O’ZBEKISTON RESPUBLIKASI OLIY VA O’RTA MAXSUS TA’LIM VAZIRLIGI

BUXORO DAVLAT UNIVERSITETI

Fizika –matematika fakulteti

5130100- “Matematika” kafedrasi

G`AFFOROVA DURDONA

“Ikki kanalli molekulyar rezonans modelining spectral xossalari” mavzusida

5130100-“Matematika” ta’lim yo’nalishi bo’yicha bakalavr darajasini olish uchun

BITIRUV MALAKAVIY ISHI

“Ish ko’rildi va himoya qilishga ruxsat berildi”

Ilmiy rahbar ________ dots. T.H.Rasulov
“______” _______________2019 y.

Kafedra mudiri
___________dots.N.H.Mamatova
“______” _______________2019 y.

Taqrizchi _________ PhD Z.Boltayev
“_______” ___________2019 y.

“Himoya qilishga ruxsat berildi”
Fakultet dekani __________ M.I.Daminov
“_______” ______________ 2019 y.

Buxoro-2019

Mundarija

KIRISH

«Bilimli avlod – buyuk kelajakning, tadbirkor xalq – farovon hayotning, do‘stona hamkorlik esa taraqqiyotning kafolatidir»

SH.M.Mirziyoyev

Rivojlanib borayotgan XXI asrda ilm-fan taraqqiyoti mamlakat rivojining asosi bo’lib hisoblanadi. Mamlakat rivojiga hissa qo’shish har bir yosh avlod va ilm ahli uchun sharafdir. So’nggi yillarda mamlakatimizda ta’lim tizimiga ayniqsa oliy ta’limga berilayotgan yuksak e’tibor esa yoshlarimizni yanada yuqori marralarni ko’zlab bilim olishga undaydi. Biz yoshlar ushbu yuksak e’tiborni faqatgina yaratilayotgan shart-sharoitlardan unumli foydalangan holda ilm-fanga qo’shiladigan hissamiz bilan oqlashimiz mumkin. Mamlakatimizda ta’lim sohasida amalga oshirilgan ishlar bilan bir qatorda oldimizda turgan vazifalar ham talaygina. Zero, O’zbekiston Respublikasining 2019-yilga mo’ljallangan davlat dasturida ham ilm-fanni rivojlantirish yo’lida qator muhim vazifalarni bajarishni maqsad qilib olingani ham bejiz emas.

2019-yilda mamlakatimizni rivojlantirishning eng muhim ustuvor vazifalari to‘g‘risidagi O‘zbekiston Respublikasi Prezidentining Parlamentga Murojaatnomasida Muhtaram Prezidentimiz ta’kidlaganlaridek, *“*...Yoshlarimizga munosib ta’lim berish, ularning ilm-fanga bo‘lgan intilishlarini ro‘yobga chiqarishimiz kerak. Shu maqsadda, maktabgacha ta’lim tizimini rivojlantirishimiz, o‘rta va oliy o‘quv yurtlarining moddiy-texnik bazasini, ilmiy va o‘quv jarayonlari sifatini tubdan yaxshilashimiz kerak.

Xalqimiz salomatligini mustahkamlash, sog‘lom turmush tarzini qaror toptirish, biz uchun hayotiy muhim masaladir. Takror aytaman, tinchlik va sog‘likni ta’minlasak, qolgan hamma narsaga erishamiz.

2019 yil – “Faol investitsiyalar va ijtimoiy rivojlanish yili”da ijtimoiy sohani yanada rivojlantirish uchun quyidagi vazifalarni amalga oshirish zarur.

Jumladan, ilm-fan, zamonaviy va uzluksiz ta’lim tizimini yanada takomillashtirish zarur. Xalqimizda **“ta’lim va tarbiya beshikdan boshlanadi”** degan hikmatli bir so‘z bor. Faqat ma’rifat insonni kamolga, jamiyatni taraqqiyotga yetaklaydi. Shu sababli, ta’lim sohasidagi davlat siyosati uzluksiz ta’lim tizimi prinsipiga asoslanishi, ya’ni, ta’lim bog‘chadan boshlanishi va butun umr davom etishi lozim.

Rivojlangan mamlakatlarda ta’limning to‘liq sikliga investitsiya kiritishga, ya’ni, bola 3 yoshdan 22 yoshgacha bo‘lgan davrda uning tarbiyasiga sarmoya sarflashga katta e’tibor beriladi. Chunki ana shu sarmoya jamiyatga 15-17 barobar miqdorda foyda keltiradi. Bizda esa bu ko‘rsatkich atigi 4 barobarni tashkil etadi. Binobarin, inson kapitaliga e’tiborni kuchaytirishimiz, buning uchun barcha imkoniyatlarni safarbar etishimiz shart.

Shu yo‘ldagi muhim amaliy qadam sifatida bolalarni maktabgacha ta’lim bilan qamrab olish darajasini bugungi 34 foizdan 2019 yilda 44 foizga yetkazamiz. Umumiy o‘rta ta’lim tizimini bugungi kun talablari asosida tashkil etish, farzandlarimiz har tomonlama kamol topishi uchun, barcha sharoitlarni yaratish lozim.

Oliy ta’lim tizimida tahsil olish uchun teng imkoniyat yaratishga qaratilgan ishlarni yanada kuchaytirishimiz zarur. O‘zbekistonda oliy va o‘rta maxsus ta’lim maskanlari bitiruvchilarini oliy ta’lim bilan qamrab olish o‘tgan davrda **9-10 foiz** darajasida bo‘lib kelayotgan edi. So‘nggi ikki yilda ko‘rilgan chora-tadbirlar tufayli, biz bu raqamni **15 foiz**dan oshirishga erishdik.

Lekin bu hali yetarli emas. Chunki dunyodagi rivojlangan davlatlar tajribasiga qaraydigan bo‘lsak, bu ko‘rsatkich ularda **60-70 foiz**ni tashkil etadi. Shuning uchun 2019 yilda mamlakatimizda bitiruvchilarni oliy ta’lim bilan qamrab olish darajasini **20 foiz**ga yetkazish va kelgusi yillarda oshirib borish – muhim vazifamizdir.

Oliy o‘quv yurtlari nufuzini oshirish, nodavlat ta’lim maskanlari sonini ko‘paytirib, sohaga yuqori malakali kadrlarni jalb etish va raqobatni kuchaytirish lozim.

Yoshlarimizga **bir vaqtning o‘zida bir nechta oliy o‘quv yurti**ga hujjat topshirish imkoniyatini berishimiz, o‘ylaymanki, ularning ta’lim olish huquqlarini kengaytirishga xizmat qiladi.

Oliy ta’lim muassasalariga real imkoniyatlardan kelib chiqqan holda, qabul kvotalarini mustaqil belgilash tizimini joriy etish kerak.

Bakalavriat yo‘nalishida tahsil olayotgan talabalarga xorijda o‘qishni davom ettirish imkoniyatlari yanada kengaytiriladi. Chunki jamiyatimizda oliy ma’lumotga ega, yuksak malakali mutaxassislar qancha ko‘p bo‘lsa, rivojlanish shuncha tez va samarali bo‘ladi. Vazirlar Mahkamasi ushbu takliflar yuzasidan ikki oy muddatda tegishli chora-tadbirlar ishlab chiqishi kerak.

Oliy ta’lim muassasalarida ilmiy salohiyatni yanada oshirish, **ilmiy va ilmiy-pedagog kadrlar tayyorlash ko‘lamini kengaytirish** – eng muhim masalalardan biridir.

Har bir ishlab chiqarish sohasida tarmoq ilmiy-tadqiqot muassasalari, konstruktorlik byurolari, tajriba-ishlab chiqarish va innovatsion markazlar bo‘lishi maqsadga muvofiqdir.

Biz mamlakatimizda investitsiyalarni faqatgina iqtisodiyot tarmoqlariga emas, balki ilmiy ishlanmalar **“nou-xau”**lar sohasiga ham keng jalb qilishimiz kerak.

Mamlakatimiz aholisining qariyb yarmini tashkil etadigan yoshlar bilan ishlash masalasi, bundan buyon ham eng asosiy vazifalarimizdan biri bo‘lib qoladi. Yoshlarni tadbirkorlikka keng jalb etish, ularning bandligini ta’minlash maqsadida **“Yoshlar – kelajagimiz” jamg‘armasi** faoliyatini yanada kengaytirish zarur.

2019 yilda jamg‘arma uchun 2 trillion so‘mdan ziyod mablag‘ ajratish va shu orqali 50 mingdan ortiq yangi ish o‘rni yaratish lozim.

Farzandlarimizning turli radikal va zararli g‘oyalar ta’siriga tushib qolishiga yo‘l qo‘ymaslik – asosiy vazifamizdir. Bu boradagi ishlarni yangicha yondashuvlar bilan davom ettirishimiz kerak.

Jumladan, davlat-xususiy sheriklik asosida yangi madaniyat va istirohat bog‘larini tashkil etish, ularni zamonaviy yoshlar maskanlariga aylantirish choralarini ko‘rish zarur. Ushbu bog‘lar tarkibida birinchi navbatda sport maydonchalari, amfiteatr va kichik sahnalar, kutubxona, “Kitob kafelari” bo‘lishi lozim.

Bugungi kunda yoshlarimizning bilim va ma’lumot olishining asosiy manbai Internet ekani hech kimga sir emas. Shu sababli tadbirkorlarni qo‘llab-quvvatlagan holda, jamoat joylarida bepul “vay-fay” hududlarini tashkil etish choralarini ko‘rishimiz kerak…”

Shuningdek, Prezident Shavkat Mirziyoyevning O‘zbekiston Respublikasi Konstitutsiyasi qabul qilinganining 26 yilligiga bag‘ishlangan tantanali marosimdagi ma’ruzasida *“*...Joriy yilda xalq ta’limi tizimini isloh qilish, pedagog-o‘qituvchilar uchun munosib mehnat sharoitini yaratish bo‘yicha ham sezilarli ishlar amalga oshirildi. O‘qituvchilarning ish haqi bosqichma-bosqich ko‘paytirilib, ularni rag‘batlantirishning yangi mexanizmlari joriy qilinmoqda.

Ta’lim tizimining keyingi bosqichi – oliy ta’lim sohasida ham salmoqli islohotlar olib borilmoqda. So‘nggi ikki yilda mamlakatimizda 5 ta yangi oliy ta’lim muassasasi hamda 12 ta nufuzli xorijiy oliy o‘quv yurtining filiallari tashkil etildi.

Mamlakatimiz taraqqiyoti uchun iste’dodli kadrlarni yetakchi xorijiy ta’lim markazlarida tayyorlash va malakasini oshirish maqsadida “El-yurt umidi” jamg‘armasi tashkil etilganidan xabaringiz bor.

Qanday og‘ir bo‘lmasin, tan olishimiz kerak, yurtimiz ravnaqi uchun eng zarur yo‘nalishlar bo‘yicha izlanuvchan, iste’dodli yosh kadrlarni chetda, rivojlangan davlatlarda o‘qitishga majburmiz. Shuning uchun ham Oliy va o‘rta maxsus ta’lim vazirligi, oliy o‘quv yurtlari, mamlakatimizdagi ilmiy markazlar “El-yurt umidi” jamg‘armasi bilan yaqin hamkorlikda samarali ish olib borishi kerak…" degan fikrlarni ilgari surganlar. Yuqoridagi qilinayotgan say'i-harakatlar nafaqat yoshlarimizni bilim olishiga, balki ularning olingan bilimlardan unumli foydalangan holda taraqqiyotimizga sezilarli hissa qo'shishga undaydi.

Oliy ta'lim malakali pedagoglarni tayyorlashda muhim tizim bo'lib hisoblanadi. Aniq fanlar esa oliy ta'limning asosini tashkil etadi. Mamlakatimiz siyosatida oliy ta'limni qo'llab – quvvatlash bilan birgalikda aniq fanlarning rivojiga ham muhim e'tibor qaratilmoqda.

Binobarin, Prezidentimiz Shavkat Miromonovich Mirziyoyevning Oliy Majlisga qilgan birinchi Murojaatnomalarida "…Joylardagi o'qituvchilarga bo'lgan ehtiyojni qoplash uchun Toshkent viloyatida Chirchiq davlat pedagogika instituti tashkil etildi. Bundan tashqari, 15 ta oliy ta'lim muassasasida tashkil etilgan maxsus sirtqi bo'limlarda o'rta maxsus ma'lumotga ega bo'lgan 5 mingdan ortiq pedagoglar uchun oliy ma'lumot olish imkoniyati yaratildi. Ta'lim tizimidagi innovatsiya va kreativ yondashuvlar asosida Muhammad Xorazmiy va Mirzo Ulug'bek nomlari bilan ataladigan, aniq fanlar chuqur o'qitiladigan maxsus maktablar tashkil etildi. Oliy ta'lim tizimini yanada takomillashtirish borasida ham ko'plab ishlar amalga oshirilmoqda. Jumladan, 2017-2021 yillarda oliy ta'lim tizimini kompleks rivojlantirish dasturi qabul qilindi. Yangi tashkil etilgan institut va filiallar hisobidan yurtimizdagi oliy ta'lim muassasalari soni 81 taga, hududlardagi filiallar 15 taga, xorijiy universitetlar filiallari 7 taga yetdi. Shular qatorida Olmaliq shahrida Moskva po'lat va qotishmalar institutining, Toshkent shahrida esa AQShning Vebster universitetining filiallarini tashkil etish bo'yicha kelishuvlarga erishilganini ta'kidlash lozim. Oliy ta'lim muassasalarida iqtisodiyotning real sektoridagi talab va ehtiyojdan kelib chiqib, sirtqi va kechki bo'limlar ochildi. O'zbekiston Fanlar akademiyasi tizimi takomillashtirildi, moddiy-texnik bazasi mustahkamlandi, uning tarkibida bir qator ilmiy-tadqiqot institutlari va markazlar faoliyati tiklandi. Ko'p yillik tanaffusdan so'ng Fanlar akademiyasiga saylov o'tkazilib, o'zining ilmiy ishlari bilan mamlakatimiz va xalqaro miqyosda nom qozongan iste'dodli olimlar akademik degan yuksak sharafga sazovor bo'ldilar. Endi barchamiz Fanlar akademiyasidan yangi ilmiy ishlanmalar, istiqbolli tadqiqotlar yaratish bo‘yicha amaliy natijalar kutib qolamiz. Bularning barchasidan biz yagona bir maqsadni ko‘zda tutmoqdamiz. Ya’ni O‘zbekiston ilm-fan, intellektual salohiyat sohasida, zamonaviy kadrlar, yuksak texnologiyalar borasida dunyo miqyosida raqobatbardosh bo‘lishi shart…” deb ta`kidlab o’tganlar.

Yuqoridagilardan kelib chiqqan holda oliy ta’limning muhim bo’lagi hisoblanuvchi bitiruv malakaviy ishlarini (BMI) to’liq, sifatli, namunali tarzda yaratilishi muhim ahamiyatga ega. Zeroki, BMIni talabaning ta’lim jarayonida egallagan bilimlarining ko’zgusi desak mubolag’a bo’lmaydi. Uning muallifi BMIning predmeti, obyekti, maqsadi, vazifasi hamda uning dolzarbligiga e’tibor qaratishi lozim.

Bitiruv malakaviy ishi mavzusining dolzarbligi: Ma’lumki, kvant maydon nazariyasi, qattiq jismlar nazariyasi, kvant fizikasi, statistik fizika, magneto gidrodinamika va yana ko’plab sohalarda ikki kanalli molekulyar rezonans modeli bilan bog’liq qiziqarli masalalar uchrab turadi. Xususan, bunday modellarning xos qiymatlari sonini o’rganish ko’plab masalalar uchun asos bo’lib xizmat qiladi. Ko’p hollarda o’rganilgan model umumlashgan Fridrixs modeli ham ataladi. Shu sababli bitiruv malakaviy ishining mavzusi zamonaviy matematik fizikaning dolzarb masalalardan biri hisoblanadi.

Bitiruv malakaviy ishi mavzusining maqsadi: Bitiruv malakaviy ishida ko’zlangan asosiy maqsad birinchi kanal va ikkinchi kanal deb ataluvchi fazolar to’g’ri yig’indisida ta’sir qiluvchi ko’pi bilan $n+2$ o’lchamli qo’zg’alishga ega molekulyar rezonans modelining muhim spektrini, Fredgolm determinantini, xos qiymatlar sonini hamda rezolventa operatorini o’rganishdir. Xos qiymatlar sonini qo’zg’alish o’lchamidan bog’liq holda o’rganish hozirda muhim masala sanaladi.

Bitiruv malakaviy ishi mavzusining vazifalari: Bitiruv malakaviy ishini bajarish uchun quyidagi vazifalar qo’yiladi,

1) Funksional analizning fazolar to’g’ri yig’indisi hamda unda aniqlangan chiziqli chegaralangan operatorlar bilan bog’liq ma’lumotlarni o’rganish;

2) Qo’zg’alish o’lchami xususiy va umumiy bo’lgan hollarda molekulyar rezonans modelning muhim spektrini, diskret spektri, Fredgolm determinantini hamda rezolventa operatorini o’rganish. Qo’zg’alish o’lchami ortib borishi bilan xos qiymatlar sonining o’sib borishini tadqiq qilish.

Bitiruv malakaviy ishi mavzusining o’rganilganlik darajasi: Bitiruv malakaviy ishida qo’yilgan barcha vazifalar to’liq bajarildi. Masala to’liq o’z yechimini topdi.

Bitiruv malakaviy ishi mavzusining predmeti: Matematik analiz, chiziqli algebra, funksional analiz, kompleks analiz elementlari.

Bitiruv malakaviy ishi mavzusining obyekti: Kanal fazolar, molekulyar rezonans modeli, muhim spektr, Fredgolm determinanti, diskret spektr, rezolventa operatori.

Bitiruv malakaviy ishi mavzusining amaliy ahamiyati: Bitiruv malakaviy ishida keltirilgan ma’lumotlardan bakalavriatning uchinchi, to’rtinchi-bosqich talabalarini funksional analiz, funksional analizning tanlangan boblari fanlarini magistraturaning matematika mutaxasisligi bo’yicha tehsil olayotgan magistrlarni “O’z-o’ziga qo’shma operatorlar”, “operatorli matritsalarning spektral nazariyasi” fanlarni o’qitishda o’quv-uslubiy qo’llanma sifatida foydalanish mumkin. Bundan tashqari undan operatorlar spektral nazariyasi bo’yich ilmiy tadqiqot ishlari olib borayotgan iqtidorli talabalar, magistrlar, yosh olimlar foydalanishlari mumkin.

Bitiruv malakaviy ishi mavzusining metodologik asosi: Chiziqli operatorlar spektral nazariyasi elementlarini ikki kanalli molekulyar rezonans modelning muhim va diskret spektrlarini, Fredgolm determinantlarini hamda rezolventa operatorini o’rganishda qo’llash.

Bitiruv malakaviy ishi mavzusining metodlari: Bitiruv malakaviy ishini yoritishda funksional va kompleks analiz usullaridan foydalanildi.

<u>Bitiruv malakaviy ishi mavzusining tarkibi va hajmi:</u> Bitiruv malakaviy ishi mundarija, kirish, 2 ta bob, 7 ta paragraf, har bir bob uchun xulosa, xotima va foydalanilgan adabiyotlar ro'yxatidan iborat bo'lib,55 sahifadan iborat.

I BOB. Bir va ikki o'lchamli holda ikki kanalli molekulyar rezonans modelning spektral xossalari

1.1. Fok fazolari va uning qirqilgan qism fazolari

C-bir o'lchamli kompelks sonlar fazosi bo'lsin. Ixtiyoriy $m\epsilon N$ natural soni uchun $L_2[a,b]$ orqali $[a,b]^n$da aniqlangan kvadrati bilan integrallanuvchi funksiyalarning Gilbert fazosini belgilaymiz. Quyidagicha belgilashlar kiritamiz

$$H_0 \coloneqq C, H_n \coloneqq L_2([a,b]^n), n\epsilon N$$

$$H^{(m)} \coloneqq \bigoplus_{n=0}^{m} H_n, H^{(m)} \coloneqq \bigoplus_{n=0}^{\infty} H_n$$

1.1.1-Ta'rif. H Gilbert fazoga Fok fazosi deyiladi $H^{(m)}$ Gilbert fazosiga esa Fok fazosining qirqilgan m-zarrachali qism fazosi deyiladi.

Shunday qilib,

$$H^{(1)} \coloneqq H_0 \oplus H_1 = \{(f_0, f_1): f_k \epsilon H_k, k = 0,1\}$$

$$H^{(2)} \coloneqq H_0 \oplus H_1 \oplus H_2 = \{(f_0, f_1, f_2): f_k \epsilon H_k, k = 0,1,2\}$$

…….. ……… ……….. …….

$$H^{(m)} \coloneqq H_0 \oplus H_1 \oplus H_2 \oplus \dots \oplus H_m = \{(f_0, f_1, f_2 \dots f_m): f_k \epsilon H_k, k = 0, m\}$$

Odatda $L_2[a,b]$ fazo yordamida qurilgan Fok fazosi $F(L_2[a,b])$ kabi belgilanadi.

$m\epsilon N$ fiksirlangan natural son bo'lsin. Ixtiyoriy ikkita $f = (f_0, f_1, \dots, f_m)\epsilon H^{(m)}$ va $g = (g_0, g_1, \dots, g_m)\epsilon H^{(m)}$ vektor funksiyalar uchun ularning skalyar ko'paytmasi

$$(f,g) = (f_0, g_0)_0 + (f_1, g_1)_1 + \dots + (f_m, g_m)_m$$

kabi aniqlanadi,bu yerda $(f_0, g_0)_0 = f_0\overline{g_0}$: $(f_k, g_k)_k = \int_a^b f_k(t)\overline{g_k(t)}\,dt, k = \overline{0,m}$

Xuddi shuningdek, $f = (f_0, f_1, \dots, f_m)\epsilon H^{(m)}$ vektor funksiyaning normasi

$$\|f\| = \sqrt{\sum_{k=0}^{m} \|f_k\|_k^2}$$

tenglik yordamida aniqlanadi.Bunda

$$\|f_0\|_0 \coloneqq |f_0|, \|f_k\|_k \coloneqq \sqrt{\int_a^b |f_k(t)|^2\, dt}, \ \ k\epsilon\overline{1,m}$$

Endi H Fok fazosida skalyar ko'paytma va normani aniqlaymiz.

Ixtiyoriy ikkita

$$F = (f_0, f_1, \dots, f_n, \dots)\epsilon H \text{ va } G = (g_0, g_1, \dots, g_n, \dots)\epsilon H$$

Elementlar uchun ularning skalyar ko'paytmasi

$$(F, G) \coloneqq \sqrt{\sum_{k=0}^{\infty} \|f_k\|_k^2}$$

kabi aniqlanadi.

Ko'rinib turibdiki, H_0-bir o'lchamli chiziqli fazo, ixtiyoriy $n\epsilon N$ natural soni uchun H_n cheksiz o'lchamli chiziqli fazo bo'ladi.

Demak, $H^{(m)}$ va H chiziqli fazolar cheksiz o'lchamlidir. Masalan, ixtiyoriy $n\epsilon N$ natural soni uchun

$$f^{(1)} \coloneqq (0, t, 0, \dots, 0)\epsilon H^{(m)}$$

$$f^{(2)} \coloneqq (0, t^2, 0, \dots, 0)\epsilon H^{(m)}$$

$$\dots \dots \dots \dots \dots \dots \dots \dots \dots \dots$$

$$f^{(n)} \coloneqq (0, t^n, 0, \dots, 0)\epsilon H^{(m)}$$

elementlar chiziqli bog'lanmagan. Haqiqatan ham $\alpha_1, \alpha_2, \dots, \alpha_n$ sonlari uchun

$$\alpha_1 f^{(1)} + \alpha_2 f^{(2)} + \cdots + \alpha_n f^{(n)} = 0$$

tenglikni qaraymiz. Mazkur tenglik

$$\alpha_1 t + \alpha_2 t^2 + \cdots + \alpha_n t^n = 0 \quad \forall t\epsilon[a, b]$$

tenglikka ekvivalentdir. Oxirgi tenglik ixtiyoriy $t\epsilon[a, b]$da o'rinli bo'lishi uchun

$\alpha_1 = \alpha_2 = \cdots = \alpha_n = 0$ bo'lishi zarur va yetarlidir. $f^{(1)}, f^{(2)}, \dots, f^{(n)}$elementlarni chiziqli bog'lanmaganini bildiradi. Demak $dimH^{(m)} = \infty$ ekan.

Endi bozonli Fok fazosi tushunchasini kiritamiz. Ixtiyoriy $n \epsilon N$ natural soni uchun $L_2^{sym}([-a,a]^n)$orqali $[-a,a]^n$da aniqlangan, istalgan ikkita argumenti bo'yicha simmetrik bo'lgan kvadrati bilan integrallanuvchi (ummuman olganda kompleks qiymatli funksiyalarning Gilbert fazosini belgilaymiz.

$f_2(t_1,t_2) = cost_1 + cost_2$ funksiya $L_2^{sym}([-a,a]^2)$ ga tegishli element, $g_2(t_1,t_2) = cost_1 - cost_2$ funksiya esa $L_2^{sym}([-a,a]^2)$ ga tegishli bo'lmagan elementga misol bo'ladi.

1.1.2-Ta'rif: Ushbu

$$F_b\left(L_2^{sym}([-a,a]^n)\right) \coloneqq C \oplus L_2^{sym}([-a,a]^2) \oplus L_2^{sym}([-a,a]^3) \oplus \dots$$

Gilbert fazosiga bozonli Fok fazosi deyiladi.

1.2. Bir va ikki o'lchamli holda ikki kanalli molekulyar rezonans modeli chiziqli chegaralangan va o'z-o'ziga qo'shma operator sifatida

$\mathcal{H}$:=$\mathcal{H}_0 \oplus \mathcal{H}_1$ orqali 1 kanal deb ataluvchi $\mathcal{H}_0$:=C bir o'lchamli kompelks fazo va n-kanal deb ataluvchi $\mathcal{H}_1$:=$L_2(\Omega^n)$ da aniqlangan, kvadrati bilan integrallanuvchi, umuman olganda kompleks qiymatlarni qabul qiluvchi funksiyalarning Gilbert fazolaridan tashkil topgan ikki kanalli Gilbert fazoni belgilaymiz. Bunda Ω:=$[-a, a]$ va $\mathcal{H}$ fazoning elementlari f=(f_0,f_1), ko'rinishidagi vektorlar bo'lib $f_i \in \mathcal{H}_i$, i=0,1.Odatda H_0 vaH_1 fazolarga $L_2(\Omega^n)$ fazo yordamida qurilgan F($L_2(\Omega^n)$) Fok fazoning mos ravishda bir zarrachali va ikki zarrachali qism fazolari deyiladi.Ikkita f=(f_0,f_1),g=($g_{0,}g_1$)) $\in\mathcal{H}$ elementlar uchun ularning skalyar ko'paytmasi

$$(f, g)_{\mathcal{H}}=:= (f_0, g_0)_0+(f_1, g_1)_1$$

kabi aniqlanadi, bu yerda

$$(f_0, g_0)_0 \coloneqq f_0\bar{g}_0, \qquad (f_1, g_1)_1:=\int_{\Omega^n} f_1(t)\overline{g_1(t)}dt.$$

$\mathcal{H}$ Gilbert fazosida 2x2 o'lchamli

$$H:=\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix} \tag{1.2.1}$$

blok operatorli matritsani qaraymiz bu yerda H$_{ij}$:$\mathcal{H}_j \to \mathcal{H}_i$, i≤j, i,j=0,1 bir o'lchamli holda matritsaviy elementlar quyidagi formulalar yordamida aniqlanadi:

$$H_{00}f_0=\omega f_0,\ H_{01}f_1=\int_{\Omega} v(t)f_1(t)dt$$

$$H_{11} \coloneqq H_{11}^0 - K, \qquad (H_{11}^0 f_1)(x) = u(x)f_1(x)$$

$$(Kf_1)(x) = \mu\varphi(x)\int_{\Omega}\varphi(t)f_1(t)dt,\ H_{01}f_0=v(x)f_0,$$

$$\mathrm{f}_i \epsilon\mathcal{H}_i, i = 0{,}1.$$

1.2.1-lemma. $\mathcal{H}$ Gilbert fazosida (1.2.1) formula bo'yicha tasir qiluvchi H blok operatorli matritsa parametrlarga qo'yilgan yuqoridagi shartlarda chiziqli, chegaralangan va o'z-o'ziga qo'shma operator bo'ladi.

1. Ushbu

$$H{:=}\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}$$

blok operatorli matritsani chiziqli operator ekanligini isbotlaymiz.

Dastlab,

$$Hf=\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}\begin{pmatrix} f_0 \\ f_1 \end{pmatrix}=\begin{pmatrix} H_{00}f_0 + & H_{01}f_1 \\ H_{01}^{*}f_0 & H_{11}f_1 \end{pmatrix}=$$

$$=\begin{pmatrix} \omega f_0+\int_{\Omega} v(t)f_1(t)dt \\ v(x)f_0+u(x)f_1(x)-\mu\varphi\,(x)\int_{\Omega}\varphi\,(t)f_1(t)dt \end{pmatrix}$$

$$H(\alpha f+\beta g)=$$

$$=\begin{pmatrix} \omega(\alpha f_0+\beta g_0)+\int_{\Omega} v(t\,)(\alpha f_1+\beta g_1)dt \\ v(x)(\alpha f_0+\beta g_0)+u(x)(\alpha f_1+\beta g_1)-\mu\varphi\,(x)\int_{\Omega}\varphi\,(t)(\alpha f_1+\beta g_1)(t)dt \end{pmatrix}$$

$$=\begin{pmatrix} \alpha\omega f_0+\beta\omega g_0+\alpha\int_{\Omega} v(t\,)f_1dt+\beta\int_{\Omega^n} v(t\,)g_1dt. \\ \alpha v f_0+\beta v g_0+u\alpha f_1+u\beta g_1-\mu\varphi\,(x) \\ \left[\alpha\int_{\Omega}\varphi\,(t\,)f_1dt+\beta\int_{\Omega}\varphi\,(t\,)g_1dt\right] \end{pmatrix}$$

$$=\alpha\begin{pmatrix} \omega f_0+\int_{\Omega^n} v(t\,)f_1(t\,)dt \\ v(x\,)f_0+u(x\,)f_1(x)-\mu\varphi\,(x)\int_{\Omega}\varphi\,(t)f_1(t)dt \end{pmatrix}+$$

$$+\beta\begin{pmatrix} \omega g_0+\int_{\Omega^n} v(t\,)g_1(t\,)dt \\ v(x\,)g_0+u(x\,)g_1(x)-\mu\varphi\,(x)\int_{\Omega}\varphi\,(t)f_1(t)dt \end{pmatrix}=$$

$$=\alpha Hf+\beta Hg$$

Demak, Hchiziqli operator ekan.

Endi H operatorni chegaralanganlikka tekshiramiz. Buning uchun shunday $M>0$ soni topilib ixtiyoriy $f\epsilon H$ uchun

$$\|H\,f\|\leq M\|f\|$$

tengsizlik bajarilishini ko'rsatamiz. Buning uchun biz quyidagi munosabatlardan foydalanamiz

$$\|f\|^2 = \|f_0\|^2 + \|f_1\|^2$$
$$\|f_0\| = |f_0|, \|f_1\|^2 = \int_{\pi d} \|f_1\|^2$$
$$\|Hf\|^2 = \|Hf_0\|^2 + \|Hf_1\|^2$$
$$\|Hf_0\|^2 = \left|\omega f_0 + \int_\Omega v(t) f_1(t) dt\right|^2$$
$$\|Hf_1\|^2 = \int_\Omega \left|v(x) f_0 + u(x) f_1(x) - \mu\varphi(x) \int_\Omega \varphi(t) f_1(t) dt\right|^2$$

ni hosil qilamiz.

So'ngra 3 haqiqiy qiymatli a_1, a_2, a_3 sonlar uchun

$$(a_1 + a_2 + a_3)^2 \le 3|a_1|^2 + 3|a_2|^2 + 3|a_3|^2$$

tengsizlikdan foydalanamiz.

$$\|Hf_1\|^2 = \int_\Omega \left|v(x) f_0 + u(x) f_1(x) - \mu\varphi(x) \int_\Omega \varphi(t) f_1(t) dt\right|^2 \le$$
$$3\int_\Omega |v(x) f_0|^2 + 3\int_\Omega |u(x) f_1|^2 + 3\int_\Omega \left|\mu\,\varphi(x) \int_\Omega \varphi(t) f_1(t) dt\right|^2 dx$$

Endi Koshi-Bunyakovskiy tengsizligi deb atalovchi

$$|\int f(x) g(x) dx|^2 \le |\int f(x) dx|^2 |\int g(x) dx|^2$$

tengsizlikdan foydalanamiz

$$\int_\Omega |v(x) f_0|^2 \le \int_\Omega |v(x)|^2 \int_\Omega |f_0|^2$$
$$\int_\Omega |u(x) f_1|^2 \le \int_\Omega |u(x)|^2 \int_\Omega |f_1|^2$$
$$\int_\Omega \left|\mu\,\varphi(x) \int_\Omega \varphi(x) f_1(t) dt\right|^2 \le$$
$$\int_\Omega |\mu\,\varphi(x)|^2 \int_\Omega \left|\int_\Omega \varphi(t) dt\right|^2 \int_\Omega \left|\int_\Omega f_1(t) dt\right|^2 \le \|\varphi_1\|^4 \|f_1\|^2$$

yuqoridagi yig'indi

$$3\|f_1\|^2 (\mu\,\|\varphi\|^4) + 3|u|^2 \|f_1\|^2 + 3|v|^2 \|f_0\|^2$$

ifodadan kichik bo'ladi.

$$\|Hf_0\|^2 = \left|\omega f_0 + \int_\Omega v(t) f_1(t) dt\right|^2 \le 2\|\omega\|^2 \|f_0\|^2 + 2\|v\|^2 \|f_1\|^2;$$

$$\|(Hf)\|^2 = \|(Hf)_0\|^2 + \|(Hf)_1\|^2$$

$$\|(Hf)\|^2 = 2\|\omega\|^2\|f_0\|^2 + 2\|v\|^2\|f_1\|^2 + 3\|f_1\|^2(\mu \|\varphi\|^4) +$$
$$+3|u|^2\|f_1\|^2 + 3|v|^2\|f_0\|^2 = (2\|\omega\|^2 + 3|v|^2)\|f_0\|^2 + \left[(2\|v\|^2 +\right.$$
$$\left.+3\left((\mu \|\varphi\|^4) + |u|^2\right)\right]\|f_1\|^2$$
$$M^2 = max\left\{2\|\omega\|^2 + 3|v|^2, 2\|v\|^2 + 3\left((\mu \|\varphi\|^4) + |u|^2\right)\right\}$$

Demak, H operator chegaralangan operator ekan.

Endi H operatorning o'z-o'ziga qo'shma operator ekanligini ko'rsatamiz, ya'ni $f = (f_0, f_1)$ va $g = (g_0, g_1,)\epsilon H$ elementlar uchun

$$(Hf, g) = (f, Hg)$$

tenglik o'rinli bo'lishi kerak. Bizga ma'lumki,

$$(f_0, g_0) = f_0, \overline{g_0}\ ,\ \ (f_1, g_1) = \int_{\pi d} f_1(x)\overline{g_1(x)}\, dx$$
$$(f_2, g_2) = \iint_{\pi d} f_1(x, y)\overline{g_1(x, y)}\, dxdy$$

hamda

$$(Hf, g) = ((Hf)_0, g_0)_0 + ((Hf)_1, g_1)_1$$
$$(Hf, g) = \left(\omega f_0 + \int_\Omega v(t)f_1(t)dt\right)\overline{g_0} + \int_\Omega (v(x)f_0 + u(x)f_1(x) -$$
$$\mu\varphi(x)\int_\Omega \varphi(t)f_1(t)dt)dx$$

$$= \omega f_0\overline{g_0} + \left(\int_\Omega v(t)f_1(t)dt\right)\overline{g_0(t)} + \int_\Omega v(x)f_0\,\overline{g_1} + u(x)f_1\overline{g_1} -$$
$$\mu\varphi(x)\int_\Omega \varphi(t)g_1(t)dt = f_0\overline{\left(\omega g_0 + \int_{\Omega^n} v(x)\, g_1\right)} +$$
$$\int f_1(x)\overline{\left(\int_{\Omega^n} v(t) + u(x)g_1 + \mu\varphi(x)\int_\Omega \varphi(t)g_1(t)dt\right)} = (f_0, (Hg)_0) +$$
$$(f_1, (Hg)_1) = (f, Hg)$$

Demak H o'z-o'ziga qo'shma operator ekan.

1.2.1-lemma to'liq isbotlandi.

n=2 holda H –Gilbert fazosida 2×2-o'lchamli

$$H{:=}\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix} \qquad (1.2.1)$$

Blok-operatorli matritsani qaraymiz, bu yerda $H_{ij}\colon H_j \to H_i, i \le j, i, j = 0,1$ matritsaviy elementlar quyidagi formulalar yordamida aniqlanadi:

$$H_{00}f_0{=}\omega f_0,\ H_{01}f_1{=}\int_{\Omega^2} v(t_1,t_2)f_1(t_1,t_2)dt_1dt_2$$

$$H_{11} \coloneqq H_{11}^0 - K, \qquad (H_{11}^0 f_1)(x_1,x_2) = u(x_1,x_2)f_1(x_1,x_2)$$

$$(Kf_1)(x_1,x_2) =$$

$$\mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1)f_1(t_1,t_2)dt_1dt_2 + \mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2)f_1(t_1,t_2)dt_1dt_2, (H_{01}f_0)(x_1,x_2){=}v(x_1,x_2)f_0$$

$$\mathrm{f}_i \epsilon \mathcal{H}_i, i = 0,1$$

1.2.2-lemma. $\mathcal{H}$ Gilbert fazosida (1.2.1) formula bo’yicha tasir qiluvchi H blok operatorli matritsa parametrlarga qo’yilgan yuqoridagi shartlarda chiziqli, chegaralangan va o’z-o’ziga qo’shma operator bo’ladi.

Ushbu

$$H{:=}\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}$$

blok operatorli matritsani chiziqli operator ekanligini isbotlaymiz.

Dastlab,

$$Hf = \begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}\begin{pmatrix} f_0 \\ f_1 \end{pmatrix} = \begin{pmatrix} H_{00}f_0 + & H_{01}f_1 \\ H_{01}^{*}f_0 & H_{11}f_1 \end{pmatrix} =$$

$$\begin{pmatrix} \omega f_0 + \int_{\Omega^2} v(t_1,t_2)f_1(t_1,t_2)dt_1dt_2 \\ v(x_1,x_2)f_0 + u(x_1,x_2)f_1(x_1,x_2) - \\ -\mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1)f_1(t_1,t_2)dt_1dt_2 + \mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2)f_1(t_1,t_2)dt_1dt_2 \end{pmatrix}$$

$$H(\alpha f + \beta g) =$$

$$\begin{pmatrix} \omega(\alpha f_0 + \beta g_0) + \int_{\Omega^2} v(t_1,t_2)(\alpha f_1 + \beta g_1)dt_1dt_2 \\ v(x_1,x_2)(\alpha f_0 + \beta g_0) + u(x_1,x_n)(\alpha f_1 + \beta g_1) - \mu_1\varphi_1(x_1) \\ \int_{\Omega^2}\varphi_1(t_1)(\alpha f_1 + \beta g_1)dt_1dt_2 - \mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2)(\alpha f_1 + \beta g_1)dt_1dt_2 \end{pmatrix} =$$

$$= \begin{pmatrix} \alpha\omega f_0 + \beta\omega g_0 + \alpha \int_{\Omega^n} v(t_1\,, t_2) f_1 dt_1 dt_2 + \beta \int_{\Omega^2} v(t_1\,, t_2) g_1 dt_1 dt_2. \\ \alpha v f_0 + \beta v g_0 + u\alpha f_1 + u\beta g_1 - \mu_1\varphi_1(x_1) \\ \left[\alpha \int_{\Omega^2} \varphi_1(t_1) f_1 dt_1 dt_2 + \beta \int_{\Omega^2} \varphi_1(t_1) g_1 dt_1 dt_2\right] - \mu_2\varphi_2(x_2) \\ \left[\alpha \int_{\Omega^2} \varphi_2(t_2) f_1 dt_1 dt_2 + \beta \int_{\Omega^2} \varphi_2(t_2) g_1 dt_1 dt_2\right] \end{pmatrix}$$

$$= \alpha \begin{pmatrix} \omega f_0 + \int_{\Omega^n} v(t_1\,, t_2) f_1(t_1, t_2) dt_1 dt_2 \\ v(x_1, x_2) f_0 + u(x_1, x_2) f_1(x_1, x_2) - \\ -\mu_1\varphi_1(x_1) \int_{\Omega^2} \varphi_1(t_1) f_1(t_1, t_2) dt_1 dt_2 + \mu_2\varphi_2(x_2) \int_{\Omega^2} \varphi_2(t_2) f_1(t_1, t_2) dt_1 dt_2 \end{pmatrix}$$

$$+ \beta \begin{pmatrix} \omega g_0 + \int_{\Omega^n} v(t_1\,, t_2) g_1(t_1, t_2) dt_1 dt_2 \\ v(x_1, x_2) g_0 + u(x_1, x_2) g_1(x_1, x_2) - \\ -\mu_1\varphi_1(x_1) \int_{\Omega^2} \varphi_1(t_1) g_1(t_1, t_2) dt_1 dt_2 + \mu_2\varphi_2(x_2) \int_{\Omega^2} \varphi_2(t_2) g_1(t_1, t_2) dt_1 dt_2 \end{pmatrix}$$

$$= \alpha H f + \beta H g.$$

Demak, H chiziqli operator ekan.

Endi H operatorni chegaralanganlikka tekshiramiz. Buning uchun shunday $M > 0$ soni topilib ixtiyoriy $f \epsilon H$ uchun

$$\|Hf\| \le M\|f\|$$

tengsizlik bajarilishini ko'rsatamiz. Buning uchun biz quyidagi munosabatlardan foydalanamiz:

$$\|f\|^2 = \|f_0\|^2 + \|f_1\|^2$$

$$\|f_0\| = |f_0|, \|f_1\|^2 = \int_{\Omega} \|f_1\|^2$$

$$\|Hf\|^2 = \|Hf_0\|^2 + \|Hf_1\|^2$$

$$\|Hf_0\|^2 = \left|\omega f_0 + \int_{\Omega^2} v(t_1\,, t_2) f_1(t_1, t_2) dt_1 dt_2\right|^2$$

$$\|Hf_1\|^2 =$$

$$= \int_{\Omega^2} \left| \begin{matrix} v(x_1, x_2) f_0 + u(x_1, x_2) f_1(x_1, x_2) - \\ -\mu_1\varphi_1(x_1) \int\limits_{\Omega^2} \varphi_1(t_1) f_1(t_1, t_2) dt_1 dt_2 + \mu_2\varphi_2(x_2) \int\limits_{\Omega^2} \varphi_2(t_2) f_1(t_1, t_2) dt_1 dt_2 \end{matrix} \right.$$

ni hosil qilamiz

So'ngra 4 haqiqiy qiymatli a_1, a_2, a_3, a_4 sonlar uchun

$$(a_1 + a_2 + a_3 + a_4)^2 \le 4|a_1|^2 + 4|a_2|^2 + 4|a_3|^2 + 4|a_3|^2$$

tengsizlikdan foydalanamiz

$$\|Hf_1\|^2 =$$

$$= \int_{\Omega^2} \left| \begin{gathered} v(x_1, x_2)f_0 + u(x_1, x_2)f_1(x_1, x_2) - \\ -\mu_1\varphi_1(x_1) \int\limits_{\Omega^2} \varphi_1(t_1)f_1(t_1, t_2)dt_1dt_2 + \mu_2\varphi_2(x_2) \int\limits_{\Omega^2} \varphi_2(t_2)f_1(t_1, t_2)dt_1dt_2 \end{gathered} \right.$$

$$\le 4\int_{\Omega^2} |v(x_1, x_2)f_0|^2 + 4\int_{\Omega^2} |u(x_1, x_2)f_1|^2$$

$$+ 4\int_{\Omega^2} \left|\mu_1\varphi_1(x_1) \int_{\Omega^2} \varphi_1(t_1)f_1(t_1, t_2)dt_1dt_2\right|^2 dx$$

$$+ 4\int_{\Omega^2} \left|\mu_2\varphi_2(x_2) \int_{\Omega^2} \varphi_2(t_2)f_1(t_1, t_2)dt_1dt_2\right|^2 dx$$

Endi Koshi-Bunyakovskiy tengsizligi deb atalovchi

$$|\int f(x)g(x)dx|^2 \le |\int f(x)dx|^2 |\int g(x)dx|^2$$

tengsizlikdan foydalanamiz

$$\int_{\Omega^2} |v(x_1, x_2)f_0|^2 \le \int_{\Omega^2} |v(x_1, x_2)|^2 \int_{\Omega^2} |f_0|^2$$

$$\int_{\Omega^2} |u(x_1, x_2)f_1|^2 \le \int_{\Omega^2} |u(x_1, x_2)|^2 \int_{\Omega^2} |f_1|^2$$

$$\int_{\Omega^2} \left|\mu_1\varphi_1(x_1) \int_{\Omega^2} \varphi_1(t_1)f_1(t_1, t_n)dt_1dt_2\right|^2 \le$$

$$\int_{\Omega^2} |\mu_1\varphi_1(x_1)|^2 \int_{\Omega^2} \left|\int_{\Omega^2} \varphi_1(t_1)dt_1\right|^2 \int_{\Omega^2} \left|\int_{\Omega^2} f_1(t_1, t_2)dt_1dt_2\right|^2 \le$$

$$\|\varphi_1\|^4 \|f_1\|^2$$

yuqoridagi yig'indi

$$4\|f_1\|^2(\mu_1\|\varphi_1\|^4\|f_1\|^2 + \mu_2\|\varphi_2\|^4\|f_2\|^2) + 4|u|^2\|f_1\|^2 + 4|v|^2\|f_0\|^2$$

ifodadan kichik bo'ladi.

$$\|Hf_0\|^2 = \left|\omega f_0 + \int_{\Omega^2} v(t_1,t_2) f_1(t_1,t_2) dt_1, dt_2\right|^2 \leq$$

$$\leq 2\|\omega\|^2\|f_0\|^2 + 2\|v\|^2\|f_1\|^2;$$

$$\|(Hf)\|^2 = \|(Hf)_0\|^2 + \|(Hf)_1\|^2$$

$$\|(Hf)\|^2 = 2\|\omega\|^2\|f_0\|^2 + 2\|v\|^2\|f_1\|^2 + 4\|f_1\|^2(\mu_1\|\varphi_1\|^4 + \mu_2\|\varphi_2\|^4) +$$

$$+4|u|^2\|f_1\|^2 + 4|v|^2\|f_0\|^2 = (2\|\omega\|^2 + 4|v|^2)\|f_0\|^2 + \left[(2\|v\|^2 + \right.$$

$$\left.4\left((\mu_1\|\varphi_1\|^4 + \mu_2\|\varphi_2\|^4) + |u|^2\right)\right]\|f_1\|^2$$

$$M^2 = max\left\{2\|\omega\|^2 + 4|v|^2, 2\|v\|^2 + 4\left((\mu_1\|\varphi_1\|^4 + \mu_2\|\varphi_2\|^4) + |u|^2\right)\right\}$$

Demak, H operator chegaralangan operator ekan.

Endi H operatorning o'z-o'ziga qo'shma operator ekanligini ko'rsatamiz, ya'ni $f = (f_0, f_1)$ va $g = (g_0, g_1) \epsilon H$ elementlar uchun

$$(Hf, g) = (f, Hg)$$

tenglik o'rinli bo'lishi kerak. Bizga ma'lumki

$$(f_0, g_0) = f_0, \overline{g_0}\ ,\ (f_1, g_1) = \int_{\pi d} f_1(x)\overline{g_1(x)}\, dx$$

$$(f_2, g_2) = \iint_{\Omega^2} f_1(x,y)\overline{g_1(x,y)}\, dxdy$$

hamda

$$(Hf, g) = ((Hf)_0, g_0)_0 + ((Hf)_1, g_1)_1$$

$$(Hf, g) = \left(\omega f_0 + \int_{\Omega^2} v(t_1, t_2) f_1(t_1,t_2) dt_1 dt_2\right)\overline{g_0} + \int_{\Omega^2}(v(x_1,x_2) f_0 +$$

$$u(x_1,x_2) f_1(x_1,x_2) - \mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1) f_1(t_1,t_2) dt_1 dt_2 +$$

$$\mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2) f_1(t_1,t_2) dt_1 dt_2$$

$=\omega f_0\overline{g_0} +$
$\left(\int_{\Omega^2} v(t_1, t_2) f_1(t_1,t_2) dt_1 dt_2\right)\overline{g_0(t_1,t_2)} + \int_{\Omega^2} v(x_1,x_2) f_0\, \overline{g_1} + u(x_1,x_2) f_1\overline{g_1} -$
$\mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1) f_1\overline{g_1} +$
$\mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2) f_1\overline{g_1} = f_0\overline{\left(\omega g_0 + \int_{\Omega^2} v(x_1,x_n)\, g_1\right)} +$

$$\int f_1(x)\overline{\begin{pmatrix} \int_{\Omega^2} v(t_1\,, t_n) + u(x_1, x_2)g_1 + \mu_1\varphi_1(x_1) \\ \int_{\Omega^2} \varphi_1(t_1)f_1 g_1 + \mu_2\varphi_2(x_2)\int_{\Omega^2} \varphi_2(t_2)f_1 \end{pmatrix}} = (f_0, (Hg)_0) + (f_1, (Hg)_1) = (f, Hg)$$

Demak H o’z-o’ziga qo’shma operator ekan.

1.3. Bir o'lchamli holda ikki kanalli molekulyar rezonans modelning spektr va rezolventasini tadqiq qilish.

n=1 o'lchamli holda ikki kanalli molekulyar rezonans modelni qaraymiz. Bu holda:

$$H_{00}f_0=\omega f_0,\ H_{01}f_1=\int_\Omega v(t)f_1(t)dt$$

$$H_{11} := H_{11}^0 - K, \qquad (H_{11}^0 f_1)(x) = u(x)f_1(x)$$

$$(Kf_1)(x) = \mu\varphi(x)\int_\Omega \varphi(t)f_1(t)dt,\ H_{01}f_0=v(x)f_0,$$

bo'ladi.

Fredgolm determinantini qurish maqsadida $Hf = zf$ xos qiymatga nisbatan tenglamani qaraymiz. Bu tenglama quyidagi tenglamalar sistemasiga ekvivalent bo'ladi.

$$\begin{cases} \omega f_0 + \int_\Omega v(t)f_1(t)dt = zf_0 \\ v(x)f_0 + u(x)f_1(x) - \mu\varphi(x)\int_\Omega \varphi(t)f_1(t)dt = zf_1 \end{cases} \qquad (1.3.1)$$

(1.3.1)-tenglamalar sistemasini quyidagicha yozib olamiz

$$\begin{cases} (\omega - z)f_0 + \int\limits_\Omega v(t)f_1(t)dt = 0 \\ v(x)f_0 + (u(x) - z)f_1(x) - \mu\varphi(x)\int\limits_\Omega \varphi(t)f_1(t)dt = 0 \end{cases} \qquad (1.3.2)$$

(1.3.2) tenglamalar sistemasida quyidagicha belgilash kiritamiz:

$$C = \int\limits_\Omega \varphi(t)f_1(t)dt \qquad (1.3.3)$$

U holda (1.3.2)-tenglamalar sistemasini

$$\begin{cases} (\omega - z)f_0 + \int_\Omega v(t)f_1(t)dt = 0 \\ v(x)f_0 + (u(x) - z)f_1(x) - \mu\varphi(x)C = 0 \end{cases} \quad (1.3.4)$$

kabi yozish mumkin.$z \notin Imu$ bo'lganligi uchun $u(x) - z \neq 0$ bo'ladi.

(1.3.4)-tenglamalar sistemasining ikkinchi tenglamasidan $f_1(x)$ ni topib olamiz.

$$f_1(x) = -\frac{v(x)f_0}{u(x)-z} + \frac{\mu\varphi(x)C}{u(x)-z} \quad (1.3.5)$$

$f_1(x)$ uchun topilgan ifodani (4)-tenglamalar sistemasining birinchi tenglamasiga va (1.3.5) tenglikka etib qo'yamiz:

$$\begin{cases} (\omega - z)f_0 + \int_\Omega v(t)(-\frac{v(t)f_0}{u(t)-z} + \frac{\mu\varphi(t)C}{u(t)-z})dt = 0 \\ C = \int_\Omega \varphi_1(t)(-\frac{v(t)f_0}{u(t)-z} + \frac{\mu\varphi(t)C}{u(t)-z})dt \end{cases} \quad (1.3.6)$$

hamda f_0 va C ga nisbatan tenglamalar sistemasini hosil qilamiz.

$$\begin{cases} (\omega - z - \int_\Omega \frac{v^2(t)dt}{u(t)-z})f_0 + \int_\Omega v(t)(\frac{\mu\varphi(t)C}{u(t)-z})dt = 0 \\ \int_\Omega \frac{\varphi(t)v(t)dt}{u(t)-z} f_0 + (1 - \int_\Omega \frac{\mu\varphi(t)C}{u(t)-z}dt) = 0 \end{cases} \quad (1.3.7)$$

Quyidagi belgilashlarni olamiz:

$$\Delta_0(z) = \omega - z - \int_\Omega \frac{v^2(t)dt}{u(t)-z}$$

$$\Delta_1(z) = 1 - \int_\Omega \frac{\mu\varphi(t)C}{u(t)-z}dt \quad (1.3.8)$$

$$J_0(z) = \int_\Omega \frac{\varphi(t)v(t)dt}{u(t)-z}$$

Bu belgilashlar yordamida (1.3.7)-tenglama quyidagi ko'rinishni oladi.

$$\begin{cases} \Delta_0(z)f_0 + \mu J_0(z)C = 0 \\ J_0(z)f_0 + \Delta_1(z)C = 0 \end{cases} \quad (1.3.9)$$

(1.3.9)-tenglamalar sistemasi nolmas yechimga ega bo'lishi uchun uning asosiy determinant

$$\Delta(z) = \begin{vmatrix} \Delta_0(z) & \mu J_0(z) \\ J_0(z) & \Delta_1(z) \end{vmatrix} = 0$$

bo'lishi zarur va yetarli,shunday qilib quyidagi lemma to'liq isbotlandi.

1.3.1-Lemma: $z = C/[u_{min}, u_{max}]$ soni H operatorning xos qiymati bo'lishi uchun $\Delta(z) = 0$ bo'lishi zarur va yetarlidir.

Bu lemmadan quyidagi natija kelib chiqadi.

Natija: H operatorning diskret spektri uchun

$$\delta_{disk}(H) = \{z \epsilon C/[u_{min}, u_{max}]: \Delta(z) = 0\}$$

tenglik o'rinlidir.

Endi H operatorga mos rezolventa operatorini quramiz.

1.3.1-Teorema: H operatorga mos rezolventa operatori

$$R(z) = \begin{pmatrix} R_{00}(z) & R_{01}(z) \\ R_{10}(z) & R_{11}(z) \end{pmatrix}$$

ko'rinishda bo'ladi.

H operatorga mos rezolventa operatorini qurish uchun ixtiyoriy $f = (f_0, f_1)$ va $g = (g_0, g_1) \epsilon \mathcal{H}_0 \oplus \mathcal{H}_1$ elementlar uchun

$$Hf - zf = g$$

tenglamani yechish kerak bo'ladi, yani quyidagi tenglamalar sistemasini qaraymiz.

$$\begin{cases} (\omega - z) f_0 + \int_\Omega v(t) f_1(t) dt = g_0 \\ v(x) f_0 + (u(x) - z) f_1(x) - \mu\varphi(x) \int_\Omega \varphi(t) f_1(t) dt = g_1(x) \end{cases} \tag{1.3.10}$$

Quyidagicha belgilash kiritamiz:

$$C = \int_\Omega \varphi(t) f_1(t) dt \tag{1.3.11}$$

U holda (1.3.10)- tenglamalar sistemasini

$$\begin{cases} (\omega - z)f_0 + \int_\Omega v(t)f_1(t)dt = g_0 \\ v(x)f_0 + (u(x) - z)f_1(x) - \mu\varphi(x)C = g_1(x) \end{cases} \qquad (1.3.12)$$

kabi yozish mumkin. $z \notin Imu$ bo'lganligi uchun $u(x) - z \neq 0$ bo'ladi.

(1.3.12)-tenglamalar sistemasining ikkinchi tenglamasidan $f_1(x)$ ni topib olamiz.

$$f_1(x) = \frac{g_1(x)}{u(x)-z} - \frac{v(x)f_0}{u(x)-z} + \frac{\mu\varphi(x)C}{u(x)-z}$$

$f_1(x)$ uchun topilgan ifoda (1.3.9)-sistemaga va (1.3.10) tenglikka etib qo'yamiz

$$\begin{cases} (\omega - z)f_0 + \int_\Omega v(t)\left(\frac{g_1(t)}{u(t)-z} - \frac{v(t)f_0}{u(t)-z} + \frac{\mu\varphi(t)C}{u(t)-z}\right)dt = g_0 \\ C = \int_\Omega \varphi_1(t)\left(\frac{g_1(t)}{u(t)-z} - \frac{v(t)f_0}{u(t)-z} + \frac{\mu\varphi(t)C}{u(t)-z}\right)dt \end{cases} \qquad (1.3.13)$$

hamda f_0 va C ga nisbatan tenglamalar sistemasini hosil qilamiz.

$$\begin{cases} \left(\omega - z - \int_\Omega \frac{v^2(t)}{u(t)-z}\right)f_0 + \int_\Omega v(t)\frac{\mu\varphi(t)C}{u(t)-z}dt = g_0 - \int_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} \\ \int_\Omega \frac{v(t)\varphi_1(t)dt}{u(t)-z} f_0 + \left(1 - \int_\Omega \frac{\mu\varphi^2(t)Cdt}{u(t)-z}\right) = \int_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z} \end{cases} \qquad (1.3.14)$$

(1.3.8)-belgilashlar yordamida (1.3.14)-tenglamalar sistemasi quyidagi ko'rinishni oladi.

$$\begin{cases} \Delta_0(z)f_0 + \mu J_0(z)C = g_0 - \int_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} \\ J_0(z)f_0 + \Delta_1(z)C = \int_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z} \end{cases}$$

(1.3.15)-tenglamalar sistemasini Kramer usulida yechish uchun unga mos determinantlarni tuzib olamiz.

$$\Delta(z) = \begin{vmatrix} \Delta_0(z) & \mu J_0(z) \\ J_0(z) & \Delta_1(z) \end{vmatrix} = \Delta_0(z)\Delta_1(z) - \mu J_1^2(z)$$

$$\Delta^1(z) = \begin{vmatrix} \Delta_0(z) & \left(g_0 - \int\limits_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z}\right) \\ J_0(z) & \int\limits_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z} \end{vmatrix} =$$

$$= \Delta_0(z) \int\limits_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z} - J_0(z)\left(g_0 - \int\limits_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z}\right)$$

$$\Delta^0(z) = \begin{vmatrix} g_0 - \int\limits_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z} & \mu J_0(z) \\ \left(\int\limits_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z}\right) & \Delta_1(z) \end{vmatrix}$$

$$= \left(g_0 - \int\limits_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z}\right)\Delta_1(z) - \left(\int\limits_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z}\right)\mu J_0(z)$$

Endi $f_0$va Cni topib olash uchun quydagi ifodalarni tuzamiz

$$f_0 = \frac{\Delta^0(z)}{\Delta(z)}; \quad C = \frac{\Delta^1(z)}{\Delta(z)}.$$

Endi $f_0$va Cni topamiz:

$$f_0 = \frac{\Delta_1(z)g_0 - \Delta_1(z)\int_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z} - \mu J_0(z)\int_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z}}{\Delta_0(z)\Delta_1(z) - \mu J_1^2(z)}$$

$$C = \frac{\Delta_0(z)\int_{\Omega} \frac{\varphi(t)g_1(t)dt}{u(t)-z} - J_0(z)g_0 + J_0(z)\int_{\Omega} \frac{v(t)g_1(t)dt}{u(t)-z}}{\Delta_0(z)\Delta_1(z) - \mu J_1^2(z)}$$

$f_0$va Cni (1.3.13)-ifodaga qo’yib $f_1(x)$ni topib olamiz

$$f_1(x) =$$

$$= \frac{g_1(x)}{u(x)-z}$$

$$- \frac{v(x)\Delta_1(z)g_0 - v(x)\Delta_1(z)\int_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} - v(x)\mu J_0(z)\int_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z}}{\Delta(z)(u(x)-z)}$$

$$+ \frac{\mu\varphi(x)\Delta_0(z)\int_\Omega \frac{\varphi_1(t)g_1(t)dt}{u(t)-z} - \mu\varphi(x)J_0(z)g_0 + \mu\varphi(x)J_0(z)\int_\Omega \frac{v(t)g_1(t)dt}{u(t)-z}}{\Delta(z)(u(x)-z)}$$

f_0 va $f_1(x)$ uchun topilgan ifodalarni

$$\begin{cases} f_0 = \frac{\Delta_1(z)}{\Delta(z)}g_0 - \frac{\Delta_1(z)}{\Delta(z)}\int\limits_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} - \frac{\mu J_0(z)}{\Delta(z)}\int\limits_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z} \\ f_1(x) = \frac{-v(x)\Delta_1(z) - \mu\varphi(x)J_0(x)}{\Delta(z)(u(x)-z)}g_0 + \frac{g_1(x)}{u(x)-z} + \left(\frac{v(x)\Delta_1(z) + \mu\varphi(x)J_0(z)}{\Delta(z)(u(x)-z)}\right. \\ \int\limits_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} + \left(\frac{v(x)\mu J_0(z) + \mu\varphi(x)\Delta_0(z)}{\Delta(z)(u(x)-z)}\right)\int\limits_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z} \end{cases}$$

kabi yozib olamiz: Bunda

$$R_{00}(z)g_0 = \frac{\Delta_1(z)}{\Delta(z)}g_0$$

$$R_{01}(z)g_1 = -\frac{\Delta_1(z)}{\Delta(z)}\int\limits_\Omega \frac{v(t)g_1(t)dt}{u(t)-z} - \frac{\mu J_0(z)}{\Delta(z)}\int\limits_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z}$$

$$R_{10}(z)g_0 = \frac{-v(x)\Delta_1(z) - \mu\varphi(x)J_0(x)}{\Delta(z)(u(x)-z)}g_0$$

$$R_{11}(z)g_1$$

$$= \frac{g_1(x)}{u(x)-z} + \left(\frac{v(x)\Delta_1(z) + \mu\varphi(x)J_0(z)}{\Delta(z)(u(x)-z)}\right)\int\limits_\Omega \frac{v(t)g_1(t)dt}{u(t)-z}$$

$$+ \left(\frac{v(x)\mu J_0(z) + \mu\varphi(x)\Delta_0(z)}{\Delta(z)(u(x)-z)}\right)\int\limits_\Omega \frac{\varphi(t)g_1(t)dt}{u(t)-z};$$

bo’ladi.

(1.3.16) ifoda quyidagi ko’rinishni oladi.

$$\begin{cases} f_0 = R_{00}(z)g_0 + R_{01}(z)g_1 \\ f_1(x) = R_{10}(z)g_0 + R_{11}(z)g_1 \end{cases}$$

1.3.1-teorema isbotlandi.

1.4 Ikki o'lchamli holda ikki kanalli molekulyar rezonans modelning spektr va rezolventasini tadqiq qilish

n=2 o'lchamli holda ikki kanalli molekulyar rezonans modelni qaraymiz. Bu yerda:

$$H_{00}f_0=\omega f_0,\ \ H_{01}f_1=\int_{\Omega^2} v(t_1,t_2)f_1(t_1,t_2)dt_1dt_2$$

$$H_{11} := H_{11}^0 - K, \qquad (H_{11}^0 f_1)(x_1,x_2) = u(x_1,x_2)f_1(x_1,x_2)$$

$$(Kf_1)(x_1,x_2) =$$

$$\mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1)f_1(t_1,t_2)dt_1dt_2 + \mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2)f_1(t_1,t_2)dt_1dt_2, ($$

$$H_{01}f_0)(x_1,x_2)=v(x_1,x_2)f_0,$$

$f_i \epsilon H_i,\ \ i = 1{,}0;$ ω-fiksirlangan haqiqiy son, $\mu_i > 0,$ $i = 1{,}0;$ tasirlashuv parametric hisoblanadi.

Fredgolm determinantini qurish maqsadida $Hf = zf$ xos qiymatga nisbatan tenglamani qaraymiz. Bu tenglama quyidagi tenglamalar sistemasiga ekvivalent bo'ladi.

$$\begin{cases} \omega f_0 + \int\limits_{\Omega^2} v(t_1,t_2)f_1(t_1,t_2)dt_1dt_2 = zf_0 \\ v(x_1,x_2)f_0 + u(x_1,x_2)f_1(x_1,x_2) - \mu_1\varphi_1(x_1) \\ -\mu_2\varphi_2(x_2)\int\limits_{\Omega^2}\varphi_2(t_2)f_1(t_1,t_2)dt_1dt_2 = zf_1 \end{cases} \qquad (1.4.1)$$

(1.4.1)-tenglamalar sistemasini quyidagicha yozib olami

$$\begin{cases} (\omega - z)f_0 + \int_{\Omega^2} v(t_1,t_2)f_1(t_1,t_2)dt_1dt_2 = 0 \\ v(x_1,x_2)f_0 + (u(x_1,x_2) - z)f_1(x_1,x_2) - \mu_1\varphi_1(x_1)\int_{\Omega^2}\varphi_1(t_1)f_1(t_1,t_2)dt_1dt_2 - \\ -\mu_2\varphi_2(x_2)\int_{\Omega^2}\varphi_2(t_2)f_1(t_1,t_2)dt_1dt_2 = 0 \end{cases}$$

(1.4.2) tenglamalar sistemasida quyidagicha belgilash kiritamiz:

$$C_1 = \int_{\Omega^2}\varphi_1(t_1)f_1(t_1,t_2)dt \qquad (1.4.3)$$

$$C_2 = \int\limits_{\Omega^2} \varphi_2(t_2) f_1(t_1, t_2) dt$$

U holda (1.4.2)-tenglamalar sistemasini

$$\begin{cases} (\omega - z) f_0 + \int_{\Omega^2} v(t_1, t_2) f_1(t_1, t_2) dt_1 dt_2 = 0 \\ v(x_1, x_2) f_0 + (u(x_1, x_2) - z) f_1(x_1, x_2) - \mu_1 \varphi_1(x_1) \mathrm{C}_1 - \mu_2 \varphi_2(x_2) \mathrm{C}_2 = 0 \end{cases}$$

kabi yozish mumkin.$z \notin Imu$ bo'lganligi uchun $u(x) - z \neq 0$ bo'ladi.

(1.4.4)-tenglamalar sistemasining ikkinchi tenglamasidan $f_1(x)$ ni topib olamiz.

$$f_1(x) = -\frac{v(x_1,x_2) f_0}{u(x_1,x_2) - z} + \frac{\mu_1 \varphi_1(x_1) \mathrm{C}_1}{u(x_1,x_2) - z} + \frac{\mu_2 \varphi_2(x_2) \mathrm{C}_2}{u(x_1,x_2) - z} \qquad (1.4.5)$$

$f_1(x)$ uchun topilgan ifodani (1.4.4)-tenglamalar sistemasining birinchi tenglamasiga va (1.4.5) tenglikka etib qo'yamiz:

$$\begin{cases} (\omega - z) f_0 + \int\limits_{\Omega^2} v(t_1, t_2) \left(-\frac{v(t_1, t_2) f_0}{u(t_1, t_2) - z} + \frac{\mu_1 \varphi_1(t_1) C_1}{u(t_1, t_2) - z} + \frac{\mu_2 \varphi_2(t_2) C_2}{u(t_1, t_2) - z}\right) dt_1 dt_2 = 0 \\ C_1 = \int\limits_{\Omega^2} \varphi_1(t_1) \left(-\frac{v(t_1, t_2) f_0}{u(t_1, t_2) - z} + \frac{\mu_1 \varphi_1(t_1) C_1}{u(t_1, t_2) - z} + \frac{\mu_2 \varphi_2(t_2) C_2}{u(t_1, t_2) - z}\right) dt_1 dt_2 \\ C_2 = \int\limits_{\Omega^2} \varphi_2(t_2) \left(-\frac{v(t_1, t_2) f_0}{u(t_1, t_2) - z} + \frac{\mu_1 \varphi_1(t_1) C_1}{u(t_1, t_2) - z} + \frac{\mu_2 \varphi_2(t_2) C_2}{u(t_1, t_2) - z}\right) dt_1 dt_2 \end{cases}$$

hamda f_0 va C_1, C_2 ga nisbatan tenglamalar sistemasini hosil qilamiz.

$$
\begin{cases}
\left(\omega - z - \int\limits_{\Omega} \frac{v^2(t_1,t_2)dt}{u(t_1,t_2)-z})f_0\right) + \\
+\int_{\Omega^2} v(t_1,t_2)\frac{\mu_1\varphi_1(t_1)C_1dt_1dt_2}{u(t_1,t_2)-z} + \int_{\Omega^2} v(t_1,t_2)\frac{\mu_2\varphi_2(t_2)C_2dt_1dt_2}{u(t_1,t_2)-z} = 0 \\
\int\limits_{\Omega^2} \varphi_1(t_1)\frac{v(t_1,t_2)f_0dt_1dt_2}{u(t_1,t_2)-z} + \left(1-\mu_1\int\limits_{\Omega^2}\frac{\varphi_1^2(t_1)dt_1dt_2}{u(t_1,t_2)-z}\right)C_1 - \\
-\mu_2\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\mathrm{C}_2 = 0 \\
\int\limits_{\Omega^2} \varphi_1(t_1)\frac{v(t_1,t_2)f_0dt_1dt_2}{u(t_1,t_2)-z} - \mu_1\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\mathrm{C}_1 + \\
+\left(1-\mu_2\int\limits_{\Omega^2}\frac{\varphi_2^2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\right)\mathrm{C}_2 = 0
\end{cases}
$$

Quyidagi belgilashlarni olamiz:

$$
\Delta_0(z) = \omega - z - \int\limits_{\Omega}\frac{v^2(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

$$
\Delta_1(z) = 1-\mu_1\int_{\Omega^2}\frac{\varphi_1^2(t_1)dt_1dt_2}{u(t_1,t_2)-z} \tag{1.4.8}
$$

$$
\Delta_2(z) = 1-\mu_2\int_{\Omega^2}\frac{\varphi_2^2(t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

$$
I_1(z) = \int\limits_{\Omega^2}\frac{\varphi_1(t_1)v(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

$$
I_2(z) = \int\limits_{\Omega^2}\frac{\varphi_2(t_2)v(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

$$
I_{12}(z) = -\mu_2\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

$$
I_{21}(z) = -\mu_1\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}
$$

Bu belgilashlar yordamida (1.4.7)-tenglama quyidagi ko'rinishni oladi.

$$\begin{cases} \Delta_0(z)f_0 + \mu_1 I_1(z)C_1 + \mu_2 I_2(z)C_2 = 0 \\ I_1(z)f_0 + \Delta_1(z)C_1 + I_{12}(z)C_2 = 0 \\ I_2(z)f_0 + I_{21}(z)C_1 + \Delta_2(z)C_2 = 0 \end{cases}$$

(1.4.9)-tenglamalar sistemasi nolmas yechimga ega bo'lishi uchun uning asosiy determinant

$$\Delta(z) = \begin{vmatrix} \Delta_0(z) & \mu_1 I_1(z) & \mu_2 I_2(z) \\ I_1(z) & \Delta_1(z) & I_{12}(z) \\ I_2(z) & I_{21}(z) & \Delta_2(z) \end{vmatrix} = 0$$

bo'lishi zarur va yetarli, shunday qilib quyidagi lemma to'liq isbotlandi.

1.4.1-Lemma: $z = C/[u_{min}, u_{max}]$ soni H operatorning xos qiymati bo'lishi uchun $\Delta(z) = 0$ bo'lishi zarur va yetarlidir.

Bu lemmadan quyidagi natija kelib chiqadi.

1.4.1-Natija: H operatorning diskret spektri uchun

$$\delta_{disk}(H) = \{z \epsilon C \setminus [u_{min}, u_{max}] : \Delta(z) = 0\}$$

tenglik o'rinlidir.

1.4.1-Teorema: H operatorga mos rezolventa operatori

$$R(z) = \begin{pmatrix} R_{00}(z) & R_{01}(z) \\ R_{10}(z) & R_{11}(z) \end{pmatrix}$$

ko'rinishda bo'ladi.

Endi H operatorga mos rezolventa operatorini quramiz. H operatorga mos rezolventa operatorini qurish uchun ixtiyoriy $f = (f_0, f_1)$ va

$g = (g_0, g_1) \epsilon \mathcal{H}_0 \oplus \mathcal{H}_1$ elementlar uchun

$$Hf - zf = g$$

tenglamani yechish kerak bo'ladi, yani quyidagi tenglamalar sistemasini qaraymiz.

$$\begin{cases} (\omega - z) f_0 + \int_{\Omega^2} v(t_1, t_2) f_1(t_1, t_2) dt_1 dt_2 = g_0 \\ v(x_1, x_2) f_0 + (u(x_1, x_2) - z) f_1(x_1, x_2) - \mu_1 \varphi_1(x_1) \int_{\Omega^2} \varphi_1(t_1) f_1(t_1, t_2) dt_1 dt_2 - \\ -\mu_2 \varphi_2(x_2) \int_{\Omega^2} \varphi_2(t_2) f_1(t_1, t_2) dt_1 dt_2 = g_1(x_1, x_2) \end{cases}$$

Quyidagicha belgilash kiritamiz:

$$C_1 = \int_{\Omega^2} \varphi_1(t_1) f_1(t_1, t_2) dt \qquad (1.4.11)$$

$$C_2 = \int_{\Omega^2} \varphi_2(t_2) f_1(t_1, t_2) dt$$

U holda (1.4.10)- tenglamalar sistemasini

$$\begin{cases} (\omega - z) f_0 + \int_{\Omega^2} v(t_1, t_2) f_1(t_1, t_2) dt_1 dt_2 = g_0 \\ v(x_1, x_2) f_0 + (u(x_1, x_2) - z) f_1(x_1, x_2) - \mu_1 \varphi_1(x_1) \mathrm{C}_1 - \mu_2 \varphi_2(x_2) \mathrm{C}_2 = g_1(x_1, x_2) \end{cases}$$

kabi yozish mumkin. $z \notin Imu$ bo'lganligi uchun $u(x) - z \neq 0$ bo'ladi.

(1.4.12)-tenglamalar sistemasining ikkinchi tenglamasidan $f_1(x)$ ni topib olamiz.

$$f_1(x_1, x_2) = \frac{g_1(x_1, x_2)}{u(x_1, x_2) - z} - \frac{v(x_1, x_2) f_0}{u(x_1, x_2) - z} + \frac{\mu_1 \varphi_1(x_1) \mathrm{C}_1}{u(x_1, x_2) - z} + \frac{\mu_2 \varphi_2(x_2) \mathrm{C}_2}{u(x_1, x_2) - z}$$

$f_1(x_1, x_2)$ uchun topilgan ifoda (1.4.9)-sistemaga va (1.4.10) tenglikka etib qo'yamiz

hamda f_0 va C_1, C_2 ga nisbatan tenglamalar sistemasini hosil qilamiz.

$$\begin{cases}\left(\omega - z - \int\limits_{\Omega} \frac{v^2(t_1,t_2)dt}{u(t_1,t_2)-z})f_0\right) + \int\limits_{\Omega^2} v(t_1,t_2)\frac{\mu_1\varphi_1(t_1)C_1}{u(t_1,t_2)-z} + \\ + \int_{\Omega^2} v(t_1,t_2)\frac{\mu_2\varphi_2(t_2)C_2}{u(t_1,t_2)-z} = g_0 - \int\limits_{\Omega^2}\frac{v(t_1,t_2)g_1(t_1,t_2)}{u(t_1,t_2)-z} \\ \int\limits_{\Omega^2}\varphi_1(t_1)\frac{v(t_1,t_2)f_0}{u(t_1,t_2)-z} + \left(1-\mu_1\int\limits_{\Omega^2}\frac{\varphi_1^2(t_1)dt_1dt_2}{u(t_1,t_2)-z}\right)C_1 - \\ -\mu_2\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\mathrm{C}_2 = \int\limits_{\Omega^2}\frac{\varphi_1(t_1)g_1(t_1,t_2)}{u(t_1,t_2)-z} \\ \int\limits_{\Omega^2}\varphi_1(t_1)\frac{v(t_1,t_2)f_0}{u(t_1,t_2)-z} - \mu_1\int\limits_{\Omega^2}\frac{\varphi_1(t_1)\varphi_2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\mathrm{C}_1 + \\ + \left(1-\mu_2\int\limits_{\Omega^2}\frac{\varphi_2^2(t_2)dt_1dt_2}{u(t_1,t_2)-z}\right)\mathrm{C}_2 = \int\limits_{\Omega^2}\frac{\varphi_2(t_2)g_1(t_1,t_2)}{u(t_1,t_2)-z}\end{cases}$$

(1.4.8)-belgilashlar yordamida (1.4.14)-tenglamalar sistemasi quyidagi ko'rinishni oladi.

$$\begin{cases}\Delta_0(z)f_0 + \mu_1 I_1(z)C_1 + \mu_2 I_2(z)C_2 = g_0 - \int_{\Omega^2}\frac{v(t_1,t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} \\ I_1(z)f_0 + \Delta_1(z)C_1 + I_{12}(z)C_2 = \int_{\Omega^2}\frac{\varphi_1(t_1)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} \\ I_2(z)f_0 + I_{21}(z)C_1 + \Delta_2(z)C_2 = \int_{\Omega^2}\frac{\varphi_2(t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z}\end{cases}$$

(1.4.15)-tenglamalar sistemasini Kramer usulida yechish uchun unga mos determinantlarni tuzib olamiz.

$$\Delta_2(z) = \begin{vmatrix}\Delta_0(z) & \mu_1 I_1(z) & \mu_2 I_2(z) \\ I_1(z) & \Delta_1(z) & I_{12}(z) \\ I_2(z) & I_{21}(z) & \Delta_2(z)\end{vmatrix}$$

$$\Delta_2^{(0)}(z)=\begin{vmatrix} g_0-\int\limits_{\Omega^2}\frac{v(t_1,t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & \mu_1 I_1(z) & \mu_2 I_2(z) \\ \int\limits_{\Omega^2}\frac{\varphi_1(t_1)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & \Delta_1(z) & I_{12}(z) \\ \int\limits_{\Omega^2}\frac{\varphi_2(t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & I_{21}(z) & \Delta_2(z) \end{vmatrix}$$

$$\Delta_2^{(1)}(z)=\begin{vmatrix} \Delta_0(z) & g_0-\int\limits_{\Omega^2}\frac{v(t_1,t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & \mu_2 I_2(z) \\ I_1(z) & \int\limits_{\Omega^2}\frac{\varphi_1(t_1)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & I_{12}(z) \\ I_2(z) & \int\limits_{\Omega^2}\frac{\varphi_2(t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} & \Delta_2(z) \end{vmatrix}$$

$$\Delta_2^{(2)}(z)=\begin{vmatrix} \Delta_0(z) & \mu_1 I_1(z) & g_0-\int\limits_{\Omega^2}\frac{v(t_1,t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} \\ I_1(z) & \Delta_1(z) & \int\limits_{\Omega^2}\frac{\varphi_1(t_1)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} \\ I_2(z) & I_{21}(z) & \int\limits_{\Omega^2}\frac{\varphi_2(t_2)g_1(t_1,t_2)dt_1dt_2}{u(t_1,t_2)-z} \end{vmatrix}$$

Endi $f_0$va C_1, C_2ni topib olash uchun quydagi ifodalarni tuzamiz

$$f_0=\frac{\Delta^0(z)}{\Delta(z)};\quad C_1=\frac{\Delta^1(z)}{\Delta(z)};\quad C_2=\frac{\Delta^2(z)}{\Delta(z)}.$$

Endi $f_0$va C_1, C_2ni topamiz:

Topilgan $f_0$va C_1, C_2larni $f_1(x_1,\dots,x_1)$ tenglikka olib borib qo'yamiz quyidagi sistema hosil bo'ladi.

$$\begin{cases} f_0=R_{00}(z)g_0+R_{01}(z)g_1 \\ f_1(x)=R_{10}(z)g_0+R_{11}(z)g_1 \end{cases}$$

1.4.1-teorema to'liq isbotlandi.

I-BOB XULOSASI

Bitiruv malakaviy ishining birinchi bobi “Bir va ikki o’lchamli holda ikki kanalli molekulyar rezonans modeli va uning spektral xossalari” deb nomlangan bo’lib, u to’rtta bo’limdan tashkil topgan.1.1-bo’limda Fok fazosi va uning qirqilgan qism fazosi tushunchalari bayon qilingan, bozonli Fok fazosi haqida ma’lumotlar kiritilgan. 1.2- bo’limda bir va ikki o’lchamli holda ikki kanalli molekulyar rezonans modeli chiziqlilikka, chegaralanganlikka va o’z-o’ziga qo’shmalikka tekshirilgan. 1.3-bo’limda qo’zg’alishi $n = 1$ holda ikki kanalli molekulyar rezonans modelning Fredgolm determinanti qurilgan hamda uning analitik xossalari o’rganilgan. Ba’zi xususiy hollarda Fredgolm determinanti o’rganish uchun nisbatan qulay bo’lgan bir nechta regulyar funksiyalarning nollarini o’rganish masalasiga keltirilgan. Bu holda regulyar funksiyalar monotonlik xossasiga ega bo’lganligi uchun xos qiymatlar bilan bog’liq bo’lgan aniqroq ma’lumotlar keltirilgan. H-operatorga mos rezolventa operatori uchun aniq formula topilgan.1.4-bo’limda esa ikki o’lchamli holda ikki kanalli molekulyar rezonans modeli Fok fazosining qirqilgan ikki zarrachali qism fazosida o’rganilgan. Fredgolm determinant qurilgan va uning xossalari o’rganilgan. H-operatorning rezolventa operatorining ta’sir formulasi aniq topilgan.

I-bobdagi barcha natijalarni isbotlashda matematik analiz, chiziqli algebra, kompleks analiz va funksional analiz usullaridan foydalanilgan.

2.1. n- o'lchamli holda ikki kanalli molekulyar rezonans modelning muhim spektri

Biz H –Gilbert fazosida 2×2-o'lchamli

$$H{:=}\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix} \qquad (2.1.1)$$

blok-operatorli matritsani qaraymiz, bu yerda $H_{ij}: H_j \to H_i, i \le j, i,j = 0,1$ matritsaviy elementlar quyidagi formulalar yordamida aniqlanadi:

$$H_{00}f_0{=}\omega f_0,\ \ H_{01}f_1{=}\int_{\Omega^n} v(t_1,\ldots,t_n)f_1(t_1,\ldots,t_n)dt_1\ldots dt_n,$$

$$H_{11} \coloneqq H_{11}^0 - K,\quad (H_{11}^0 f_1)(x_1,\ldots,x_n) = u(x_1,\ldots,x_n)f_1(x_1,\ldots,x_n),$$

$$(Kf_1)(x_1,\ldots,x_n) = \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\ldots,t_n)dt_1\ldots dt_n,$$

$$\mathrm{f}_i \epsilon \mathcal{H}_i, i = 0,1$$

2.1.1-lemma. $\mathcal{H}$ Gilbert fazosida (2.1.1) formula bo'yicha tasir qiluvchi H blok operatorli matritsa parametrlarga qo'yilgan yuqoridagi shartlarda chiziqli, chegaralangan va o'z-o'ziga qo'shma operator bo'ladi.

1. Ushbu

$$H{:=}\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}$$

blok operatorli matritsani chiziqli operator ekanligini isbotlaymiz.

Dastlab,

$$Hf = \begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}\begin{pmatrix} f_0 \\ f_1 \end{pmatrix} = \begin{pmatrix} H_{00}f_0 + & H_{01}f_1 \\ H_{01}^{*}f_0 & H_{11}f_1 \end{pmatrix} =$$

$$= \begin{pmatrix} \omega f_0 + \int_{\Omega^n} v(t_1,\ldots,t_n)f_1(t_1,\ldots,t_n)dt_1\ldots dt_n \\ v(x_1,\ldots,x_n)f_0 + u(x_1,\ldots,x_n) \\ f_1(x_1,\ldots,x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\ldots,t_n)dt_1\ldots dt_n \end{pmatrix}$$

$$H(\alpha f+\beta g)=$$

$$=\begin{pmatrix} \omega(\alpha f_0+\beta g_0)+\int_{\Omega^n} v(t_1,\dots,t_n)(\alpha f_1+\beta g_1)dt_1\dots dt_n \\ v(x_1,\dots,x_n)(\alpha f_0+\beta g_0)+u(x_1\dots,x_n)(\alpha f_1+\beta g_1)-\sum_{K=1}^{n}\mu_K\varphi_k(x_k) \\ \int_{\Omega^n}\varphi_k(t_k)(\alpha f_1+\beta g_1)\,dt_1\dots dt_n \end{pmatrix}$$

$$=$$

$$=\begin{pmatrix} \alpha\omega f_0+\beta\omega g_0+\alpha\int_{\Omega^n} v(t_1,\dots,t_n)f_1dt_1\dots dt_n+\beta\int_{\Omega^n} v(t_1,\dots,t_n)g_1dt_1\dots dt_n \\ \alpha v f_0+\beta v g_0+u\alpha f_1+u\beta g_1-\sum_{K=1}^{n}\mu_K\varphi_k(x_k) \\ \left[\alpha\int_{\Omega^n}\varphi_k(t_k)f_1dt_1\dots dt_n+\beta\int_{\Omega^n}\varphi_k(t_k)g_1dt_1\dots dt_n\right] \end{pmatrix}$$

$$=\alpha\begin{pmatrix} \omega f_0+\int_{\Omega^n} v(t_1,\dots,t_n)f_1(t_1,\dots,t_n)dt_1\dots dt_n \\ v(x_1,\dots,x_n)f_0+u(x_1,\dots,x_n) \\ f_1(x_1,\dots,x_n)-\sum_{K=1}^{n}\mu_K\varphi_k(x_k)\int_{\Omega^n}\varphi_k(t_k)\,f_1(t_1,\dots,t_n)dt_1\dots dt_n \end{pmatrix}$$

$$+\beta\begin{pmatrix} \omega g_0+\int_{\Omega^n} v(t_1,\dots,t_n)g_1(t_1,\dots,t_n)dt_1\dots dt_n \\ v(x_1,\dots,x_n)g_0+u(x_1,\dots,x_n) \\ g_1(x_1,\dots,x_n)-\sum_{K=1}^{n}\mu_K\varphi_k(x_k)\int_{\Omega^n}\varphi_k(t_k)\,g_1(t_1,\dots,t_n)dt_1\dots dt_n \end{pmatrix}$$

$$=$$

$$=\alpha Hf+\beta Hg.$$

Demak, H chiziqli operator ekan.

Endi H operatorni chegaralanganlikka tekshiramiz. Buning uchun shunday $M>0$ soni topilib ixtiyoriy $f\epsilon H$ uchun

$$\|Hf\|\le M\|f\|$$

tengsizlik bajarilishini ko'rsatamiz. Buning uchun biz quyidagi munosabatlardan foydalanamiz

$$\|f\|^2=\|f_0\|^2+\|f_1\|^2$$

$$\|f_0\|=|f_0|,\ \|f_1\|^2=\int_{\pi d}\|f_1\|^2$$

$$\|Hf\|^2=\|Hf_0\|^2+\|Hf_1\|^2$$

$$\|Hf_0\|^2=\left|\omega f_0+\int_{\Omega^n} v(t_1,\dots,t_n)f_1(t_1,\dots,t_n)dt_1\dots dt_n\right|^2$$

$$\|Hf_1\|^2 =$$

$$= \int_{\Omega^n} \left| f_1(x_1,\dots,x_n) - \frac{v(x_1,\dots,x_n)f_0 + u(x_1,\dots,x_n)}{\sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int\limits_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\dots,t_n)dt_1 \dots dt_n} \right|^2$$

ni hosil qilamiz

So'ngra n+2 haqiqiy qiymatli $a_1, \dots, a_n$ sonlar uchun

$$(a_1 + a_2 + \dots + a_{n+1} + a_{n+2})^2 \le (n+2)|a_1|^2 + \dots + (n+2)|a_{n+2}|^2$$

tengsizlikdan foydalanamiz.

$$\|Hf_1\|^2$$

$$= \int_{\Omega^n} \left| f_1(x_1,\dots,x_n) - \frac{v(x_1,\dots,x_n)f_0 + u(x_1,\dots,x_n)}{\sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int\limits_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\dots,t_n)dt_1 \dots dt_n} \right|^2 \le$$

$$\le (n+2)\int_{\Omega^n} |v(x_1,\dots,x_n)f_0|^2 + (n+2)\int_{\Omega^n} |u(x_1,\dots,x_n)f_1|^2$$

$$+ (n+2)\int_{\Omega^n} \left| \mu_1\varphi_1(x_1) \int_{\Omega^n} \varphi_1(t_1) f_1(t_1,\dots,t_n)dt_1 \dots dt_n \right|^2 dx$$

$$+ (n+2)\int_{\Omega^n} \left| \mu_2\varphi_2(x_2) \int_{\Omega^n} \varphi_2(t_2) f_1(t_1,\dots,t_n)dt_1 \dots dt_n \right|^2 dx + \cdots$$

$$+ (n+2)\int_{\Omega^n} \left| \mu_n\varphi_n(x_n) \int_{\Omega^n} \varphi_n(t_n) f_1(t_1,\dots,t_n)dt_1 \dots dt_n \right|^2 dx$$

Endi Koshi-Bunyakovskiy tengsizligi deb atalovchi

$$\left| \int f(x)g(x)dx \right|^2 \le \left| \int f(x)dx \right|^2 \left| \int g(x)dx \right|^2$$

tengsizlikdan foydalanamiz:

$$\int_{\Omega^n} |v(x_1,\dots,x_n)f_0|^2 \le \int_{\Omega^n} |v(x_1,\dots,x_n)|^2 \int_{\Omega^n} |f_0|^2$$

$$\int_{\Omega^n} |u(x_1,\dots,x_n)f_1|^2 \le \int_{\Omega^n} |u(x_1,\dots,x_n)|^2 \int_{\Omega^n} |f_1|^2$$

$$\int_{\Omega^n}\left|\mu_1\varphi_1(x_1)\int_{\Omega^n}\varphi_1(t_1)f_1(t_1,\dots,t_n)dt_1\dots dt_n\right|^2$$

$$\leq\int_{\Omega^n}|\mu_1\varphi_1(x_1)|^2\int_{\Omega^n}\left|\int_{\Omega^n}\varphi_1(t_1)dt_1\right|^2\int_{\Omega^n}\left|\int_{\Omega^n}f_1(t_1,\dots,t_n)dt_1\dots dt_n\right|^2$$

$$\leq\|\varphi_1\|^4\|f_1\|^2$$

yuqoridagi yig'indi

$$(n+2)\|f_1\|^2\left(\sum_{k=1}^{n}\mu_k\|\varphi_k\|^4\right)+(n+2)|u|^2\|f_1\|^2+(n+2)|v|^2\|f_0\|^2$$

ifodadan kichik bo'ladi.

$$\|Hf_0\|^2=\left|\omega f_0+\int_{\Omega^n}v(t_1,\dots,t_n)f_1(t_1,\dots,t_n)dt_1,\dots,dt_n\right|^2\leq$$

$$\leq 2\|\omega\|^2\|f_0\|^2+2\|v\|^2\|f_1\|^2;$$

$$\|(Hf)\|^2=\|(Hf)_0\|^2+\|(Hf)_1\|^2$$

$$\|(Hf)\|^2=2\|\omega\|^2\|f_0\|^2+2\|v\|^2\|f_1\|^2+(n+2)\|f_1\|^2\left(\textstyle\sum_{k=1}^{n}\mu_k\|\varphi_k\|^4\right)+$$
$$(n+2)|u|^2\|f_1\|^2+(n+2)|v|^2\|f_0\|^2=(2\|\omega\|^2+(n+2)|v|^2)\|f_0\|^2+$$
$$\left[(2\|v\|^2+(n+2)\left(\left(\textstyle\sum_{k=1}^{n}\mu_k\|\varphi_k\|^4\right)+|u|^2\right)\right]\|f_1\|^2$$

$$M^2=max\left\{2\|\omega\|^2+(n+2)|v|^2,2\|v\|^2+(n+2)\left(\left(\sum_{k=1}^{n}\mu_k\|\varphi_k\|^4\right)+|u|^2\right)\right\}$$

Demak, H operator chegaralangan operator ekan.

Endi H operatorning o'z-o'ziga qo'shma operator ekanligini ko'rsatamiz, ya'ni $f=(f_0,f_1,\dots,f_n)$ va $g=(g_0,g_1,\dots,g_n)\epsilon H$ elementlar uchun

$$(Hf,g)=(f,Hg)$$

tenglik o'rinli bo'lishi kerak. Bizga ma'lumki,

$$(f_0,g_0)=f_0,\overline{g_0}\ ,\ (f_1,g_1)=\int_{\pi d}f_1(x)\overline{g_1(x)}\,dx$$

$$(f_2, g_2) = \iint_{\pi d} f_1(x,y)\overline{g_1(x,y)}\,dxdy$$

hamda

$$(Hf, g) = ((Hf)_0, g_0)_0 + ((Hf)_1, g_1)_1$$

$$(Hf, g) =$$

$$\left(\omega f_0 + \int_{\Omega^n} v(t_1, \dots, t_n) f_1(t_1, \dots, t_n) dt_1 \dots dt_n\right)\overline{g_0} + \int_{\Omega^n} (v(x_1, \dots, x_n) f_0 + u(x_1, \dots, x_n) f_1(x_1, \dots, x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int_{\Omega^n} \varphi_k(t_k)$$

$$f_1(t_1, \dots, t_n) dt_1 \dots dt_n) dx_1 \dots dx_n$$

$$= \omega f_0 \overline{g_0} +$$

$$\left(\int_{\Omega^n} v(t_1, \dots, t_n) f_1(t_1, \dots, t_n) dt_1 \dots dt_n\right)\overline{g_0(t_1, \dots, t_n)} + \int_{\Omega^n} v(x_1, \dots, x_n) f_0\, \overline{g_1} +$$

$$u(x_1, \dots, x_n) f_1 \overline{g_1} -$$

$$\sum_{K=1}^{n} \mu_K \varphi_k(x_k) \overline{g_1} = f_0 \overline{\left(\omega g_0 + \int_{\Omega^n} v(x_1, \dots, x_n)\, g_1\right)} +$$

$$\int f_1(x) \overline{\left(\int_{\Omega^n} v(t_1, \dots, t_n) + u(x_1, \dots, x_n) g_1 + \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int \varphi_k(t)_k g_1\right)} =$$

$$(f_0, (Hg)_0) + (f_1, (Hg)_1) = (f, Hg)$$

Demak H o’z-o’ziga qo’shma operator ekan. $\sigma_{ess}(H)$ va $\sigma_{disk}(H)$ to’plamlar orqali chegaralangan o’z-o’ziga qo’shma operatorning mos ravishda spektrini, muhim spektrini va diskret spektrini belgilaymiz.

2.1.1-Ta’rif: Barcha xos qiymatlari to’plami H-operatorning diskret spektri deyiladi.

2.1.2-Ta’rif: Agar biror $\lambda \epsilon \delta(H)$ son uchun nolga kuchsiz yaqinlashuvchi $f_n \epsilon H$ birlik vektorlar ketma-ketligi mavjud bo’lib

$$\lim_{n\to\infty} \|(H - \lambda I) f_n\| = 0$$

bo’lsa uholda λ son $H = H^*$ operatorning muhim spektriga qarashli deyiladi.

K n-o’lchamli operator H_{00}, H_{01}, H_{01}^* operatorlar esa bir o’lchamli bo’lganligi sababli chekli o’lchamli qo’zg’alishlarda muhim spektrning o’zgarmasligi haqidagi Veyl teoremasiga ko'ra H operatorning $\sigma_{ess}(H)$ muhim spektri H_{11}^0 operatorning spektri bilan ustma-ust tushadi.

2.1.2-lemma: Hoperatorning muhim spektri uchun quyidagi tenglik o'rinlidir

$$\sigma_{ess}(H) = [u_{min}, u_{max}]$$

bu yerda

$$u_{min} := \min_{x_1,\dots,x_n \epsilon \Omega} u(x_1, \dots x_n), u_{max} := \max_{x_1,\dots,x_n \epsilon \Omega} u(x_1, \dots x_n).$$

Isbot.H-operator muhim spektrini o'rganish maqsadida H Gilbert fazosida

$$H_{\mathbf{0}} := \begin{pmatrix} 0 & 0 \\ 0 & H_{11}^0 \end{pmatrix}$$

kabi aniqlangan H_0 operatorli matrisani qaraymiz. U holda $H - H_0$ operator uchun

$$H - H_0 = \begin{pmatrix} H_{00} & H_{01} \\ H_{01}^* & H_{11} \end{pmatrix} - \begin{pmatrix} 0 & 0 \\ 0 & H_{11}^0 \end{pmatrix} = \begin{pmatrix} H_{00} - 0 & H_{01} - 0 \\ H_{01}^* - 0 & H_{11} - H_{11}^0 \end{pmatrix} =$$

$$= \begin{pmatrix} H_{00} & H_{01} \\ H_{01}^* & -K \end{pmatrix}$$

tenglik o'rinli. Aniqlanishiga ko'ra

$$Im(H - H_0) = \{f = (f_0, f_1) \epsilon H : f = (1,0), f = (0, v(x_1, \dots, x_n)), f$$
$$= (0, a_1\varphi_1(x_1)), \dots, f = (0, a_n\varphi_n(x_n))\}.$$

Shu sababli

$$\dim Im(H - H_0) = n + 2$$

tenglik o'rinli. Chekli o'lchamli qo'zg'alishlarda muhim spektrning o'zgarmasligi haqidagi teoremaga ko'ra

$$\sigma_{ess}(H) = \sigma_{ess}(H_0)$$

tenglik o'rinli. Ma'lumki,

$$\sigma_{ess}(H_0) = [u_{min}\,, u_{max}]$$

Demak,

$$\sigma_{ess}(H) = [u_{min}\,, u_{max}]$$

tenglik o'rinli ekan, lemma isbot bo'ldi.

2.2. n-o'lchamli holda ikki kanalli malekulyar rezonans modelning Fredgolm determinanti va uning bazi xaraktristik xossalari

Biz H –Gilbert fazosida 2×2-o'lchamli

$$H:=\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix} \tag{2.2.1}$$

blok-operatorli matritsani qaraymiz, bu yerda matritsaviy elementlar quyidagi formulalar yordamida aniqlanadi:

$$H_{00}f_0=\omega f_0,\ \ H_{01}f_1=\int_{\Omega^n} v(t_1,\ldots,t_n)f_1(t_1,\ldots,t_n)dt_1\ldots dt_n,$$

$$H_{11} \coloneqq H_{11}^0 - K,\quad (H_{11}^0 f_1)(x_1,\ldots,x_n) = u(x_1,\ldots,x_n)f_1(x_1,\ldots,x_n),$$

$$(Kf_1)(x_1,\ldots,x_n) = \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \int_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\ldots,t_n)dt_1\ldots dt_n,$$

Bu yerda $f_i \epsilon \mathcal{H}_i, i = 0,1$; ω-fiksirlangan haqiqiy son, $\mu_i > 0, i = \overline{0,n}$ tasirlashuv parametri, $\varphi_i(\cdot), i = 1,2\ va\ u(\cdot,\ldots,\cdot), v(\cdot,\ldots,\cdot)$ funksiyalar mos ravishda Ω va Ω^n da aniqlangan haqiqiy qiymatli uzluksiz funksiyalar.

H Gilbert fazosida (2.2.1)-formula bo'yicha tasir qiluvchi H blok operatorli matritsa, parametrlarga qo'yilgan yuqoridagi shartlarda chiziqli, chegaralangan va o'z-o'ziga qo'shma operator bo'ladi. Bu tasdiq 1.2-bo'limda isbotlangan. Bunda $H_{01}^{*}: H_0 \to H_1$ operator H_{01} operatorga qo'shma operator bo'lib, u

$$(H_{01}^{*} f_0)(p) = v(p) f_0,\ \ f_0 \epsilon H_0$$

formula yordamida ta'sir qiladi.

Odatda H_{01} operatorga yo'qotish operatori, H_{01}^{*} operatorga esa paydo qilish operatori deyiladi. Yo'qotish operatori zarrachalar sonini bittaga kamaytiradi, paydo qilish operatori esa zarrachalar sonini bittaga oshirib, yo'qotish operatoriga qo'shma operator bo'lishini takidlab o'tamiz. Bunday xususiyatga ega operatorlar kvant mexanikasida, xususan kvant garmonik osilyatorlarni va ko'p zarrachali sistemalarni o'rganishda keng tadbiqqa ega bo'ladi.

Fredgolm determinantini qurish maqsadida $Hf = zf$ xos qiymatga nisbatan tenglamani qaraymiz.

$$\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^{*} & H_{11} \end{pmatrix}\begin{pmatrix} f_0 \\ f_1 \end{pmatrix} = z\begin{pmatrix} f_0 \\ f_1 \end{pmatrix}$$

Bu tenglama quyidagi tenglamalar sistemasiga ekvivalent bo'ladi.

$$\begin{cases} \omega f_0 + \int_{\Omega^n} v(t_1, \dots, t_n) f_1(t_1 \dots, t_n) dt_1, \dots, dt_n = z f_0 \\ v(x_1, \dots, x_n) f_0 + u(x_1, \dots, x_n) f_1(x_1, \dots, x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \\ \int_{\Omega^n} \varphi_k(t_k) f_1(t_1, \dots, t_n) dt_1 \dots dt_n = z f_1 \end{cases} \qquad (2.2.2)$$

(2.2.2)-tenglamalar sistemasini quyidagicha yozib olamiz

$$\begin{cases} (\omega - f_0) + \int_{\Omega^n} v(t_1, \dots, t_n) f_1(t_1 \dots, t_n) dt_1, \dots, dt_n = 0 \\ v(x_1, \dots, x_n) f_0 + (u(x_1, \dots, x_n) - z) f_1(x_1, \dots, x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) \\ \int_{\Omega^n} \varphi_k(t_k) f_1(t_1, \dots, t_n) dt_1 \dots dt_n = 0 \end{cases}$$

(2.2.2)-tenglamalar sistemasida quyidagicha belgilash kiritamiz

$$C_j := \int_{\Omega^n} \varphi_k(t_k)\, f_1(t_1, \dots, t_n) dt_1 \dots dt_n \qquad (2.2.3)$$

U holda (2.2.2)-tenglamalar sistemasi quyidagi ko'rinishni oladi

$$\begin{cases} (\omega - z) f_0 + \int_{\Omega^n} v(t_1, \dots, t_n) f_1(t_1, \dots, t_n) dt_1, \dots, dt_n = 0 \\ v(x_1, \dots, x_n) f_0 + (u(x_1, \dots, x_n) - z) f_1(x_1, \dots, x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) C_j = 0 \end{cases}$$

(2.2.4)-tenglamalar sistemasining ikkinchi tenglamsidan $f_1(x_1, \dots, x_n)$ ni topib olamiz.

$$f_1(x_1, \dots, x_n) = -\frac{v(x_1, \dots, x_n) f_0}{u(x_1, \dots x_n) - z} + \frac{1}{u(x_1, \dots x_n) - z} \sum_{j=1}^{n} \mu_j C_j \varphi_j(x_j)$$

$f_1(x_1, \dots, x_n)$-ni tenglamalar sistemasining birinchi tenglamasiga va (2.2.3)-tenglikka qo'yamiz:

$$\begin{cases} (\omega - f_0) + \int_{\Omega^2} v(t_1, \dots, t_n)(-\frac{v(t_1,\dots,t_n)f_0}{u(t_1,\dots t_n)-z} + \\ +\frac{1}{u(t_1,\dots t_n)-z}\sum_{j=1}^{n} \mu_j C_j \varphi_j(t_j))dt_1, \dots, dt_n = 0 \\ v(x_1, \dots, x_n)f_0 + (u(x_1, \dots, x_n) - z)(-\frac{v(t_1,\dots,t_n)f_0}{u(t_1,\dots t_n)-z} + \\ +\frac{1}{u(t_1,\dots t_n)-z}\sum_{j=1}^{n} \mu_j C_j \varphi_j(t_j)) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) C_j = 0 \end{cases}$$

$\boldsymbol{f_0}$ va C_j larga nisbatan tenglamalar sistemasi hosil bo'ladi.

$$\begin{cases} \left(\omega - z - \int_{\Omega^n} \frac{v^2(t_1,\dots,t_n)dt_1\dots dt_n}{u(t_1,\dots,t_n)-z}\right) \boldsymbol{f_0} + \int_{\Omega^n} \frac{v(t_1,\dots,t_n)}{u(x_1,\dots x_n)-z} \\ \sum_{j=1}^{n} \mu_j C_j \varphi_j(x_j))dt_1, \dots, dt_n = 0 \\ v(x_1, \dots, x_n)f_0 + (u(x_1, \dots, x_n) - z)(-\frac{v(t_1,\dots,t_n)f_0}{u(t_1,\dots t_n)-z} + \\ +\frac{1}{u(t_1,\dots t_n)-z}\sum_{j=1}^{n} \mu_j C_j \varphi_j(t_j)) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) C_j = 0 \end{cases}$$

Quyidagi belgilashlarni kiritamiz:

$$J_j(z) := \int_{\Omega^n} \frac{v(t_1,\dots,t_n)\varphi_j(t_j)dt_1\dots dt_n}{u(t_1,\dots,t_n)-z},$$

$$I_{ij}(z) := \mu_j \int_{\Omega^n} \frac{\varphi_i(t_i)\varphi_j(t_j)dt_1\dots dt_n}{u(t_1,\dots,t_n)-z},$$

$$\Delta_0^{(n)}(z) := \omega - z - \int_{\Omega^n} \frac{v^2(t_1,\dots,t_n)dt_1\dots dt_n}{u(t_1,\dots,t_n)-z},\ \Delta_j(z) := 1 - \mu_j I_{jj}(z).$$

(2.2.4)-sistema quyidagi ko'rinishni oladi:

$$\begin{cases} \Delta_0(z)f_0 + J_1(z)C_1 + \dots + J_n(z)C_n = 0 \\ J_1(z)f_0 + \Delta_1(z)C_1 + \dots + I_{1j}(z)C_n = 0 \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ J_n(z)f_0 + I_{n1}(z)C_1 + \dots + \Delta_n(z)C_n = 0 \end{cases} \qquad (2.2.5)$$

(2.2.5)-sistemaning asosiy determinant quyidagicha bo'ladi.

$$\Delta^{(n)}(z) = \begin{vmatrix} \Delta_0^{(n)} & J_1(z) & J_2(z) & \dots & J_{n-1}(z) & J_n(z) \\ J_1(z) & \Delta_1^{(n)} & I_{12}(z) & \dots & I_{1n-1}(z) & I_{1n}(z) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ J_n(z) & I_{n1}(z) & I_{n2}(z) & \dots & I_{nn-1}(z) & \Delta_n^{(n)} \end{vmatrix}.$$

2.2.1-Xossa: $z\epsilon C \setminus [u_{min}\,, u_{max}]$ soni H-operatorning xos qiymati bo'lishi uchun $\Delta^{(n)}(z)$=0 bo'lishi zarur va yetarlidir.

Bu teoremaga ko'ra $\Delta^{(n)}(z)$ funksiya integral operatorlar uchun Fredgolm determinantining xossasiga egadir. Shu sababli uni H-operatorli matritsaga mos Fredgolm determinant deb ataymiz.

2.2.1-xossadan quyidagi natija kelib chiqadi.

2.2.1-natija. H-operatorning diskret spektri $\sigma_{dick}(H)$ uchun quyidagi tenglik o'rinlidir.

$$\sigma_{dick}(H) = \left\{ z\epsilon C \setminus [u_{min}\,, u_{max}]; \Delta^{(n)}(z) = 0 \right\}$$

2.2.2-Xossa:$\Delta_i(.), i = 0,1, \dots, n$ funksiyalar (-∞; u_{min}) ∪ (u_{max};+∞) oraliqda monoton kamayuvchi funksiya bo'ladi.

Endi bazi muhim xususiy hollarni qaraymiz.

2.2.1-hol. Faraz qilaylik,$\varphi_j(t_j) = 0$ bo'lsin. Bu holda $J_i(z) = 0$ bo'ladi.

2.2.1-natija. $z\epsilon C \setminus [u_{min}\,, u_{max}]$ soni H-operatorning xos qiymati bo'lishi uchun

$$\Delta^{(n)}(z) = \begin{vmatrix} \Delta_0^{(n)} & 0 & 0 & \dots & 0 & 0 \\ 0 & \Delta_1^{(n)} & I_{12}(z) & \dots & I_{1n-1}(z) & I_{1n}(z) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & I_{n1}(z) & I_{n2}(z) & \dots & I_{nn-1}(z) & \Delta_n^{(n)} \end{vmatrix} = 0$$

tenglikning bajarilishi zarur va yetarlidir.

2.2.2-hol.$\Delta_i(z)$ funksiya H_0 operator uchun Fredgolm determinant bo'ldi.

$$\Delta_i(z) \Rightarrow H_0 := \begin{pmatrix} H_{00} & H_{01} \\ H_{01}^* & H_{11} \end{pmatrix}$$

$$H_i \coloneqq H_{11}^0 - V_i$$

$$(V_i f_1)(x_1,\dots,x_n) = \sum_{i=1}^{n} \mu_i \varphi_i(x_i) \int_{\Omega^n} \varphi_i(t_i)\, f_1(t_1,\dots,t_n) dt_1 \dots dt_n$$

2.3.3-hol. $z\epsilon C \setminus [u_{min}, u_{max}]$ soni H_i, $i=\overline{0,n}$ operatorning xos qiymati bo'lishi uchun $\Delta_i(z)$=0 bo'lishi zarur va yetarlidir.

2.3. n-o'lchamli holda molekulyar rezonans modelning rezolventa operatorini qurilishi

2.3.1- Ta'rif: Agar $\lambda\epsilon C$ son uchun $H-\lambda I$ga teskari operator mavjud bo'lib, u C ning hamma yerida aniqlangan bo'lsa, λ soni H operatorning regulyar nuqtasi deyiladi,

$$R_\lambda(H)=(H-\lambda I)^{-1}$$

Operator esa H operatorning λ nuqtadagi rezolventasi deyiladi.

2.3.1-Teorema. H operatorga mos rezolventa operatori

$$R(z)=\begin{pmatrix} R_{00}(z) & R_{01}(z) \\ R_{10}(z) & R_{11}(z) \end{pmatrix}$$

ko'rinishda bo'ladi.

Isbot: H operatorga mos rezolventa operatorini qurish uchun ixtiyoriy $f=(f_0,f_1)$ va $g=(g_0,g_1)\epsilon\mathcal{H}_0\oplus\mathcal{H}_1$ elementlar uchun

$$Hf-zf=g$$

tenglamani yechish kerak bo'ladi,

$$\begin{pmatrix} H_{00} & H_{01} \\ H_{01}^* & H_{11} \end{pmatrix}\begin{pmatrix} f_0 \\ f_1 \end{pmatrix}-z\begin{pmatrix} f_0 \\ f_1 \end{pmatrix}=\begin{pmatrix} g_0 \\ g_1 \end{pmatrix}$$

ya`ni quyidagi tenglamalar sistemasini qaraymiz.

$$\begin{cases} H_{00}f_0+H_{01}f_1-zf_0=g_0 \\ H_{01}^*f_0+H_{11}f_1-zf_1=g_1 \end{cases} \tag{2.3.1}$$

(2.3.1)-tenglamalar sistemasi quyidagi tenglamalar sistemasi bilan ekvivalent bo'ladi.

$$\begin{cases} (\omega-f_0)+\int_{\Omega^2}v(t_1,\dots,t_n)f_1(t_1\dots,t_n)dt_1,\dots,dt_n=g_0 \\ v(x_1,\dots,x_n)f_0+(u(x_1,\dots,x_n)-z)f_1(x_1,\dots,x_n)-\sum_{K=1}^{n}\mu_K\varphi_k(x_k) \\ \int_{\Omega^n}\varphi_k(t_k)f_1(t_1,\dots,t_n)dt_1\dots dt_n=g_1\,(x_1,\dots,x_n) \end{cases} \tag{2.3.2}$$

(2.3.2) tenglamalar sistemasida quyidagicha belgilash kiritamiz:

$$C_j := \int_{\Omega^n} \varphi_k(t_k)\, f_1(t_1,\dots,t_n) dt_1 \dots dt_n$$

U holda (2.3.2)-tenglamalar sistemasini

$$\begin{cases} (\omega - f_0) + \int_{\Omega^2} v(t_1, \dots, t_n) f_1(t_1 \dots, t_n) dt_1, \dots, dt_n = g_0 \\ v(x_1, \dots, x_n) f_0 + (u(x_1, \dots, x_n) - z) f_1(x_1, \dots, x_n) - \sum_{K=1}^{n} \mu_K \varphi_k(x_k) C_j = g_1(x_1, \dots, x_n) \end{cases}$$

kabi yozish mumkin.$z \notin Imu$ bo'lganligi uchun $u(x_1, \dots, x_n) - z \neq 0$ bo'ladi.

(2.3.4)-tenglamalar sistemasining ikkinchi tenglamasidan $f_1(x_1, \dots, x_n)$ ni topib olamiz.

$$f_1(q) = \frac{g_1(x_1,\dots,x_n)}{u(x_1,\dots x_n) - z} - \frac{v(x_1,\dots,x_n) f_0}{u(x_1,\dots x_n) - z} + \frac{1}{u(x_1,\dots x_n) - z} \sum_{j=1}^{n} \mu_j C_j \varphi_j(x_j)$$

$f_1(x_1, \dots, x_n)$-ni tenglamalar sistemasining birinchi tenglamasiga va (3)-tenglikka qo'yamiz:

Quyidagi belgilashlarni kiritamiz:

$$J_j(z) \coloneqq \int_{\Omega^n} \frac{v(t_1, \dots, t_n) \varphi_j(t_j) dt_1 \dots dt_n}{u(t_1, \dots, t_n) - z},$$

$$I_{ij}(z) \coloneqq \mu_j \int_{c} \frac{\varphi_i(t_i) \varphi_j(t_j) dt_1 \dots dt_n}{u(t_1, \dots, t_n) - z},$$

$$\Delta_0(z) \coloneqq \omega - z - \int_{\Omega^n} \frac{v^2(t_1, \dots, t_n) dt_1 \dots dt_n}{u(t_1, \dots, t_n) - z}, \qquad \Delta_j(z) \coloneqq 1 - \mu_j I_{jj}(z).$$

(2.3.4)-sistema quyidagi ko'rinishni oladi

$$\begin{cases} \Delta_0(z) f_0 + J_1(z) C_1 + \dots + J_n(z) C_n = g_0 - \int_{\Omega^n} \frac{v(t_1, \dots, t_n) g_1(t_1, \dots, t_n)}{u(t_1, \dots, t_n) - z} \\ J_1(z) f_0 + \Delta_1(z) C_1 + \dots + I_{1j}(z) C_n = \int_{\Omega^n} \frac{\varphi_1(t_1) g_1(t_1, \dots, t_n)}{u(t_1, \dots, t_n) - z} \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ J_n(z) f_0 + I_{n1}(z) C_1 + \dots + \Delta_n(z) C_n = \int_{\Omega^n} \frac{\varphi_n(t_n) g_1(t_1, \dots, t_n)}{u(t_1, \dots, t_n) - z} \end{cases}$$

tenglamalar sistemasini Kramer usulida yechish uchun unga mos determinantlarni tuzib olamiz.

$$\Delta^{(n)}(z)=\begin{vmatrix}\Delta_0^{(n)} & J_1(z) & J_2(z) & \dots & J_{n-1}(z) & J_n(z)\\ J_1(z) & \Delta_1^{(n)} & I_{12}(z) & \dots & I_{1n-1}(z) & I_{1n}(z)\\ \dots & \dots & \dots & \dots & \dots & \dots\\ J_n(z) & I_{n1}(z) & I_{n2}(z) & \dots & I_{nn-1}(z) & \Delta_n^{(n)}\end{vmatrix}$$

Sistemani yechib f_0 va $C_1,\dots,C_n$larni topib olamiz.Topilgan f_0 va $C_1,\dots,C_n$ larni

$$f_1(q)=\frac{g_1(x_1,\dots,x_n)}{u(x_1,\dots x_n)-z}-\frac{v(x_1,\dots,x_n)f_0}{u(x_1,\dots x_n)-z}+\frac{1}{u(x_1,\dots x_n)-z}\sum_{j=1}^{n}\mu_j C_j\varphi_j(x_j)$$

keltirib qo'yamiz

$$\begin{cases} f_0=R_{00}(z)g_0+R_{01}(z)g_1\\ f_1=R_{10}(z)g_0+R_{11}(z)g_1\end{cases} \qquad (2.3.5)$$

Tenglamalar sistemasi hosil bo'ladi.

(2.3.5)-tenglamalar sistemasidan rezolventa operatori quyidagicha bo'ladi.

$$R(z)=\begin{pmatrix}R_{00}(z) & R_{01}(z)\\ R_{10}(z) & R_{11}(z)\end{pmatrix}$$

Teorema to'liq isbotlandi.

II-BOB XULOSASI

Bitiruv malakaviy ishining ikkinchi bobi “n-o’lchamli holda ikki kanalli molekulyar rezonans modelning spektri va rezolventasini tadqiq qilish” deb nomlangan bo’lib, u uchta bo’limdan iborat. Dastlab umumiy holda ham qaralayotgan modelning chiziqliligi, chegaralanganligi va o’z-o’ziga qo’shmaligi isbotlangan. Uni yoritishda bu tushunchalarning ta’riflari, sodda tengsizliklar va mashhur Koshi-Bunyakovskiy tengsizligidan foydalanilgan. 2.1-bo’limda n -o’lchamli holda H-operatorni muhim spektri haqidagi lemma isboti qaralgan. Muhim spektrni aniqlashda chekli o’lchamli qo’zg’alishlarda muhim spektrning o’zgarmasligi haqidagi mashhur Veyl teoremasidan foydalanilgan. 2.2-bo’limda Fredgolm determinant qurigan va uning bazi bir hollari qaralgan. 2.3-bo’limda esa n -o’lchamli holda H-operatorli matritsaning rezolventa operatorining ko’rinishi aniq topilgan. Fredgolm determinantini va Rezolventa operatorini qurishda chiziqli algebra kursidan ma’lum bo’lgan chiziqli tenglamalar sistemasini yechishning Kramer usuli qo’llanilgan.

II-bobda olingan natijalarni isbotlashda Funsional analiz va kompleks analiz elementlaridan foydalanilgan.

XOTIMA

Bitiruv malakaviy ishi “Ikki kanalli molekulyar rezonans modelning spektral xossalari” mavzusida bajarilgan bo’lib, u ikkita bobdan tashkil topgan. Birinchi bobda asosan molekulyar rezonans modelning qo’zg’alish o’lchami 1 va 2 bo’lgan hollarda uning muhim spektri chekli o’lchamli qo’zg’alishlarda muhim spektrini o’zgarmasligi haqidagi Veyl teoremasi yordamida topilgan. Bu modellarga mos Fredgolm determinantlari chiziqli tenglamalar sistemalar yechishning Kramer usuli yordamida topilgan. Diskret spektr qurilgan Fredgolm determinantining nollari sifatida aniqlangan. Ba’zi xususiy hollarda Fredgolm determinantining nollarini o’rganish masalasi nisbatan soddaroq ko’rinishga ega va monotonlik xossasiga ega regulyar funksiyalarning nollarini o’rganish masalasiga keltirilgan. O’z navbatida hosil bo’lgan funksiyalar xos qiymatlar sonini va joylashish o’rnini o’rganish imkonini bergan. Rezolventa operatorlar ko’rinishi aniq hisoblangan. O’rganilayotgan model vektor-qiymatli bo’lganligi bois qurilgan rezolventa operatorlari ham vektor-qiymatli bo’lishi ko’rsatilgan.

Ikkinchi bob qo’zg’alish o’lchami ixtiyoriy n natural soni bo’lganda quyi o’lchamlar uchun olingan natijalar umumlashtirilgan. Bu holda ham molekulyar rezonans model chiziqlilikka, chegaralanganlikka va o’z-o’ziga qo’shmalikka tekshirilgan. Fredgol’m determinanti hisoblangan, uning nollari to’plami diskret spektr bilan ustma-ust tushishi isbotlangan. Rezolventa operatorining ta’sir formulasi aniqlangan bo’lib, u ham vektor-qiymatli bo’lishi ko’rsatilgan.

BMIda olingan natijalarni isbotlashda Funsional analiz va kompleks analiz elementlaridan foydalanilgan.

Foydalanilgan adabiyotlar

1. Ўзбекистон Республикаси Президенти Ш.М.Мирзиёевнинг “Ўзбекистон Республикасини янада ривожлантириш бўйича Ҳаракатлар Стратегияси тўғрисида”ги фармони. 2017 – йил, 7 – февраль.
2. Ш.М.Мирзиёев, Танқидий таҳлил, қатъий тартиб – интизом ва шахсий жавобгарлик – ҳар бир раҳбар фаолиятининг кундалик қоидаси бўлиши керак. Т. 2017.
3. Ўзбекистон Республикаси Президенти Ш.М.Мирзиёевнинг 2019 йил учун мўлжалланган энг муҳим устувор вазифалар ҳақидаги Олий Мажлисга Мурожаатномаси. 2018 – йил, 28 – декабрь.
4. J.I.Abdullayev, R.N.G`anixo`jayev, H.H.Shermatov, O.I.Egamberdiyev “Funksional analiz”. Toshkent – Samarqand. 2009.
5. Саримсоқов Т.А. Фукционал анализ курси. “Ўқитувчи” Т. 1986.
6. Архизер Н.И., Глазман И.М. Теория линейных операторов в гильбертовом пространстве. М: Наука, 1972.
7. Калмогаров А.Н., Фомин С.В. Элементы теории функций и функционального анализа. М: Наука, 1972.
8. Люстерник Л.А., Соболев В.И. Элементы функционального анализа. М: Наука, 1965.
9. Рид М., Саймон Б. Методы современной математической физики. Т. 1,4. М: Мир, 1971.
10. Macluer B.D. Elementary Functional Analysis. Springer, 2009.
11. Brain Davies E. Linear operators and their Spectra. Cambridge University Press. 2007.
12. C. Treter, “ Spectral theory of block operator matrices and applicitions” Imperial College Press, London, 2008.
13. R.P.Feynman. Statistical mechanics: a set of lectures (2^{nd} ed.). Reading, Massachustts: Addison-Wesley, 1998,-151P.
14. С.Н.Лакаев, Некаторые спектральные свойства модели Фридрихса. Труды семинара им. И.Г.Петровсково, Лелинград, 1986,№11,С.210-233
15. Т.Х.Расулов. Исследование существенного спектра одного матричного оператор. Теоретическая и математическая физика, 164:1 (2010), С. 62-77.
16. Rajendra Bhatia. Positive Definite Matrices. Prinseton University Press,2007.

17. Rajendra Bhatia. Matrix Analysis, Springer-Verlag, New York, 1997.
18. Т. Като. Теория возмущения линейных операторов. Издательство “Мир”, Масква, 1972.
19. Т. Х. Расулов. О кратности собственных значений дувухканальной молекулярно-резонансной модели. Научний вестник БухГУ, №2(2016),С,103-115.
20. С.Н.Лакаев, Ш.М. Латипов. О существовании и аналитичности собственных значенний дувухканальной молекулярно-резонансной модели. ТИФ, 2011, Т.169,№3,С.341-351.
21. www.ziyonet.uz
22. www.allmath.ru
23. www.mcce.ru
24. www.lib.mexmat.ru
25. www.webmath.ru
26. www.exponenta.ru