

Formula Phys660

$$[\hat{A}\hat{B}, \hat{C}\hat{D}] = \hat{A}[\hat{B}, \hat{C}]\hat{D} + \hat{A}\hat{C}[\hat{B}, \hat{D}] + [\hat{A}, \hat{C}]\hat{D}\hat{B} + \hat{C}[\hat{A}, \hat{D}]\hat{B} \quad (1)$$

$$[\hat{A}\hat{B}, \hat{C}\hat{D}] = \hat{A}\{\hat{B}, \hat{C}\}\hat{D} - \hat{A}\hat{C}\{\hat{B}, \hat{D}\} + \{\hat{A}, \hat{C}\}\hat{D}\hat{B} - \hat{C}\{\hat{A}, \hat{D}\}\hat{B} \quad (2)$$

$$[\hat{x}, g(\hat{p})] = i\hbar \frac{\partial g(\hat{p})}{\partial \hat{p}} \quad (3)$$

$$[\hat{p}, f(\hat{x})] = -i\hbar \frac{\partial f(\hat{x})}{\partial \hat{x}} \quad (4)$$

$$e^{\hat{A}}\hat{B}e^{-\hat{A}} = \hat{B} + [\hat{A}, \hat{B}] + \frac{1}{2!}[\hat{A}, [\hat{A}, \hat{B}]] + \frac{1}{3!}[\hat{A}, [\hat{A}, [\hat{A}, \hat{B}]]] + \dots \quad (5)$$

$$(6)$$

$$if [\hat{A}, \hat{C}] = i\hat{B}, [\hat{B}, \hat{C}] = -i\hat{A}, \quad (7)$$

$$e^{i\theta\hat{C}}\hat{B}e^{-i\theta\hat{C}} = \hat{B}\cos\theta - \hat{A}\sin\theta \quad (8)$$

$$e^{i\theta\hat{C}}\hat{A}e^{-i\theta\hat{C}} = \hat{A}\cos\theta + \hat{B}\sin\theta. \quad (9)$$

$$(10)$$

$$e^{\hat{A}+\hat{B}} = e^{\hat{A}}e^{\hat{B}}e^{-\frac{1}{2}[\hat{A}, \hat{B}]} = e^{\hat{B}}e^{\hat{A}}e^{\frac{1}{2}[\hat{A}, \hat{B}]} \quad (11)$$