3.7.3 Effect of a reflector on a cylindrical reactor

As a second example of the effect of a reflector, consider the cylindrical reactor of section 3.7.1 surrounded at larger radii by a reflector as shown in figure 1 (for simplicity it is assumed that vacuum conditions pertain at both ends of the core and the reflector). Then, as in section 3.7.1, the appropriate, non-singular solution to equation 5, section 3.6.3, for the neutron flux in the core is

$$\phi = C \cos\left(\frac{\pi z}{H_E}\right) J_0(\xi_1 r) \tag{1}$$

where $H_E = H + 1/D$ as before and C and ξ_1 are constants as yet undetermined. Turning now to the solution for equation 7, section 3.7.1, in the cylindrical

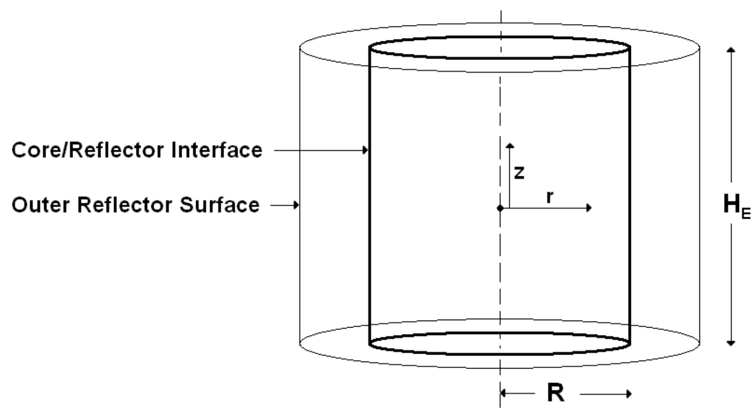

Figure 1: Cylindrical reactor with reflector.

annulus occupied by the reflector it is assumed, for simplicity, that this extends all the way from $r = R$ to $r \to \infty$ and that the reflector has the same height H_E as the core. Then, omitting terms that are singular as $r \to \infty$, the appropriate solution to equation 7, section 3.7.1, in the reflector is

$$\phi_R = C_R \cos\left(\frac{\pi z}{H_E}\right) K_0(\xi_2 r) \tag{2}$$

where ξ_2 is to be determined and K_0 is the modified Bessel function. Applying the boundary conditions at the core-reflector interface, $r = R$, (equations 8, section 3.7.1) yields the relations

$$C J_0(\xi_1 R) = C_R K_0(\xi_2 R) \quad \text{and} \quad \xi_1 D C J_1(\xi_1 R) = \xi_2 D_R C_R K_1(\xi_2 R) \tag{3}$$

and, upon elimination of C_R/C, these yield

$$D \xi_1 J_1(\xi_1 R) K_0(\xi_2 R) = D_R \xi_2 K_1(\xi_2 R) J_0(\xi_1 R) \tag{4}$$

and, in a manner analogous to equation 7, section 3.7.2, this equation must be solved numerically to determine R, the critical size of such a cylindrical reactor. The corresponding solutions for a reflector with a finite outer radius or with a reflector at the ends, though algebraically more complicated, are conceptually similar.