TALENT6: HWK 2

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The cross section for $\alpha \to \alpha$, when the particle pair α includes a neutron, is given by

$$\sigma_{\alpha\alpha} = \frac{\pi}{k_\alpha^2} \sum_{J,c\ni\alpha,c'\ni\alpha} \frac{2J+1}{(2J_{\alpha 1}+1)(2J_{\alpha 2}+1)} |\delta_{c'c} - S^J_{c'c}|^2.$$

Consider $\ell = 0$ neutron scattering from ^{16}O, a single-channel problem. Ignoring all other partial waves, show that

$$\sigma = \frac{\pi}{k^2}|1-S|^2 = \frac{4\pi}{k^2}\sin^2\delta,$$

where S is the scattering matrix and δ is the phase shift. Assume this scattering is described by a single-level R matrix using $a = 5.0$ fm, $B = 0$, $E_R = 2.212$ MeV, and $\gamma^2 = 40$ keV. Determine the width of the level. Plot the phase shift and cross section for this case, for $0 \leq E_{c.m.} \leq 4.0$ MeV. You should find an "anti-resonance" at the resonance energy. This example shows that you do not always get a classic Breit-Wigner resonance in elastic scattering, even if the resonance level is isolated. Also note that this example is actually pretty close to reality – compare your results to the data and calculation in Fig. 11 of C. H. Johnson, *Unified R-Matrix-Plus-Potential Analysis for* $^{16}\mathrm{O} + n$ *Cross Sections*, Phys. Rev. C **7**, 561-573 (1973), `https://doi.org/10.1103/PhysRevC.7.561`.