Physics
Theory Part 15

Topics: Solid State Physics/ Mathematical Methods

Course: B.Sc/ Physics

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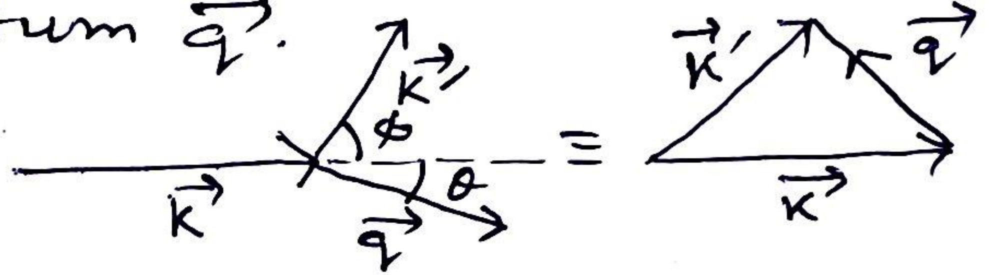
1 (a) This is a case of inelastic scattering of an electron whose initial & final momentas are $\vec{K}$, $\vec{K}'$ with emission of a phonon with momentum $\vec{q}$.

From vector diagram



$$\vec{K}' = \vec{K} + \vec{q} \quad \text{or} \quad \vec{q} = \vec{K}' - \vec{K} \quad \text{— (1)}$$

$$\text{or, } |\vec{q}|^2 = |\vec{K}' - \vec{K}|^2 = K'^2 + K^2 - 2\vec{K} \times \vec{K}' \cos\phi \quad \text{or, } \cos\phi = \frac{K'^2 + K^2 - q^2}{\vec{K} \times \vec{K}'}$$

$$\text{or, } \cos\phi = \frac{K'^2 + K^2 - |\vec{K}' - \vec{K}|^2}{\vec{K} \cdot \vec{K}'} = \frac{\cancel{K'^2} + \cancel{K^2} - \cancel{K'^2} - \cancel{K^2} + 2\vec{K} \cdot \vec{K}'}{KK'} = \frac{\vec{K} \cdot \vec{K}'}{KK'}$$

$$= \frac{\vec{K} \cdot (\vec{K} + \vec{q})}{K |\vec{K} + \vec{q}|} = \frac{K^2 + \vec{K} \cdot \vec{q}}{K\sqrt{K^2 + q^2 + 2\vec{K} \cdot \vec{q}}} = \frac{K^2 + Kq\cos\theta}{K\sqrt{K^2 + q^2 + 2Kq\cos\theta}}$$

$$\boxed{\cos\phi = \frac{K + q\cos\theta}{\sqrt{K^2 + q^2 + 2Kq\cos\theta}} = \frac{\vec{K} \cdot \vec{K}'}{KK'}}$$

QED

(b) This eqn. is known as the vector form of stoke's Theorem

$$\oint f(\vec{r})\, d\vec{l} = -\iint_S \nabla f(r) \times d\vec{s}$$

~~L.H.S~~ ~~Let the~~ scalar field $f(\vec{r})$. Let $\vec{F} = f\vec{a}$ for some constant vector $\vec{a}$, then L.H.S becomes

$$\oint f\vec{a}\cdot d\vec{l} = \iint_S \nabla \times (f\vec{a})\cdot d\vec{s} \quad \text{(By stoke's Theorem)}$$

$$= \iint_S (\nabla f \times \vec{a})\cdot d\vec{s} = -\vec{a}\cdot \iint_S \nabla f \times d\vec{s}$$

$$= -\iint \nabla f(r) \times d\vec{s} \quad \text{for } \vec{a} = \hat{i}, \hat{j} \,\&\, \hat{k} \text{ in turn}$$

$$\therefore \boxed{\oint f(r)\, d\vec{l} = -\iint_S \nabla f(r) \times d\vec{s}} \quad \text{Corollary}$$

This is the vector form of the Stoke's law.
Line integral of a continuous fn. $f(r)$ is equal to the surface integral of the curl of this fn. with vector area.

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