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E. I. du Pont de Nemours and Co.
Savannah River Laboratory
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SECTION I

PHYSICS EXPERIMENTS FOR CANDU LATTICES

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INTRODUCTION

In FY-1966 a series of experiments with mockups of burned-up D_2O reactor fuels were performed in the Process Development Pile (PDP) and Subcritical Experiment (SE). This report is concerned with a continuing analysis of these experiments. Preparations are also underway for new experiments to be performed in the PDP in June to measure $\frac{1}{\eta}\frac{d\eta}{dT}$ and the effects of asymmetric control rod placement.

SUMMARY

Analyses of substitution buckling measurements with the mocked-up burned-up fuel in the PDP have been largely completed and the results compared with calculations by the HAMMER code.

DISCUSSION

PDP Substitution Measurements

The analysis of substitution buckling measurements in the PDP is nearing completion. The experimental data have been analyzed by three methods; a heterogeneous method, a one-group perturbation method, and a two-group two-region analysis.

The heterogeneous method utilized the HERESY code, which is based on source-sink theory. This code has been shown to be quite accurate in analysis of previous substitution measurements. The primary limitation of the method is a lack of consistency in treating test fuels for which k_∞ is less than unity. Work still in progress is expected to minimize this difficulty.

The perturbation method used was the progressive substitution analysis of Persson. This method is severely affected by any non-uniformity in the test fuel pieces used in the progressive substitutions and is therefore not considered as accurate as the heterogeneous method for most cases. It was used primarily as a check on the HERESY results and for cases not treatable with HERESY.

The two-group two-region analysis used a computer code written specifically for this purpose. The code considers differences in diffusion and absorption properties between test and reference regions, but treats only cylindrical regions.

The HAMMER* cell code was used to calculate the material bucklings for comparison with the experimental results and to furnish necessary input data for the three methods of analysis. The specific way in which HAMMER was applied has been discussed in detail in previous reports.

Three different reference lattices were used in the experiments. Descriptions of the lattices and pertinent data are shown in Table I. The buckling values were measured twice in each lattice by gold pin flux traverses.

The material buckling results are shown in Table II. The error flags shown reflect the confidence in analysis in most cases. Random and systematic error in the performance of the experiments is felt to be less than the uncertainty in analysis for all cases with a probable error greater than $\pm 0.20\ cm^{-2}$.

These results are more complete than the preliminary results reported in DPST-66-83-8.

A comparison of experimental buckling results with the bucklings calculated by HAMMER is shown in Figures 1 through 3. The purpose of these figures is to show any inconsistencies in experimental or calculated results. Figure 3, which gives the results for lattice number three, shows a larger average difference between experimental and calculated results than is seen in the other two lattices. It has been found that HAMMER, using the Nordheim treatment for resonance capture, underestimates the material buckling at small moderator-to-fuel ratios. This effect is believed to account for the discrepancy and is currently under study.

The comparisons indicate, as expected, that the experimental results are less reliable for the very low buckling cases. In those cases with HB-40 as coolant, the HAMMER estimate of the buckling may be in error.

* DP-1064.

TABLE I

Reference Lattice Data

Lattice No. 1

Loading; 85 19-rod clusters at 9.33-inch triangular pitch.

$B_z^2 = 1.909\ m^{-2}$

$B_r^2 = 3.69\ m^{-2}$

$B_m^2 = 5.60\ m^{-2} \pm 0.16$

Lattice No. 2

Loading; 85 31-rod clusters at 12.12-inch triangular pitch.

$B_z^2 = 2.588\ m^{-2}$

$B_r^2 = 2.14\ m^{-2}$

$B_m^2 = 4.72\ m^{-2} \pm 0.14$

Lattice No. 3

Loading; 121 31-rod clusters at 9.33-inch triangular pitch.

$B_z^2 = 2.849\ m^{-2}$

$B_r^2 = 2.44\ m^{-2}$

$B_m^2 = 5.29\ m^{-2} \pm 0.16$

NOTE: The buckling values are for the reference lattices with control rod guide tubes in place; i.e., as in the substitution measurements.

TABLE II

MATERIAL BUCKLINGS FROM ANALYSIS OF PDP SUBSTITUTIONS

Experiments	Buckling, m^{-2}, for Fuel Type[a]				
	A	B	C	D	E
Lattice 1, 19 rods/cluster, 9.33-inch pitch					
Coolant					
D_2O	4.40 ±.10	5.22 ±.10	7.20 ±.10	0.15 ±.30	5.34 ±.10
HB-40[b]	1.45 ±.30	1.80 ±.20	(c)	-3.25 ±.75	(c)
Void	4.56 ±.10	5.30 ±.10	7.25 ±.20	0.15 ±.30	5.45 ±.10
Lattice 2, 31 rods/cluster, 12.12-inch pitch					
Coolant					
D_2O	3.50 ±.25	4.28 ±.10	6.00 ±.20	0.03 ±.30	4.41 ±.10
HB-40[b]	0.50 ±.50	0.80 ±.40	2.90 ±.25	-3.14 ±1.00	1.00 ±.60
Void	3.94 ±.10	4.60 ±.10	6.42 ±.15	0.20 ±.50	4.70 ±.10
Lattice 3, 31 rods/cluster, 9.33-inch pitch					
Coolant					
D_2O	3.73 ±.15	4.96 ±.10	7.22 ±.15	-1.20 ±.50	5.00 ±.10
HB-40[b]	0.84 ±.40	2.15 ±.30	4.55 ±.15	-7.00 ±1.00	1.65 ±.30
Void	3.86 ±.40	5.00 ±.10	7.25 ±.20	-0.70 ±.30	5.02 ±.10

(a) See Table I-II in DPST-66-83-8.

(b) Monsanto Company, St. Louis, Missouri.

(c) No experiment performed.

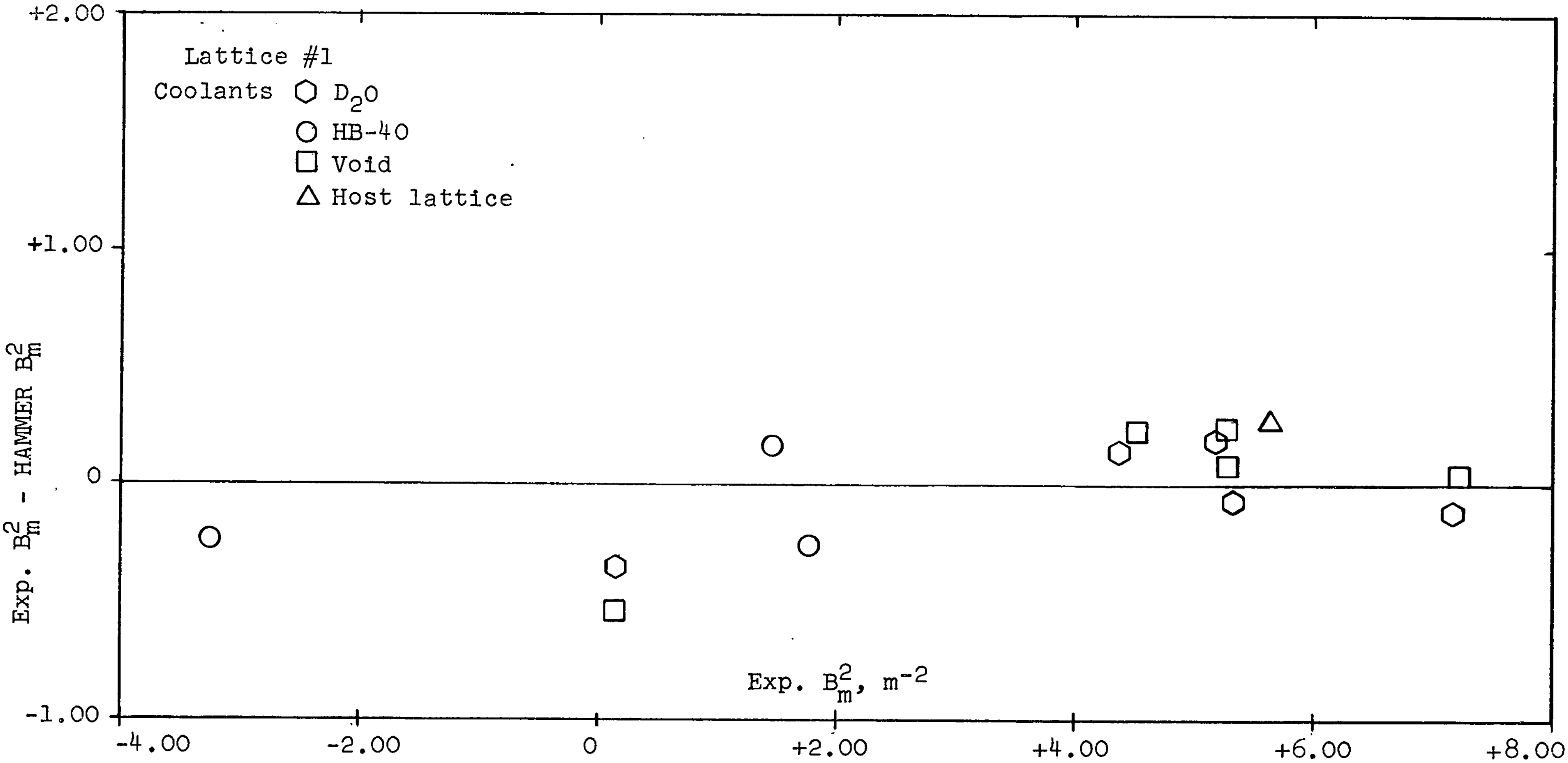

Fig. 1. Comparison of Measured Substitution Bucklings with HAMMER Calculations (19-rod cluster - 9.33-inch triangular lattice pitch)

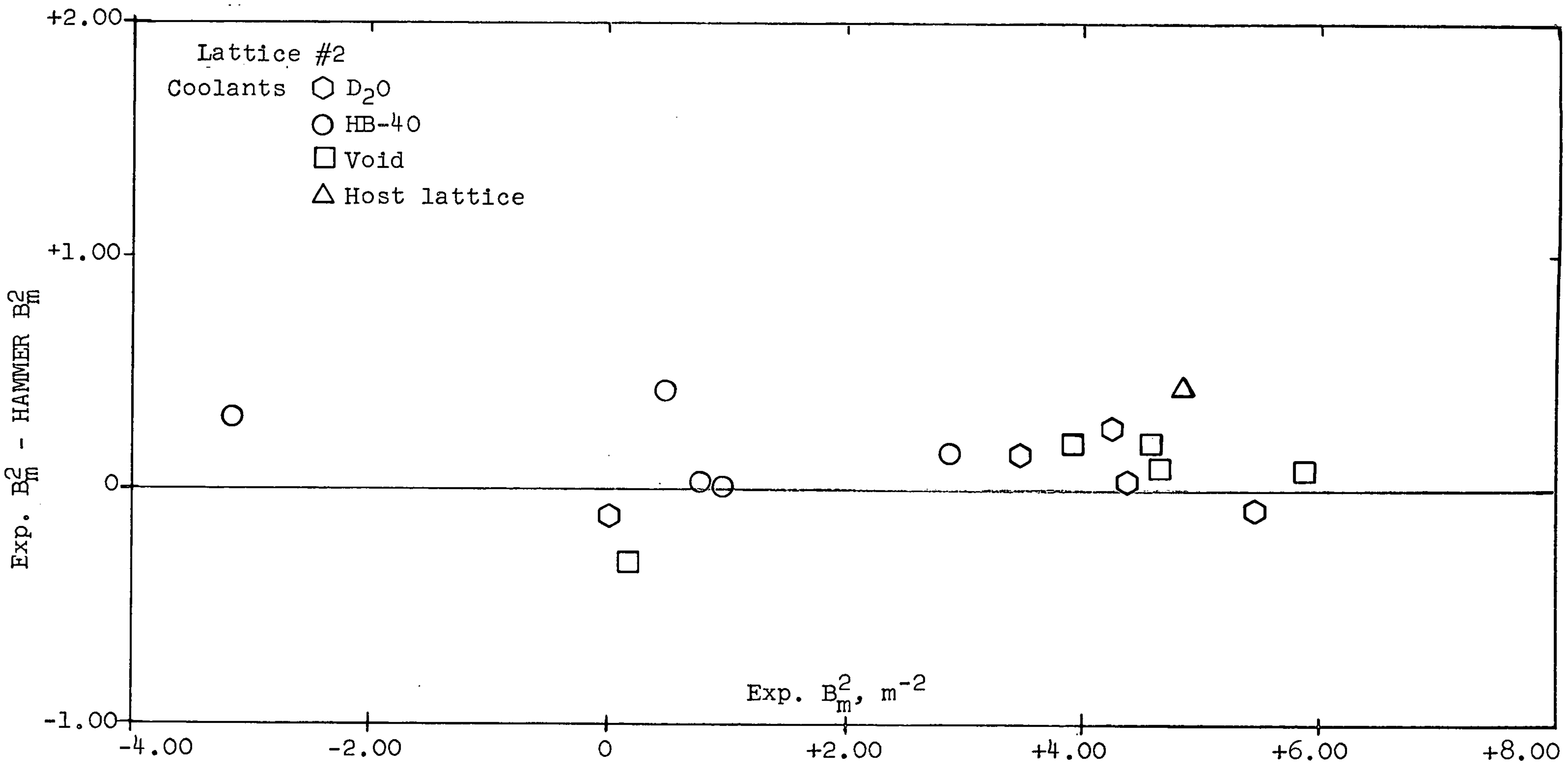

Fig. 2. Comparison of Measured Substitution Bucklings with HAMMER Calculations (31-rod clusters- 12.12-inch triangular lattice pitch)

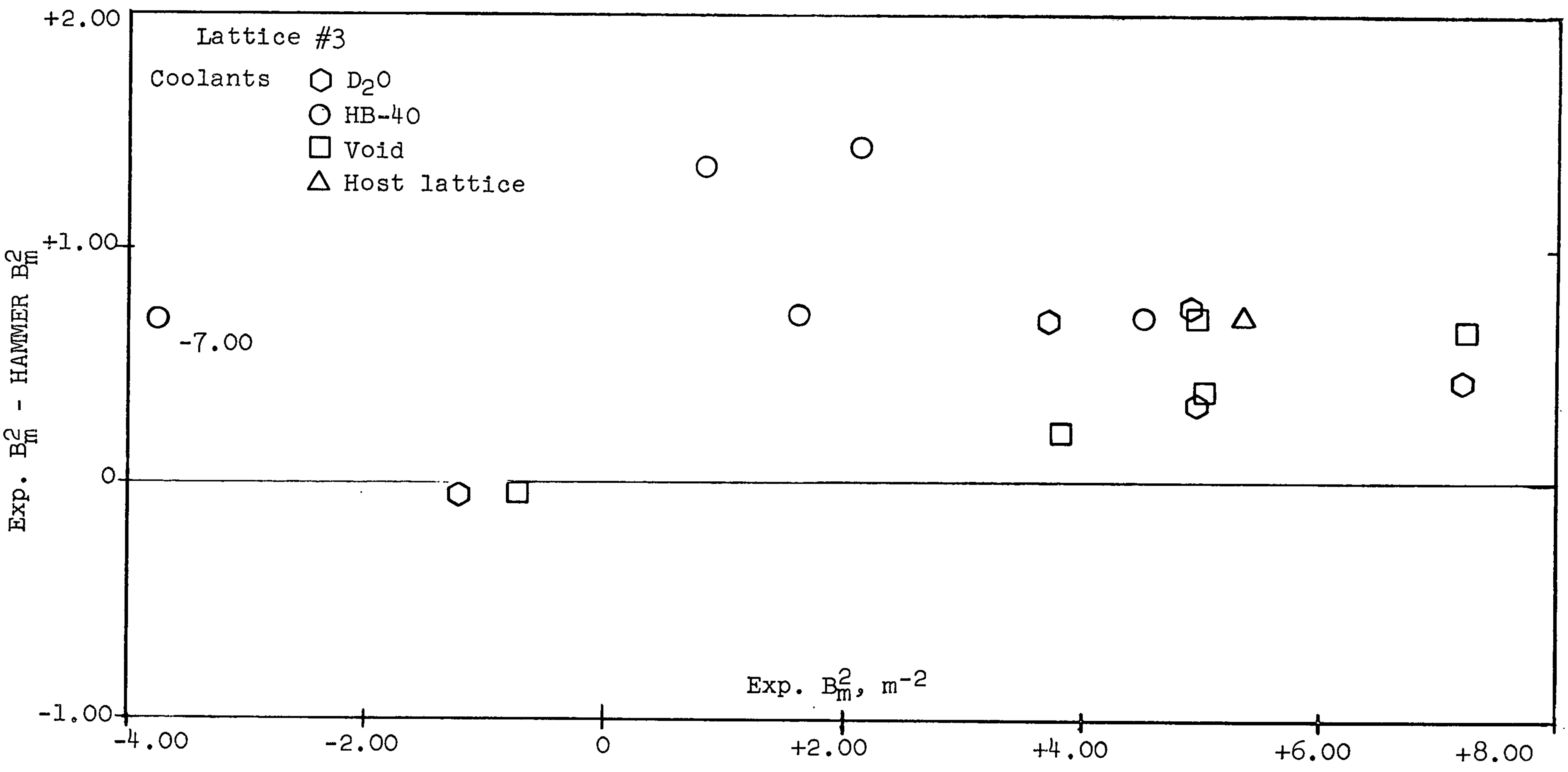

Fig. 3. Comparison of Measured Substitution Bucklings with HAMMER Calculations (31-rod clusters - 9.33-inch triangular lattice pitch)

SECTION II

AECL IN-CORE FLUX MONITORS

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An irradiation test of in-core flux monitors is being made in one of the Savannah River Plant reactors to determine the life characteristics of a selection of flux detectors and of the mineral insulation used in their construction. Self-powered flux detectors are relatively new; therefore, confidence in their use hinges to a great extent on proven performance at large integrated exposures. The chief points of interest are 1) integrity of the conductors and sheath during life, 2) life of insulation, and 3) sensitivity. The higher flux density available at SRP (vis-à-vis Chalk River) will shorten the irradiation time for a given exposure and should also show whether or not any new high intensity effects appear.

Fabrication and installation of the detector rod in the reactor has been completed and testing is in progress. There were no special tests in March. No significant changes in the detector or cable outputs from those reported in DPST-66-83-8 have occurred. The data being collected will be reported in a separate topical report at the conclusion of the tests.

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