IMPULS MOMENTINING KVADRATI $\hat{L}^2$ OPERATORINI SFERIK KOORDINATALAR TIZIMIDA IFODALASH

Nasirova Nigora Karimovna
Buxoro davlat universiteti Fizika kafedrasi katta o'qituvchisi
To'raqulov Shahzod Shahobiddinjonovich
Buxoro davlat universiteti Fizika yo'nalishi talabasi

Annotatsiya: Klassik mexanikani vujudga kelishi differensial va integral hisoblash metodlarining rivojlanishi bilan chanbarchas bog'liq. Elektrodinamika fanini va Eynshteynning relyativistik mexanikasini paydo bo'lishi esa, vektor va tenzor analizning keng hamda har tomonlama qo'llanishi bilan bog'liq. Kvant mexanikasining asosiy qonunlarini aniq va to'g'ri ifodalash uchun matematiklar tomonidan ishlatilayotgan tushunchalar va g'oyalarni shu fanga tadbiq qilish lozim edi. Kvant mexanikasidagi bu g'oyalarning eng asosiysi va keng qo'llaniladigani bu operatorlar nazariyasidir. Ishda fizik kattaliklar operatorlarini sferik koordinatalarga o'tishi hisoblangan.

Kalit so'zlar: klassik mexanika, kvant mexanikasi, operatorlar, sferik koordinatalar, Impuls momentining kvadrati $\hat{L}^2$, Impuls momentining proyeksiyasi.

Har bir fundamental fizikaviy nazariyada o'ziga xos matematik apparat qo'llaniladi. Klassik mexanikani vujudga kelishi differensial va integral hisoblash metodlarining rivojlanishi bilan chanbarchas bog'liq. Elektrodinamika fanini va Eynshteynning relyativistik mexanikasini paydo bo'lishi esa, vektor va tenzor analizning keng hamda har tomonlama qo'llanishi bilan bog'liq. Kvant mexanikasining asosiy qonunlarini aniq va to'g'ri ifodalash uchun matematiklar tomonidan ishlatilayotgan tushunchalar va g'oyalarni shu fanga tadbiq qilish lozim edi. Kvant mexanikasidagi bu g'oyalarning eng asosiysi va keng qo'llaniladigani bu operatorlar nazariyasidir.

$$\hat{M}_z = i\hbar\Big(r\sin\theta\sin\varphi\Big(\sin\theta\cos\varphi\frac{\partial}{\partial r}+\frac{\cos\theta\cos\varphi}{r}\frac{\partial}{\partial\theta}-\frac{\sin\varphi}{r\sin\theta}\frac{\partial}{\partial\varphi}\Big)$$
$$-r\sin\theta\cos\varphi\Big(\sin\varphi\sin\theta\frac{\partial}{\partial r}+\frac{\cos\theta\sin\varphi}{r}\frac{\partial}{\partial\theta}+\frac{\cos\varphi}{r\sin\theta}\Big)\Big)$$
$$= i\hbar(rsin^2\theta\sin\varphi\cos\varphi\frac{\partial}{\partial r}$$
$$+\sin\theta\sin\varphi\cos\theta\cos\varphi\frac{\partial}{\partial\theta}-sin^2\varphi\frac{\partial}{\partial\varphi}$$
$$-rsin^2\theta\sin\varphi\cos\varphi\frac{\partial}{\partial r}-\sin\theta\sin\varphi\cos\theta\cos\varphi\frac{\partial}{\partial\theta}-cos^2\varphi\frac{\partial}{\partial\varphi})$$

$$\widehat{M}_z = -i\hbar\frac{\partial}{\partial\varphi}$$

Kvant mexanikasida impuls moment kvadrati operatori fundamental ahamiyatga ega ekanligidan, uning xususiy qiymatini va xususiy funksiyasini aniqlash masalasi dolzarb masalalardan biri hisoblanishi kelib chiqadi. Avvalgi paragrafda $\widehat{M}^2$ operator uchun olingan ifodani faqat θ va φ burchaklarga ta'sir qilishini hisobga olinsa, u holda to'lqin funksiyasining ushbu burchaklarning o'ziga bog'liq qisminigina qarash mumkin, ya'ni

$$\psi = \psi(\theta,\varphi)$$

$\widehat{M}^2$ operatorning xususiy qiymatlarini aniqlab beruvchi tenglama esa

$$\hat{M}^2\,\psi = M^2\psi$$

ko'rinishda bo'ladi. $\widehat{M}^2$ ning qiymatini operatorli tenglamaga qo'yilsa va

$$\lambda = \frac{M^2}{\hbar^2}$$

belgilash kiritilsa, (2.2) tenglama quyidagi ko'rinishni oladi:

$$\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\frac{\partial}{\partial\theta}) + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\varphi^2} + \lambda\psi$$

Impuls momentining kvadrati $\hat{L}^2$ ni sferik koordinatalar tizimida ifodalamiz.

Kvant mexanikasida impuls momenti kvadrati operatori uning koordinata o'qlaridagi proyeksiyalari kvadrati operatorlarining yig'indisiga teng:

$$\hat{M}^2 = \hat{M}_x{}^2 + \hat{M}_y{}^2 + \hat{M}_Z{}^2$$

Yuqoridagi formulalarni e'tiborga olib, impuls momenti kvadratining operatori uchun

$$\widehat{M}^2 = (i\hbar(\sin\frac{\partial}{\partial\theta} + ctg\theta\cos\varphi\frac{\partial}{\partial\varphi}))^2 + \left(i\hbar(\cos\varphi\frac{\partial}{\partial\theta} - ctg\theta\sin\varphi\frac{\partial}{\partial\varphi})\right)^2$$

$$+ (-i\hbar\frac{\partial}{\partial\varphi})^2$$

$$= -\hbar^2\left(sin^2\varphi\frac{\partial^2}{\partial\theta^2}\right.$$

$$+ 2\sin\varphi\frac{\partial}{\partial\varphi}ctg\theta\cos\varphi\frac{\partial}{\partial\varphi} + cos^2\frac{\partial^2}{\partial\theta^2} - ctg^2\theta cos^2\varphi\frac{\partial^2}{\partial\varphi^2} + \frac{\partial^2}{\partial\varphi^2}$$

$$\left. - 2\cos\varphi\frac{\partial}{\partial\theta}ctg\theta\sin\varphi\frac{\partial}{\partial\varphi} + ctg^2\theta sin^2\varphi\frac{\partial^2}{\partial\varphi^2}\right)$$

$$= \frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right) + \frac{1}{sin^2\varphi}\frac{\partial^2}{\partial\varphi^2}$$

$$\hat{M}^2 = -\hbar^2\left[\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial}{\partial\theta}\right)+\frac{1}{sin^2\theta}\frac{\partial^2}{\partial\varphi^2}\right]$$

ifoda hosil qilinadi.

Adabiyotlar:

1. Блохинцев Д.И.Основны квантовой механики-М., 1983.г.стр.208-310.
2. Левич В.Г., Вдовин Ю.А., Мямлин В.А. Курс теоретической физики. Т.2. М., 1971.г.стр.354-410.
3. Nasirova N.K. Bound and ground states of a spin-boson model with at most one photon: non-integer lattice case.//Journal of Global Research in Mathematical Archives (JGRMA) 6 , (2019) PP 22-24.
4. Насырова Н.К. Методика изучения квантовой механики в программе бакалавриата.//Ученый XXI века Международный научный журнал № 5-3 , (2018). С.72-74
5. Очилов Л.И., Ашурова У.Д. Измерение силы, действующей на проводники с током со стороны магнитного поля подковообразного магнита // Наука и образование сегодня. (2020) с 9-12.
6. Очилов Л.И., Арабов Ж.О., Ашурова У.Д. Измерение преобразования потенциальной энергии в поступательную и вращательную энергию с помощью колеса максвелла //Вестник науки и образования (2020) № 18(96) Часть 2 С 18-21.
7. Hikmatov B.A. Magnit maydonda harakatlanayotgan elektronning solishtirma zaryadini aniqlash.// Involta 2022/5/5