

OPTICAL THEOREM

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Reference: Griffiths, David J. (2005), Introduction to Quantum Mechanics, 2nd Edition; Pearson Education - Problem 11.19.

There is a simple relationship between the total cross section and the scattering amplitude in three dimensional scattering. The formulas are (in terms of phase shifts):

$$(1) \quad f(\theta) = \frac{1}{k} \sum_{l=0}^{\infty} (2l+1) e^{i\delta_l} \sin \delta_l P_l(\cos \theta)$$

$$(2) \quad \sigma = \frac{4\pi}{k^2} \sum_{l=0}^{\infty} (2l+1) \sin^2 \delta_l$$

If $\theta = 0$, we can use the fact that $P_l(1) = 1$ for all l (from the definition) so taking the imaginary part of $f(0)$ we get

$$(3) \quad \Im f(0) = \frac{1}{k} \sum_{l=0}^{\infty} (2l+1) \sin^2 \delta_l$$

from which we get the *optical theorem*:

$$(4) \quad \sigma = \frac{4\pi}{k} \Im f(0)$$