Measured
15	1.07	1.08 ± 0.03
20	1.94	1.99 ± 0.05
25	3.11	3.03 ± 0.09
30	2.59	2.73 ± 0.15
35	3.80	3.6 ± 0.2
40	4.45	4.5 ± 0.2
45	5.73	5.8 ± 0.2
50	5.92	6.7 ± 0.3
55	9.54	9.4 ± 0.3

Table 2. Polarisation of the Anomalous Transmission

E	$\frac{1-R_{\parallel}^A}{(1-R_{\parallel}^A + R_{\perp}^A)}$	
	Ge	GeTe
15	1.00	—
20	0.86	—
25	0.65	—
30	0.80	—
35	0.67	—
40	0.60	—
45	0.63	0.58
50	0.58	0.55
55	0.56	0.53

Table 3. Anomalous Transmission Intensities

E(keV)	I _m (photons/s)	I _e (photons/s)	R	XFACY	I _{IR} /γ
15	1.65	2.62	0.63	1.07×10^{-7}	80.4
20	13.0	24.4	0.61	1.20×10^{-6}	36.7
25	26.4	45.5	0.58	4.86×10^{-6}	19.7
30	2.68	4.63	0.56	5.06×10^{-7}	43.8
35	13.3	15.5	0.86	1.89×10^{-6}	39.0
40	25.8	27.2	0.95	4.38×10^{-6}	26.5
45	14.5	18.3	0.79	1.50×10^{-6}	42.8
50	21.5	29.6	0.79	2.95×10^{-6}	31.6
55	35.0	36.9	0.95	4.87×10^{-6}	24.0

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