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THE EXISTENCE OF SHORT AND LONG RANGE RELAXATION LENGTHS IN HETEROGENEOUS MEDIA*

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Experimental data[1] related to boiling water reactors show that the phase of the cross power spectra density between the detector response at two points in the system is described by a pure delay process above certain values of the frequency. For this to occur the adjoint flux ("detector field of view") must be sharply peaked around each one of the detectors,[2] which in turn implies the existence of a short range relaxation length. We show that the existence of this type of relaxation length is a direct consequence of the physical properties of heterogeneous systems and not a consequence of the number of groups used to describe the neutron field in the equivalent homogeneous system as it has been done traditionally.[1,3]

To show this point we have used a one-group neutron diffusion model which accounts explicitly for the heterogeneities of the system. The "detector field of view" in this model is described as a superposition of neutron waves which can be thought as generated by an oscillating source of importance at each detector. This neutron wave propogation

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problem has been studied by Quddus et al.,[4] who gave formal expression for the dispertion law; using their nomenclature, the inverse complex relaxation lengths are given by

$$a_0 = \left[\frac{1}{L^2} + \frac{i\omega}{vD}\right]^{1/2} . \tag{1}$$

$$a_j = \left[\frac{1}{L^2} + \frac{i\omega}{vD} + b_j^2\right]^{1/2} \tag{2}$$

where b_j are solution of the transcendental equation

$$1 = \sum_k \frac{c_p\, i}{4} H_0^{(1)} \left(b_j \left|\vec{r}_s - \vec{r}_k\right|\right) \tag{3}$$

with c_p given by

$$c_p = \frac{\eta\,(1 - \beta) - 1}{D} \gamma \tag{4}$$

in Eq. (3) the sum is over all the rods k and $H_0^{(1)}$ is the Hankel function of first kind and zero order.

As seen from this general result the theory predicts the existence of several relaxation lengths including a short one corresponding to the moderator, a_0 in Eq. (1). We have solved Eq. (3) for b_j for the case of an infinite array of rods, at delayed critical we have shown there is only one solution given by

$$b = \frac{i}{L}\left[1 - \frac{\beta}{1-f}\right]^{1/2} \qquad (5)$$

where f is thermal utilization factor. Substitution of Eq. (5) in Eq. (2) shows that one of the relaxation lengths corresponds exactly to the solution of the dispertion law for the equivalent homogeneous system. Clearly, the process of homogeneizing an heterogeneous system leads to the disappearance of the short range inverse relaxation length, a_0, in Eq. (1).

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