saqarTvelos teqnikuri universiteti

xelnaweris uflebiT

beJan kotia

eleqtronebis da polaronebis Zvradobis kvanturi Teoriis zogierTi sakiTxi naxevargamtarebsa da ionur kristalebSi

doqtoris akademiuri xarisxis mosapoveblad
wardgenili disertaciis

avtoreferati

Tbilisi
2010 weli

samuSao Sesrulebulia saqarTvelos teqnikur universitetis
informatikisa da marTvis sistemebis fakultetis
fizikis departamentis
myari sxeulebis fizikis mimarTulebaze.

samecniero xelmZRvanели: ----------

recezentebi: ----------
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dacva Sedgeba ---------- wlis `_____~ ---------- saaTze
saqarTvelos teqnikuri universitetis informatikisa da marTvis
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sxdomaze, korpusi----------, auditoria----------
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disertaciis gacnoba SeiZleba stu-s biblioTekaSi,
xolo avtoreferatisa stu-s vebgverdze

sadisertacio sabWos mdivani ----------

naSromis zogadi daxasiaTeba

Sesavali kristalebSi eleqtronuli gadatanis movlenebis zonuri Teoria principSi dafuZnebulia sam ZiriTad koncefciaze: 1) denis gadamtanebi warmoadgenen kvazi nawilakebs gansazRvruli kvaziimpulsiT da dispersiis kanoniT. 2) denis gadamtanTa eleqtrogamtaroba da Zvradoba ganisazRvreba maTi gabneviT kristalis idealuri mesris struqturis dinamiur da statikur damaxinjebebze (defeqtebze). 3) denis gadamtanis Tavisufali ganarbenis sigrZe warmoadgens sasrul sidides da is bevrad aRemateba Sesabamisad kvazi nawilakis de-broilis talRis sigrZes. am pirobebis gaTvaliswinebiT denis gadamtanTa gabneva SeiZleba CaiTvalos rogorc “iSviaTi”. am debulebebidan gamomdinare, denis gadamtanTa yofaqceva kristalSi aRiwereba albaTuri ganawilebis funqciiT kvazi impulsebis mixedviT, romelic ganisazRvreba, rogorc bolcman-bloxis kinetikuri gantolebis amoxsna. gadatanis kinetikuri (meqanikuri) koeficientebis (Zvradoba, eleqtrogamtaroba) gamosaTvlelad gamoiyeneba denis gadamtanebis arawonasworuli ganawilebis funqciisTvis kinetikuri gantoleba–bolcmanis gantoleba–romelic iTvaliswinebs denis (muxtis) matarebelTa urTierTqmedebas (gabnevas) kristaluri mesris rxevebze.

ukanasknel wlebSi, eleqtronuli gadatanis movlenebis gamokvlevebSi myari sxeulebis fizikaSi, Zalian farTo gamoyeneba hpova ufro zogadma midgomam, romelic dafuZnebulia kubos wrfivi reaqciis Teoriaze. am TeoriaSi-romelsac gadamwyveti mniSvneloba aqvs wrfiv arawonasworul TermodinamikaSi–gadatanis kinetikuri (meqanikuri) koeficientebi bunebrivad gamoisaxebian (aRiwerebian) droiTi korelaciuri funqciebiT. isini asaxaven sistemis reaqcias hamiltonianis SeSfoTebisas, romlis tipiur magaliTs warmoadgens eleqtrogamtaroba.

amrigad, aRniSnulidan gamomdinare naTelia, rom rogorc samecniero, aseve akademiuri TvalsazrisiT did interess warmoadgens eleqtronuli da polaronuli gadatanis movlenebis koreqtuli kvanturi

Teoriis ageba da gadatanis meqanikuri koeficientebis gamoTvla naxevargamtarebsa da ionur kristalebSi dafuZnebuli kubos wrfivi reaqciis Teoriaze.

Temis aqtualoba Tanamedrove pirobebSi farTod gamokvlevis sagans warmoadgens eleqtronuli da polaronuli gadatanis movlenebis Seswavlis sakiTxi myari sxeulebisa da kondensirebul garemoTa fizikaSi. ukanasknel wlebSi, rTuli molekuluri aRnagobis mqone nivTierebaTa Seqmnis tendencia da maTi eleqtronuli da polaronuli Tvisebebis Seswavla stimuls aZlevda mravali Teoriuli gamokvlevebis Sesrulebas avtolokalizebuli (polaronuli) mdgomareobebis aRsawerad dinamiurad mouwesrigebel sistemebSi. polaronis koncefcias, romelic warmoadgens martiv magaliTs arawrfivi kvazi nawilakisa, Zalian didi mniSvneloba da gamoyeneba aqvs myari sxeulebis (kondensirebul garemoTa) fizikaSi, da kerZod igi mWidrod aris dakavSirebuli kvanturi dinamiuri sistemebis Teoriis funadamentur problemebTan da velis kvanturi Teoriis sakiTxebTan. eleqtronuli da polaronuli movlenebis ganxilvisa da Seswavlisas myar sxeulebSi, Teoriuli gamokvlevebis Zalian didi raodenoba samecniero literaturaSi miZRvnili aris eleqtronebisa da polaronebis eleqtrogamtarobisa da Zvradobis gamoTvlaze naxevargamtarebsa da ionur kristalebSi. es gamokvlevebi dafuZnebuli aris sxvadasxva Teoriul meTodebze–grinis funqciis teqnikaze, bolcmanis kinetikuri gantolebis Seswavlaze, TviTSeTanxmebul meTodebze da sxva. Sedegebi miRebuli sxvadasxva meTodebis gamoyenebiT da Sesabamisad sxvadasxva miaxloebebze dayrdnobiT, Zireulad gansxvavdeba erTmaneTisagan. miuxedavad imisa, rom eleqtronebis da polaronebis eleqtrogamtarobisa da Zvradobis gamoTvla warmoadgens erT-erT uZveles problemas myari sxeulebis fizikaSi, is mainc rCeba erT-erT urTules da Znel amocanad Teoriulad amoxsnis Tvalsazrisi T.

amgvarad, Tanamedrove pirobebSi kvlav aqtualurs warmoadgens sakiTxi eleqtronebis da polaronebis eleqtrogamtarobis da Zvradobis koreqtuli gamoTvlisa naxevargamtarebsa da ionur kristalebSi.

myari sxeulebis fizikisa da arawonasworuli statistikuri meqanikis mravali amocanis ganxilvisas Seiswavleba mcire dinamiuri qvesistemis evolucia droSi, romelic imyofeba kontaqtSi didi Tavisuflebis ricxvis mqone, Termodinamikur wonaswo robaSi myof sistemasTan–TermostatTan.

eleqtronuli da polaronuli gadatanis movlenebis gamokvlevebisas myar sxeulebSi kubos wrfivi gamoZaxilis Teoriaze dayrdnobiT, ZiriTad amocanas warmoadgens zusti, ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebis miReba drois ormomentiani wonasworuli korelaciuri funqciebisTvis kvazinawilakebis aRmweri Sesabamisi dinamiuri sidideebisTvis, rodesac xdeba am ukanasknelTa urTierTqmedeba (gabneva) kristaluri mesris rxevebze (fononebze), da rodesac fononuri (bozonuri) veli ganixileba rogorc Termostati. samecniero literaturaSi, aseTi saxis gantolebebis misaRebad, rogorc wesi, gamoiyeneba aprioruli hipoTeza–sawyisi korelaciebis Sesustebis principi, an msgavsi debulebebi–mag. SemTxveviTi fazebis miaxloeba (Sfm)–rodesac drois sawyisi momentisaTvis mTeli sistemis (qvesistema plus Termostati) statistikuri operatori moicema faqtorizebuli saxiT (mTeli sistemis statistikuri operatori ganixileba rogorc qvesistemisa da Termostatis statistikur operatorTa pirdapiri namravli). naTelia, rom aseTi daSvebebis Sedegad miRebuli ganzogadoebuli, kvanturi evoluciuri gantolebebi wonasworuli korelaciuri funqciebisTvis ar aris zusti.

amrigad, eleqtronuli da polaronuli gadatanis movlenebis koreqtuli kvanturi Teoriis asagebad da meqanikuri koeficientebis (mag. Zvradoba, eleqtrogamtaroba) gamosaTvlelad naxevargamtarebsa da ionur kristalebSi da agreTve eleqtron-fononuri sistemis kinetikis sakiTxebis gamosakvlevad kubos wrfivi reaqciis Teoriis CarCo-

ebSi, aqtualurs warmoadgens amocana kvazinawilakebis dinamiuri sidideebisTvis drois ormomentiani wonasworuli korelaciuri funqciebisTvis zusti, ganzogadoebuli, kvanturi evoluciuri gantolebebis miReba–sawyisi korelaciebis Sesustebis principisa da Sfm-is gamoyenebis gareSe.

samuSaos mizani da amocanebi. sadisertacio naSromis mizans warmoadgens: myari sxeulebis fizikis zogierTi kvanturi dinamiuri sistemisTvis, romelic urTierTqmedebs fononur (bozonur) velTan (eleqtron-fononuri sistema, frolixis polaronis modeli, akustikuri polaronis modeli susti eleqtron-fononuri urTierTqmedebis SemTxvevaSi, polaronis feinmanis ganzogadoebuli modeli (fgm)), mowesrigebul operatorTa formalizmsa da T-namravlTa teqnikaze dayrdnobiT, agreTve liuvilis superoperatoruli formalizmisa da proeqciuli operatoris meTodis gamoyenebiT_zusti, ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebis miReba da gamokvleva drois ormomentiani wonasworuli korelaciuri funqciebisTvis Sfm-is gamoyenebis gareSe.

–Aam modelebze dayrdnobiT, da am gantolebaTa gamoyenebiT, Tanmimdevruli, srulyofili eleqtronuli da polaronuli gamtarobisa da dabaltemperaturuli dreifuli Zvradobis kvanturi Teoriis ageba naxevargamtarebsa da ionur kristalebSi dafuZnebuli kubos wrfivi gamoZaxilisa da SeSfoTebis Teoriaze. gadatanis meqanikuri koeficientebis (eleqtrogamtaroba, Zvradoba) gamoTvla kvanturi dinamiuri sistemebis zemoTmiTiTebuli modelebisTvis.

sadisertacio naSromis ZiriTadi Sedegebi da mecnieruli siaxle warmodgenil sadisertacio naSromSi gadawyvetilia Semdegi amocanebi:

–mowesrigebul operatorTa formalizmisa da T-namravlTa teqnikis daxmarebiT, sawyisi korelaciebis Sesustebis principisa da Sfm-is gamoyenebis gareSe, gamoyvanilia da gamokvleulia axali, zusti, ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebi gamoricxuli bozonuri (fononuri) amplitudebiT drois ormomentiani wona-

sworuli korelaciuri da grinis funqciebisTvis dinamiuri qvesistemisTvis, romelic urTierTqmedebs bozonur TermostatTan. miRebulia agreTve axali, zusti kvanturi kinetikuri gantolebebi korelaciuri funqciebisTvis_liuvilis superoperatoruli formalizmisa da proeqciuli operatoris meTodis daxmarebiT.

–dinamiuri qvesistemis bozonur (fononur) TermostatTan urTierTqmedebis hamiltonianis mixedviT, SeSfoTebis Teoriis meore miaxloebaSi miRebulia axali, ganzogadoebuli kvanturi kinetikuri gantolebebi gamoricxuli bozonuri amplitudebiT, qvesistemis drois ormomentiani wonasworuli korelaciuri funqciebisTvis–rogorc markoviseuli, ise aramarkoviseuli formiT–romelTa dajaxebiTi integralebi Seicaven cxadad gamoyofil sawyisi korelaciebis evoluciur wevrebs.

–kubos wrfivi reaqciisa da SeSfoTebis Teoriis farglebSi, naxevargamtarebisa da ionuri kristalebisTvis agebulia eleqtronuli da polaronuli dabalsixSiruli gamtarobisa da dabaltemperaturuli dreifuli Zvradobis Tanmimdevruli, koreqtuli kvanturi Teoria, dafuZnebuli_kvanturi disipaciuri sistemebis zemoTmiTiTebuli modelebisTvis_ganzogadoebul kvantur kinetikur gantolebebze korelaciuri funqciebisTvis “deni-denze” eleqtronisa da polaronisTvis, romlebic urTierTqmedeben fononebTan Sfm-is gamoyenebis gareSe.

–miRebulia da gamokvleulia analizuri gamosaxulebebi eleqtronisa da polaronis relaqsaciuri maxasiaTeblebisTvis (impulsis relaqsaciis sixSire da sxv.); gamoTvlilia wonasworuli korelaciuri funqciebis–“deni-denze”–milevis dekrementebi da oscilirebadi faqtorebi. napovnia eleqtrogamtarobis tenzoris (disipaciuri nawilis) analizuri saxe eleqtron-fononuri sistemisTvis kristalis dabali temperaturebisa da dabalsixSiruli gareSe eleqtruli velebis SemTxvevaSi da gamoTvlilia gadatanis meqanikuri koeficientebi (Zvradoba, eleqtrogamtaroba) kvanturi disipaciuri sistemebis aR-

niSnul modelTaTvis; napovnia "$\frac{3}{2}\frac{K_B T}{\hbar w_0}$-problemis" nawilobrivi gadawyveta frolixis polaronis dabal temperaturuli Zvradobis TeoriaSi.

–miRebulia temperaturuli Seswo rebebi eleqtronisa da polaronis dreiful Zvradobebze, romlebic ganpirobebulia sawyisi korelaciebis evoluciuri wevrebis arsebobiT kvantur kinetikur gantolebebSi wonasworuli korelaciuri funqciebisTvis "siCqare-siCqareze" ("impulsi-impulsze") eleqtronisa da polaronisTvis. dadgenilia, rom es Seswo rebebi warmoadgenen mcire sidideebs Sesrulebuli miaxloebebisa da ganxiluli TeoriisfarglebSi.

<u>sadisertacio naSromis praqtikuli mniSvneloba</u>

naSromSi dasmuli amocanebis gadawyvetam moiTxova arawonasworuli statistikuri meqanikis zogierTi meTodis Semdgomi ganviTareba. sadisertacio naSromSi miRebuli ZiriTadi Teoriuli Sedegebis praqtikuli mniSvneloba (Rirebuleba) ganisazRvreba imiT, rom miRebuli zusti, ganzogadoebuli kvanturi evoluciuri gantolebebi wonasworuli korelaciuri funqciebisTvis SesaZlebelia gamoyenebuli iqnas gadatanis movlenebis gansaxilvelad da gamosakvlevad_kubos wrfivi reaqciis Teoriis farglebSi, sawyisi korelaciebis Sesustebis principisa da Sfm-is daSvebebis gareSe_myari sxeulebis da kondensirebul garemoTa fizikis dinamiur qvesistemaTa sxva modelTaTvis (kvanturi disipaciuri sistemebisTvis), romlebic urTierTqmedeben bozonur velTan (TermostatTan). (mag. brounis kvanturi nawilakis moZraobis Sesaswavlad, romelic ganixileba rogorc wrfivi, milevadi harmoniuli oscilatori, da romlis dinamika aRiwereba kaldeiralegetis mikroskopuli modeluri hamiltonianiT).

naSromSi ganviTarebuli formalizmi, meTodebi da miRebuli kinetikuri gantolebebi martivad SesaZlebelia ganvrcobil iqnas kinetikuri movlenebis Sesaswavlad da gadatanis meqanikuri koeficientebis (mag. Zvradoba, eleqtrogamtaroba) gamosaTvlelad: eleqtronebis urTi-

erTqmedebisas (gabnevisas) arapolarul optikur fononebze, piezoeleqtrul fononebze, agreTve sxva didi radiusis mqone polaronTa modelTaTvis (mag. akustikuri polaronis modelisTvis-eleqtronis fononebTan Zlieri urTierTqmedebis SemTxvevaSi). gamoyvanili ganzogadoebuli kvanturi kinetikuri gantolebebi korelaciuri funqciebisTvis kvanturi dinamiuri qvesistemisTvis, romelic urTierTqmedebs fononur velTan, SesaZlebelia gamoyenebul iqnas normaluri (arazegamtari) metalebis eleqtrowinaRobis gamosaTvlelad eleqtronebis gabnevisas akustikur fononebze. naSromSi warmodgenili formalizmis daxmarebiT SesaZlebelia temperaturuli Sesworebebis povna metalTa eleqtrowinaRobisTvis (Sesworebebi blox_grunaizenis formulaSi), romlebic agreTve ganpirobebulia eleqtronebis fononebTan urTierTqmedebisas sawyisi korelaciebis gaTvaliswinebiT.

<u>dasacavad gamotanilia Semdegi debulebebi</u>:

1. osakas Sedegis ganzogadoeba dabalsixSiruli kuTri eleqtrogamtarobisTvis da "$\frac{3}{2}\frac{K_B T}{\hbar w_0}$-problemis" nawilobrivi gadawyveta frolixis polaronis (eleqtronis) dabal temperaturuli Zvradobis TeoriaSi.
2. eleqtronis dabal temperaturuli statikuri Zvradobis gansxvavebuli (2-jer naklebi) mniSvneloba `bolcmaniseul~ ZvradobasTan SedarebiT akustikuri polaronis modelSi susti eleqtron-fononuri urTierTqmedebis SemTxvevaSi.
3. Zlieri eleqtron_fononuri urTierqmedebis SemTxvevaSi dabaltemperaturuli Zvradobis gansxvavebuli yofaqceva eleqtron-fononuri bmis mudmivas rigis mixedviT polaronis fgm_Si, pekaris modelTan SedarebiT.
4. mcire sididis temperaturuli Sesworebebis arseboba eleqtronis da polaronis dabal temperaturul Zvradobebze ganxilul modelebSi.

<u>naSromis aprobacia</u> disertaciis ZiriTadi Sinaarsi moxsenebuli iyo informatikisa da marTvis sistemebis fakultetis fizikis departa-

mentisa da myari sxeulebis fizikis kolegiis samecniero seminarebis sxdomebze.

disertaciis Sinaarsi da ZiriTadi Sedegebi wardgenili iyo: 1986w. q. TbilisSi Catarebul 24-e sakavSiro TaTbirze_»24-? ?????? ???? ?????????? ?????? ?????? ??????????», Tbilisi, 1986w; 1991w q. xarkovSi (ukraina) Catarebul sakavSiro konferenciaze «?????????????????? ?????????????? ??????», ???????, 14-17??? 1991?; 1992w. q. puSCinoSi (ruseTi) Catarebul saerTaSoriso skolaSi_International Workshop `POLARONS and APPLICATIONS~ May 23-31, 1992, Pushchino, Russia; 1992w. q. berlinSi (germania) Catarebul saerTaSoriso konferenciaze `The 18th IUPAP International Conference on Statistical Physics, Berlin, 2-8 August 1992~; saqarTvelos teqnikuri universitetis profesor_maswavlebelTa samecniero_teqnikur konferenciaze, 16-19 noemberi, Tbilisi, 1993w; 1993w. q. trondhaimSi (norvegia) Catarebul saerTaSoriso simpoziumze `The Lars Onsager Symposium. Coupled Transport Processes and Phase Transitions~, June 2-4 1993, Trondheim, Norway; 1993w. q. florenciaSi (italia) Catarebul saerTaSoriso konferenciaze `EPS9 TRENDS IN PHYSICS~ Firenze, 14-17 September 1993; 1995w. q. qsiamenSi (CineTi) Catarebul saerTaSoriso konferenciaze `The 19th UPAP International Conference on Statisitcal Physics~, Xiamen 31 July-4 August 1995; 1998w. q. parizSi (safrangeTi) Catarebul saerTaSoriso konferenciaze `XXth IUPAP INTERNATIONAL CONFERENCE ON STATISTICAL PHYSICS~, Paris, July 20-24, 1998, UNESCO Sorbonne.

publikaciebi: disertaciis ZiriTadi Sedegebi gamoqveyenebulia Cvidmet samecniero naSromSi, romelTa dasaxeleba moyvanilia avtoreferatis bolos.

naSromis moculoba da struqtura: disertaciis sruli moculoba Seadgens 157 nabeWd gverds; disertacia Sedgeba reziumesagan (or enaze), sarCevisagan, naxazebis nusxisagan, Sesavlisagan, samiTavisagan, ilustraciis saxiT moyvanili sami naxazisgan, daskvnebisa da 125 dasaxelebis mqone gamoyenebuli literaturis siisgan, erTi danarTisa

da avtoris mier gamoqveynebuli samecniero naSromebisgan, romlebSiac asaxulia disertaciis ZiriTadi Sedegebi.

sadisertacio naSromis Sinaarsi

Sesavali dasabuTebulia Temis aqtualoba, Camoyalibebulia naSromis miznebi da amocanebi, da gansazRvrulia kvlevis obieqtebi da meTodebi.

pirveli Tavi ZiriTadad atarebs mimoxilviT xasiaTs

§1.1 (1.1.1-1.1.6)_Si moyvanilia modeluri hamiltonianis saxe dinamiuri sistemebisa, romlebic urTierTqmedeben bozonur TermostatTan da ganxilulia zogierTi aqtualuri magaliTi kvanturi disipaciuri da Ria arawonasworuli modeluri sistemebisa Tanamedrove fizikis sxadasxva dargidan, romlebic gaxdnen intensiuri kvlevisa da Seswavlis sagani ukanasknel 30-40 wlis ganmavlobaSi. am farTo gamokvlevaTa speqtri moicavda metalTa eleqtrogamtarobisa da zegamtarobis Teoriis, metalTa Senadnobebisa da gadacivebuli `metaluri minebis~ eleqtronuli Teoriis sakiTxebs; susti da Zlieri lokalizaciisa da Zlier araerTgvarovan nivTierebaTa eleqtrogamtarobis Teoriis sakiTxebs mouwesrigebel sistemaTa fizikaSi; lazeruli gamosxivebisa da zegamosxivebis Teoriis aspeqtebs kvantur radiofizikaSi; magnituri polaronebis da fluqtuonebis (fazonebis) Teoriis sakiTxebs magnitur nivTierebebSi (garemoebSi) da sxva.

§1.2 (1.2.1-1.2.2.)_Si ganxilulia dinamiurad mouwesrigebeli sistema eleqtron-fononuri sistema da eleqtronis urTierTqmedeba akustikur da polarul optikur fononebTan; moyvanilia eleqtron-fononuri sistemis hamiltonianis zogadi saxe (frolix-pekaris tipis hamiltoniani), eleqtronis akustikur da polarul optikuri fononebTan urTierTqmedebis hamiltonianTa saxeebi da mokled mimoxilulia agreTve deformaciis potencialis meTodi.

§1.3 (1.3.1-1.3.3)_Si moyvanilia didi radiusis mqone polaronTa modelebi. ganxilulia polaronis frolixisa da pekaris modelebi da polaronis feinmanis erToscilatoriani da feinmanis ganzogadoebu-

li modelebi. amave paragrafSi ganxilulia agreTve ukanasknel wlebSi ganviTarebuli da gamoyenebuli axali midgoma polaronuli sistemebis Termodinamikisa da kinetikis sakiTxebis gamokvlevebisas _ mowesrigebuli operatorTa formalizmi, T_namravlTa meTodi da fononuri operatorebis gamoricxvis teqnika eleqtron-fononuri sistemis maxasiaTebeli fizikuri sidideebis wonasworuli da arawonasworuli saSualo mniSvnelobebidan. aRniSnulia zogierT SemTxvevebSi am axali midgomis upiratesoba, kontinualuri integri-rebis meTodTan SedarebiT, eleqtron-fononuri sistemis kinetikis sakiTxebis Seswavlisas.

$ 1.4._Si ganxilulia fizikuri kinetikis zogierTi principuli sakiTxi dinamiuri sistemebisa, romlebic urTierTqmedeben fononur (bozonur) velTan. mimoxilulia metad mniSvnelovani da principuli sakiTxi, K_tipis dinamiur sistemebSi (rogorc klasikuris, aseve kvanturisTvis), evoluciuri (kinetikuri) gantolebebis gamoyvanis dros Semoklebuli aRweris SesaZleblobaze, romelic ar eyrdnoba hipoTezas_sawyisi korelaciebis Sesustebisa da Sfm-is gamoyenebis Sesaxeb. aRwerilia is ZiriTadi sqemebi da meTodebi, romlebsac mivyavarT bolcmanis saxis kinetikuri gantolebisa da ZiriTadi kinetikuri gantolebis miRebamde. ganxilulia is ZiriTadi principuli xasiaTis sirTuleebi, romlebic warmoiSvebian eleqtron-fononuri sistemisa da polaronTa zemoTmoyvanil modelTaTvis dreifuli Zvradobebis gamoTvlisas, gamomdinare rogorc bolcmanis kinetikuri gantolebidan da kubos wrfivi reaqciis Teoriidan, aseve gamtarobis wrfivi da arawrfivi Teoriebis zogierTi sxva meTodebis (arawonasworuli simkvrivis matricis meTodi, balansis gantolebis meTodi) gamoyenebisas.

meore Tavi sadisertacio naSromSi originaluri xasiaTisaa.

am TavSi dasmulia da gadawyvetilia zogadi saxis amocana_dinamiuri qvesistemisTvis, romelic urTierTqmedebs bozonur (fononur) TermostatTan_axali, zusti ganzogadoebuli kvanturi evoluciuri gantolebebis miReba drois ormomentiani wonasworuli korelciuri

da grinis funqciebisTvis sawyisi korelaciebis Sesustebis principisa da Sfm_is gamoyenebis gareSe.

$2.1_Si ganxilulia mowesrigebuli operatorTa formalizmi da T_namravlTa meTodi.

$2.2_Si am formalizmze dayrdnobiT gamoyvanilia axali, zusti, araCaketili ganzogadoebuli kvanturi kinetikuri gantolebebi wonasworuli korelaciuri funqciebisTvis, rogorc markoviseuli, aseve aramarkoviseuli saxis, saidanac gamoricxulia bozonuri amplitudebi. miRebuli zusti kvanturi kinetikuri gantolebebis dajaxebiTi integralebi Seicaven damatebiT wevrebs, romlebic aRweren sawyisi korelaciebis evolucias droSi, ganpirobebuls qvesistemis urTierTqmedebiT bozonur TermostatTan drois sawyis momentSi. napovnia agreTve msgavsi saxis evoluciuri gantoleba grinis (dagvianebuli) funqciisTvis. sadisertacio naSromis danarTSi detalurad aris aRwerili bozonuri operatorebis (amplitudebis) gamoricxvis teqnika drois ormomentiani wonasworuli korelaciuri funqciebis evoluciuri (kinetikuri) gantolebebidan.

$2.3_Si ganxilulia markoviseuli miaxloeba qvesistemis dinamikisTvis da qvesistemis TermostatTan urTierTqmedebis hamiltonianis mixedviT SeSfoTebis Teoriis meore miaxloebaSi gamoyvanilia axali, ganzogadoebili markoviseuli kvanturi kinetikuri gantoleba drois ormomentiani wonasworuli korelaciuri funqciisTvis $\langle B_s A_s(-t)\rangle$:

$$\frac{\partial}{\partial t}\left\langle B_s A_s(-t)\right\rangle = \frac{i}{\hbar}\left\langle [H_s B_s]_- \cdot A_s(-t)\right\rangle - \frac{1}{\hbar^2}\sum_k \int_0^t dx \Big[\big(1+N_k(b)\big)\times$$
$$\times e^{iw(k)x}\left\langle C_{kH_0}(s,-x)\cdot\big[C_k^+(s),B_s\big]_- A_s(-t)\right\rangle + N_k(b)e^{-iw(k)x}\times$$
$$\times\left\langle C_{kH_0}^+(s_1-x)\cdot\big[C_k(s),B_s\big]_- A_s(-t)\right\rangle\Big] + \frac{1}{\hbar^2}\sum_k\int_0^t dx\Big[\big(1+N_k(b)\big)\times$$
$$\times e^{-iw(k)x}\cdot\left\langle\big[C_k(s),B_s\big]_- C_{kH_0}^+(s,-x)A_s(-t)\right\rangle + N_k(b)e^{iw(k)x}\times \qquad (1)$$
$$\times\left\langle\big[C_k^+(s),B_s\big]_-\cdot C_{kH_0}(s,-x)A_s(-t)\right\rangle\Big] - \frac{i}{\hbar^2}\sum_k\int_0^{\hbar b} dq\Big[\big(1+N_k(b)\big)\times$$
$$\times e^{-qw(k)}e^{iw(k)t}\left\langle C_{kH_0}(s,-t-iq)\big[C_k^+(s),B_s\big]_-\cdot A_s(-t)\right\rangle + N_k(b)e^{qw(k)}\times$$
$$\times e^{-iw(k)t}\left\langle C_{kH_0}^+(s,-t-iq)\cdot\big[C_k(s),B_s\big]_-\cdot A_s(-t)\right\rangle\Big].$$

sadac H_s_qvesistemis hamiltoniania, A_s, B_s $C_k(s)$, $C_k^+(s)$ –qvesistemis operatorebia, $N_k(\beta)=[e^{\beta\hbar\omega(k)}-1]^{-1}$_warmoadgens bozonebis Sevsebis saSualo ricxvs, xolo operatorebi $C_{kH_0}(S,Z)$ da $C_{kH_0}(S,Z)$ _ gansazRvrulia tolobebiT:

$$C_{kH_0}(S,Z)=e^{\frac{i}{h}H_0Z}C_k(S)e^{-\frac{i}{h}H_0Z}\quad C_{kH_0}{}^+(S,Z)=e^{\frac{i}{h}H_0Z}C_k{}^+(S)e^{-\frac{i}{h}H_0Z}\quad H_0=H_s+H_\Sigma;$$

da H_Σ- aris bozonuri Termostatis hamiltoniani. analogiuri saxis gantolebebia miRebuli agreTve sxva korelaciuri funqciebisTvis.

§2.4_Si ganxilulia da ganviTarebulia meore (gansxvavebuli) midgoma igive problemisadmi, romelic eyrdnoba liuvilis superoperatorul formalizmsa da proeqciuli operatoris meTods. am formalizmisa da meTodis daxmarebiT napovnia axali, zusti ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebi wonasworuli korelaciuri funqciebisTvis Sfm_is gamoyenebis gareSe. gamoyvanil kinetikur gantolebas $<A_sB_s(-t)>$_korelaciuri funqciisTvis aqvs Semdegi saxe:

$$\frac{\partial}{\partial t}\langle A_s B_s(-t)\rangle = i\langle [\mathrm{P}L_s \mathrm{P}A_s] B_s(-t)\rangle - i\langle \{\mathrm{P}\Im_Q(t,b)\times$$
$$\times\left[1+M_Q(t)\Im_Q(t,b)\right]^{-1} M_Q Q L_i \mathrm{P}A_s\} B_s(-t)\rangle + \int_0^t dt \times$$
$$\times\langle \{\mathrm{P}L_i Q M_Q(t-t)\Im_Q(t,b)\left[1+M_Q(t)\Im_Q(t,b)\right]^{-1}\times \qquad (2)$$
$$\times M_Q(t) Q L_i \mathrm{P}A_s\} B_s(-t)\rangle - \int_0^t dt\, \langle [\mathrm{P}L_i Q M_Q(t-t) Q\times$$
$$\times L_i \mathrm{P}A_s] B_s(-t)\rangle.$$

sadac $L_S \ldots = \frac{1}{\hbar}[H_{S,} \ldots]_-$ _ liuvilis superoperatoria, romelic Seesabameba S–qvesistemis H_S–hamiltonians, P-warmoadgens Termostatis (bozonuri velis) mdgomareobebis mixedviT gasaSualebis proeqciul operators: $P^2 = P$ da $Q = 1 - P$; xolo `masuri~ $M_Q(t)$ da integraluri $\Im_Q(t,b)$ superoperatorebi gansazRvrulia Semdegi tolobebiT:

$$M_Q(t) = \exp[iQLQt]; \qquad \Im_Q(t,b) = \int_0^b d l e^{-iLt} e^{lH} H_{\mathrm{int}} e^{-lH} Q$$

miRebuli aramarkoviseuli saxis zusti, ganzogadoebuli (2) _kinetikuri gantolebis dajaxebiTi integrali Seicavs wevrebs, romlebic aRweren sawyisi korelaciebis evolucias droSi. (sawyisi korelaciebis evolucia drois mixedviT aRiwereba $\Im_Q(t,b)$ _ integraluri superoperatoriT da es evolucia moicema rogorc markoviseuli, aseve aramarkoviseuli formiT).

§2.5_Si, iseve rogorc §2.3_Si, ganxilulia markoviseuli miaxloeba qvesistemis dinamikisTvis da qvesistemis TermostatTan urTierTqmedebis liuvilianis mixedviT _ SeSfoTebis Teoriis meore miaxloebaSi, proeqciuli operatoris meTodis daxmarebiT_napovnia axali, ganzogadoebuli markoviseuli kvanturi kinetikuri gantoleba wonasworuli korelaciuri funqciisTvis $\langle A_s B_s(-t)\rangle$_gamoricxuli bozonuri amplitudebiT:

$$\frac{\partial}{\partial t}\langle A_s B_s(-t)\rangle = -\frac{i}{\hbar}\langle [A_s, H_s]_- B_s(-t)\rangle - \frac{1}{\hbar^2}\int_0^t dx \sum_k \{N_k(b) e^{iw(k)x} \times$$
$$\times \left\langle \left[\left[A_s, C_k^+(s) \right]_- \cdot C_k(s,-x) \right]_{-w(k)} B_s(-t) \right\rangle + (1+N_k(b)) e^{-iw(k)x} \times$$
$$\times \left\langle \left[\left[A_s, C_k(s) \right]_- \cdot C_k^+(s,-x) \right]_{w(k)} B_s(-t) \right\rangle + \frac{i}{\hbar}\int_0^b dl \sum_k \{N_k(b) e^{-iw(k)(t-i\hbar l)} \times \qquad (3)$$
$$\times \left\langle C_k^+(s,-t-i\hbar l) \cdot \left[A_s, C_k(s) \right]_- B_s(-t) \right\rangle + (1+N_k(b)) e^{iw(k)(t+i\hbar l)} \times$$
$$\times \left\langle C_k(s,-t-i\hbar l) \cdot \left[A_s, C_k^+(s) \right]_- B_s(-t) \right\rangle \},$$

$$C_k(s_1 \pm Z) = e^{\pm i L_s Z} C_k(s); \quad C_k^+(s_1 \pm Z) = e^{\pm i L_s Z} C_k^+(s)$$

xolo $[E,D]_{\pm w(k)} = ED - e^{\mp b\hbar w(k)} DE.$

sadac: $C_k(S_, \pm Z) = e^{\pm i L_s Z} C_k(S)$; $C_k{}^+(S_, \pm Z) = e^{\pm i L_s Z} C_k{}^+(S)$; xolo $[E,D]_{\pm w(k)} = ED - e^{\pm b\hbar w(k0} DE$ _ nebismieri E da D_operatorebisTvis.

$$e^{\pm i L_\Sigma t} b_k = e^{\mp i w(k) t} b_k; \quad e^{\pm i L_\Sigma t} b_k^+ = e^{\pm i w(k) t} b_k^+$$
$$\mathrm{P}\left(b_k^+, b_{k'}\right) = N_k(b) d_{k,k'}; \quad \mathrm{P}\left(b_k, b_{k'}^+\right) = (1+N_k(b)) d_{k,k'}$$
$$\mathrm{P}\left(b_k, b_{k'}\right) = \mathrm{P}\left(b_k^+, b_{k'}^+\right) = 0.$$

amrigad, sadisertacio naSromis meore TavSi miRebuli ZiriTadi Sedegebi SesaZlebelia Camovayaliboт Semdegi saxiT: _ dinamiuri qvesistemisTvis, romelic urTierTqmedebs bozonur velTan mowesrigebul operatorTa, liuvilis sauperoperatoruli formalizmisa da proeqciuli operatoris meTodis daxmarebiT, sawyisi korelaciebis Sesustebis proncipisa da Sfm_is gamoyenebis gareSe wonasworuli korelaciuri funqciebisTvis gamoyvanili axali, ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebis dajaxebiTi integralebi_Seicaven rogorc wevrebs, romlebic aRweren dajaxebiTi korelaciebis evolucias droSi, aseve sawyisi korelaciebis evoluciur wevrebs, romlebic ganpirobebulia qvesistemis urTierTqmedebiT bozonur velTan drois sawyis momentSi.

<u>mesame TavSi</u> ganxilulia da gamokvleulia eleqtronuli da polaronuli gadatanis wrfivi movlenebis sakiTxebi dinamiur sistemebSi_eleqtron_fononur sistemaSi, frolixis da akustikur polaro-

nTa modelebSi, polaronis fgm_Si. gamokvleva dafuZnebulia kubos wrfivi gamoZaxilisa da SeSfoTebis Teoriaze. gamoTvlilia eleqtronuli da polaronuli gadatanis meqanikuri koeficientebi (dabal temperaturuli Zvradoba, eleqtrogamtaroba) zemoT miTiTebul modelebSi_korelaciuri funqciebisTvis miRebul ganzogadoebul kvantur kinetikur gantolebebze dayrdnobiT.

$3.1_Si gamokvleulia eleqtron-fononuri sistema da gamoTvlilia eleqtronis dabal temperaturuli Zvradoba da dabalsixSiruli eleqtogamtaroba susti eleqtron-fononuri urTierTqmedebis SemTxvevaSi (1) da (3)_gantolebebze dayrdnobiT miRebulia miaxloebiTi kinetikuri gantoleba eleqtronis `siCqare_siCqareze~ wonasworuli korelaciuri funqciisTvis. napovnia am bolcmanis tipis gantolebis amonaxsni kristalis dabali temperaturebis SemTxvevaSi erTi zonisa da relaqsaciis drois miaxloebaSi (rdm) eleqtronisTvis, da fononebis dispersiis nebismieri izotropuli kanonis dros. dadgenilia, rom eleqtronis (qvesistemis) korelaciuri funqciebi miilevian oscilaciebiT didi droebis asimptotur areSi, gamoTvlilia korelaciuri funqciebis milevis dekrementi da oscilirebadi faqtori. gamoyvanilia zogadi formulebi kuTri eleqtrogamtarobis disipaciuri nawilisTvis izotropul SemTxvevaSi da eleqtronis dabal temperaturuli, eleqtruli velis ω_sixSireze damokidebuli ZvradobisTvis (ac mobility). am formulebs aqvs Semdegi saxe:

$$\mathrm{Re}\, s_{mn}^{s} = ne^2 \frac{th\left(\frac{1}{2} b\hbar w\right)}{\hbar w} \int d\vec{\mathrm{P}} r_s(b,\overline{\mathrm{P}}) V_n(\overline{\mathrm{P}}) V_m(\overline{\mathrm{P}}) \left\{ \cos\left[\frac{b\hbar}{2}\Gamma_n^{rel}(b,\overline{\mathrm{P}})\right] \times \right.$$

$$\left. \times \frac{\Gamma_n^{rel}(b,\overline{\mathrm{P}})}{w^2 + \left[\Gamma_n^{rel}(b,\overline{\mathrm{P}})\right]^2} + \cos\left[\frac{b\hbar}{2}\Gamma_m^{rel}(b,\overline{\mathrm{P}})\right] \frac{\Gamma_m^{rel}(b,\overline{\mathrm{P}})}{w^2 + \left[\Gamma_m^{rel}(b,\overline{\mathrm{P}})\right]^2} \right\}, \qquad (4)$$

sadac: $m(w) = m_0(w) - \Delta m(w)$

$$m_0(w)=\frac{eth\left(\frac{1}{2}b\hbar w\right)}{\hbar w}\int d\vec{P}r_s(b,\vec{P})V_V(\vec{P})V_m(\vec{P})\left\{\frac{\Gamma_V^{rel}(b,\vec{P})}{w^2+\left[\Gamma_V^{rel}(b,\vec{P})\right]^2}+\frac{\Gamma_m^{rel}(b,\vec{P})}{w^2+\left[\Gamma_m^{rel}(b,\vec{P})\right]^2}\right\};$$

$$\Delta m(w)=\frac{2eth\left(\frac{1}{2}b\hbar w\right)}{\hbar w}\int d\vec{P}r_S(b,\vec{P})V_V(\vec{P})V_m(\vec{P})\times \qquad (5)$$

$$\times\left\{\sin^2\left[\frac{b\hbar}{4}\Gamma_V^{rel}(b,\vec{P})\right]\frac{\Gamma_V^{rel}(b,\vec{P})}{w^2+\left[\Gamma_V^{rel}(b,\vec{P})\right]^2}+\sin^2\left[\frac{b\hbar}{4}\Gamma_m^{rel}(b,\vec{P})\right]\cdot\frac{\Gamma_m^{rel}(b,\vec{P})}{w^2+\left[\Gamma_m^{rel}(b,\vec{P})\right]^2}\right\};(w<<t_0^{-1}).$$

aq: e-eleqtronis muxtia, n-eleqtronebis koncentraciaa gamtarobis zonaSi, $V_m(\vec{P})$eleqtronis siCqaris μ_komponentia gamtarobis zonidan, $\vec{P}$_eleqtronis kvaziimpulsia, da $r_s(b,\overline{P})=e^{-bT(\overline{P})}/d\vec{p}e^{-bT(\vec{P})}$ naTelia, rom Δμ(ω)_sidide warmoadgens temperaturul Seswo rebas eleqtronis $\mu_0(\omega)$-_dabal temperaturul da sixSirul Zvradobaze, romelic gamowveulia sawyisi korelaciebis arsebobiT eleqtronis urTierTqmedebisas fononebTan arsebul sistemaSi. am paragrafSi moyvanili gamosaxulebebi kuTri eleqtrogamatrobisTvis da dabal temperaturuli ZvradobisTvis warmoadgenen sakmaod zogads ganxiluli modelis CarCoebSi da Sesrulebuli miaxloebebis farglebSi.

§3.2_Si gamokvleulia eleqtronis Zvradobis sakiTxi polaronis frolixis modelSi da napovnia metad mniSvnelovani da principuli sakiTxis: `$\frac{3}{2bhw_0}$problemis~ nawilobrivi gadawyveta polaronis dabaltemperaturuli, Zvradobis TeoriaSi. §3.1_Si eleqtron-fononuri sistemisTvis, miRebul zogad formulebsa da Tanafardobebze dayrdnobiT gamoTvlilia eleqtronis `siCqare_siCqareze~ korelaciuri funqciis milevis dekrementi (eleqtronis impulsis relaqciis sixSire) da oscilirebadi faqtori. `mcire~ siCqariT moZravi eleqtronisTvis kristalis Zalian dabali temperaturebis SemTxvevaSi impu-

lsis relaqsaiciis sixSire ar aris damokidebuli TviT eleqtronis impulsze da warmoidgineba Semdegi saxiT:

$$\Gamma_z^{rel}(g,\tilde{\tilde{P}}) \equiv \Gamma_0^{rel}(g) = \frac{2}{3} a w_0 N_0(g); (\tilde{P}^2 << 1, g = b\hbar w_0 >> 1) \qquad (6)$$

sadac: ω_0_ fononebis rxevis sixSirea, α_ warmoadgens eleqtron-fononuri urTierTqmedebis (frolixis) bmis mudmivas, da $N_0(g) = [e^g - 1]^{-1}$ eleqtronis `siCqare-siCqareze~ korelaciuri funqciisTvis miRebuli bolcmanis tipis miaxloebiTi kinetikuri gantoleba amoxsnilia rdm-Si kristalis dabali temperaturebis SemTxvevaSi, da napovnia eleqtrogamtarobis da Zvradobis mniSvnelobebi frolixis polaronis modelSi_rac faqtiurad warmoadgens osakas Sedegis ganzogadoebas (drudes formulas) dabal sixSiruli eleqtrogamtarobisTvis da dabal temperaturuli ZvradobisTvis, romlebic Seicaven temperaturul Sesworebebs, ganpirobebuls eleqtronis fononebTan arsebuli sawyisi korelaciebiT:

$$\mathrm{Re}\, s(\tilde{w}) = \frac{ne^2}{mw_0}\frac{2}{g\tilde{w}} th\left(\frac{1}{2}g\tilde{w}\right)\left[1 - 2\sin^2\left(\frac{g}{2}\Gamma_0(g)\right)\right]\frac{\Gamma_0(g)}{\tilde{w}^2 + \Gamma_0^2(g)}; \qquad (7)$$
$$(a < 1, g >> 1, \tilde{w}g << 1),$$

sadac: $s(\tilde{w}) = s_{xx}(\tilde{w}) = s_{yy}(\tilde{w}) = s_{zz}(\tilde{w});\ \tilde{w} = \frac{w}{w_{0;}}; \Gamma_0(g) = w_0^{-1}\Gamma_0^{rel}(g) = \frac{2}{3}aN_0(g);$ xolo dabal temperaturuli da dabalsixSiruli ZvradobisTvis Sesabamisad gveqneba:

$$m_0(\tilde{w}) = \frac{e}{mw_0}\frac{2}{g\tilde{w}} th\left(\frac{1}{2}g\tilde{w}\right)\frac{\Gamma_0(g)}{\tilde{w}^2 + \Gamma_0^2(g)}; \qquad (8)$$

$$\Delta m(\tilde{w}) = \frac{e}{mw_0}\frac{4}{g\tilde{w}} th\left(\frac{1}{2}g\tilde{w}\right)\sin^2\left(\frac{g}{2}\Gamma_0(g)\right)\frac{\Gamma_0(g)}{\tilde{w}^2 + \Gamma_0^2(g)}$$
$$(a < 1, g >> 1, \tilde{w}g << 1).$$

dabal temperaturuli statikuri ZvradobisTvis (dc mobility) miRebulia Semdegi mniSvneloba (mcire temperaturuli SeswrebiT).

$$m_0 = \frac{e}{mw_0}\Gamma_0^{-1}(g) = \frac{e}{mw_0}\frac{3}{2a}e^g;$$

$$\Delta m = \frac{2e}{mw_0}\sin^2\left[\frac{g}{2}\Gamma_0(g)\right]\Gamma_0^{-1}(g) \approx \frac{e}{mw_0}\frac{1}{3}ag^2e^{-g}; \qquad (9)$$

$(g >> 1, a < 1).$

gamoTvlilia agreTve eleqtrogamtaroba da eleqtronis Zvradoba eleqtruli velis maRali $\tilde{w}$-sixSireebis SemTxvevaSi. am SemTxvevaSic temperaturuli Sesworeba eleqtronis Zvradobaze warmoadgens Zalian mcire sidides.

sadisertacio naSromis am paragrafSi avtoris mier miRebuli Sedegi (ix. (9) formula) warmoadgens `$\frac{3}{2}\frac{K_BT}{\hbar w_0}$-problemis~ nawilobriv gadawyvetas frolixis polaronis (eleqtronis) dabal temperaturuli Zvradobis TeoriaSi. Zvradobis miRebuli mniSvneloba 3-jer aRemateba `bolcmaniseul~ dabal temperaturul statikur Zvradobas: $m_B = \frac{e}{mw_0}.\frac{1}{2a}e^g; \quad (w = 0, g >> 1);$ da $\frac{1}{2g}$-mamravliT gansxvavdeba fxip-isa (feinmani, xelvorsi, idingsi, platcmani) da tornberg_feinmanis Sedegisgan: $m_{FXIP} = m_{TF} = \frac{e}{mw_0}\frac{3}{2g}\frac{1}{2a}e^g; \quad (w = 0, g >> 1);$ rac Seexeba TviT fxip-isa da tornberg_feinmanis Sedegebis Tanxvedras da $\frac{1}{2g}$_mamravls, maTi warmoSobis buneba (Rrma mizezi) dRevandel dRemde bolomde dadgenili ar aris.

§3.3_Si ganxilulia da gamokvleulia eleqtronis Zvradobis yofaqceva akustikuri polaronis modelSi susti eleqtron-fononuri urTierTqmdebis dros. am SemTxvevaSi adgili aqvs eleqtronis urTierTqmedebas dispersiis mqone akustikur fononebTan: $w(\vec{k}) = V_s.|\vec{k}|$ (V_s _bgeris siCqarea kristalSi), da iseve rogorc polaronis frolixis modelSi, eleqtronis energiisTvis gamtarobis zonaSi gvaqvs dispersiis paraboluri kanoni: $T(\vec{P}) = \vec{P}^2/2m;$ (m-eleqtronis efeqturi masaa). am paragrafSic miRebuli Sedegebi eleqtrogamtarobisa da eleqtronis

Zvradobis yofaqcevis Sesaxeb eyrdnoba $3.1_Si gamoyvanil zogad Tanafardobebsa da formulebs. napovnia eleqtronis `siCqare_siCqareze~_korelaciuri funqciebis milevis dekrementebi (eleqtronis impulsis relaqsaciis sixSire) da oscilirebadi faqtorebi. ganxilulia eleqtronis aradrekadi gabnevis procesebi akustikur fononebze da dadgenilia, rom `mcire~ siCqariT ($\tilde{P} < 1$) moZravi eleqtronisTvis, implsis relaqsaciis sixSire (dro) kristalis Zalian dabali temperaturebis dros ar aris damokidebuli TviT eleqtronis impulsis mniSvnelobebze da warmoidgineba Semdegi saxiT:

$$\Gamma_{Ac}^{rel}(g) = t_{Ac}^{-1rel}(g) = \frac{mV_s^2}{\hbar} 64a \left[e^{4g} - 1\right]^{-1} \qquad (10)$$

$$(\tilde{P} << 1; \quad g >> 1; \quad a < 1).$$

sadac: $\tilde{P} = P / mV_s$: da $g = \frac{mV_s^2}{2K_B T}$: xolo α_eleqtron-fononuri urTierTqmedebis (bmis) mudmivaa: $a = \frac{D^2 m^2}{8p r \hbar^3 V_s} < 1$. D_deformaciis potencialis mudmivaa, ρ_kristalis masuri simkvrive. napovnia `siCqare-siCqareze~ korelaciuri funqciisTvis miRebuli bolcmanis tipis miaxloebiTi kinetikuri gantolebis amonaxsni rdm-Si kristalis dabali temperaturebis dros, da gamoTvlilia dabalsixSiruli kuTri eleqtrogamtaroba da eleqtronis Zvradoba am modelSi izotropul SemTxvevaSi da erTi zonis miaxloebaSi:

$$\mathrm{Res}_{Ac}(w) = \frac{ne^2}{m} \frac{\Gamma_{Ac}^{rel}(g)}{w^2 + \Gamma_{Ac}^{2rel}(g)} \cos\left[\frac{\hbar g}{mV_s^2} \Gamma_{Ac}^{rel}(g)\right] \qquad (11)$$

$$(a < 1; g >> 1; w << \frac{mV_s^2}{\hbar g}).$$

$$m_{Ac} = \lim_{w \to 0} \frac{\mathrm{Re}\, s_{Ac}(w)}{ne} = m_{oAc} - \Delta m_{Ac}$$

$$m_{0Ac} = \frac{\hbar e}{m^2 V_s^2} \frac{1}{64a} e^{4g} \qquad (12)$$

$$\Delta m_{Ac} = \frac{\hbar e}{m^2 V_s^2} \frac{1}{32a} e^{4g} \sin^2\left[32a g e^{-4g}\right]; \qquad (a < 1; g >> 1)$$

naTelia, rom temperaturuli Sesworeba eleqtronis dabal temperaturul Zvradobaze, romelic ganpirobebulia sawyisi korelaciebis gaTvaliswinebiT, warmoadgens Zalian mcire sidides. miRebuli formulebi warmoadgenen Tanmimdevrul da koreqtul Sedegs eleqtronis dabal temperaturuli ZvradobisTvis akustikuri polaronis modelSi susti eleqtron_fononuri bmis SemTxvevaSi.

am paragrafSi gamoTvlilia aseve elqtrogamtaroba da eleqtronis Zvradoba akustikuri polaronis modelSi eleqtruli velis maRali ω_sixSireebis SemTxvevaSi, kristalis rogorc maRali, aseve dabali temperaturebis dros, napovnia am sidideebis ω_sixSiresa da T_temperaturaze damokidebuleba (yofaqceva) am parametrebis sxvadasxva mniSvnelobebis dros. am SemTxvevaSic temperaturuli Sesworeba eleqtronis dabal temperaturul Zvradobaze warmoadgens Zalian mcire sidides.

eleqtronis dabatemperaturuli Zvradobis gamosaTvlelad akustikuri polaronis modelSi susti eleqtron-fononuri bmis SemTxvevaSi (α<1), gamoiyeneba kinetikuri (bolcmanis) gantolebis meTodi. am gantolebis amoxsnisas rdm_Si eleqtronis dabal temperaturuli statikuri ZvradobisTvis (dc-mobility) Sfm_Si miiReba mniSvneloba

$$m_{0BAC} = \frac{\hbar e}{m^2 Vs^2} \cdot \frac{1}{32a} e^{4g}; (g >> 1, a < 1, w = 0). \qquad (13)$$

xolo, fxip-is Teoriisa (miaxloebisa) da balansis gantolebis meTodis (tornberg-feinmanis Teoriis) gamoyenebiT napovni eleqtronis dabal temperaturuli statikuri Zvradobis mniSvneloba tolia sidids:

$$\tilde{m}_{AC}^{FXIP} = \tilde{m}_{AC}^{TF} = \frac{3}{4g} \cdot \frac{1}{64a} e^{4g}; \quad m = \frac{\hbar e}{m^2 V_s^2} \tilde{m}, (g >> 1, a < 1) \qquad (14)$$

avtoris mier napovni dabal temperaturuli statikuri Zvradobis mniSvneloba Sfm_Si (ix. 12 formula). warmoadgens Tanmimdevrul da koreqtul Sedegs akustikuri polaronis modelSi. is 2_jer naklebia

eleqtronis `bolcmaniseul~ dabal temperaturul Zvradobaze da $^{3}/_{4g}$-mamravliT gansxvavdeba fxip-isa da tornberg-feinmanis Sedegasgan. rac Sexeba fxip-isa da tornberg-feinmanis Sedegebis Tanxvedras da $^{3}/_{4g}$-mamravls_iseve, rogorc polaronis froli-xis modelSi, am modelSic maTi warmoSobis Rrma mizezi (buneba) jer-jerobiT dadgenili ar aris.

$3.4_Si ganxilulia polaronis fgm. gamoTvlilia da gamokvleulia kontinualuri optikuri polaronis drefuli Zvradoba da misi yofaqceva am modelSi dabali temperaturebis SemTxvevaSi. gamoyvanilia kvanturi kinetikuri gantolebebi polaronis `impulsi-_impulsze~ (`deni_denze~). wonasworuli korelaciuri funqciebisTvis, ganxilulia markoviseuli miaxloeba polaronis dinamikisaTvis da didi droebis asimpatotur areSi: $t \sim t_{rel} >> t_0 = \max(t_s,\ t_\Sigma);\quad t_{rel} >> b;$ $\hbar = m = w_0 = 1$). (t_s-polaronis dajaxebaTa maxasiaTebeli droa, t_Σ-aris TermostatSi fluqtuaciebis korelaciebis maxasiaTebeli dro), miRebulia miaxloebiTi gamosaxulebebi korelaciuri funqciebisTvis. gamoyvanilia agreTve kinetikuri gantolebebi korelaciuri funqciebis diagonaluri matriculi elementebisTvis. napovnia korelaciuri funqciebis milevis dekrementebi (polaronis impulsis relaqsaciis sixSire) da oscilirebadi faqtorebi.

dabali temperaturebis SemTxvevaSi ($b >> 1,\ b^{-1} << |e_1 - e_0|$) da didi droebis areSi $t >> |e_i - e_j|^{-1}$)-polaronis $\langle P_z P_z(\pm t)\rangle_{GF^-}$ korelaciuri funqciebis sidide ZiriTadad gansazRvrulia impulsTa im mniSvnelobebiT, romelTaTvisac $\frac{\vec{P}^2}{2M_{GF}} << |e_1 - e_0|$; $\frac{\vec{P}^2}{2M_{GF}} << 1$, (sadac e_l, e_j, e_1, e_0 polaronis agznebuli da ZiriTadi mdgomareobis energiebia, M_{GF}_polaronis masaa). am pirobebSi dadgenilia, rom polaronis impulsis relaqsaciis sixSire $\Gamma^{GF}_{zrel}(b, \vec{P})$_ ar aris damokidebuli TviT

polaronis $\vec{P}$ impulsze (`mcire~ siCqariT moZravi polaroni) da ganisazRvreba Tanafardobi T:

$$\Gamma^{GF}_{zrel}(b,\vec{\hat{P}}) \equiv \Gamma^{GF}_{0rel}(b) = \tfrac{2}{3} a N_0(b)\sqrt{M}\, f(\sqrt{2M}) \qquad (15)$$

$$(b >> 1, \vec{\hat{P}}^2 / 2M << 1)$$

sadac: $f(\sqrt{2M}) = f(k)|_{k=\sqrt{2M}}$; $\qquad f(k) = |<0|\, e^{im_e \vec{k}\vec{x}}\, |0>|^2 \qquad (16)$

$$N_0(b) = \left[e^b - 1\right]^{-1}$$

napovni (dabalsixSiruli) kuTri eleqtrogamtarobisTvis da polaronis dabaltemperaturuli ZvradobisaTvis gvaqvs Semdegi saxis gamosaxulebebi:

$$\mathrm{Re}\, s^{GF}(w) = Ne^2 b^{-1} M \frac{2th(\frac{1}{2} bw)}{w} \frac{\Gamma^{GF}_{0rel}(b)}{w^2 + \Gamma^{2GF}_{0rel}(b)} \cos\left[\frac{b}{2}\Gamma^{GF}_{0rel}(b)\right] \qquad (17)$$

$$(w << \Gamma^{GF}_{0rel}(b) << b^{-1} << 1);$$

$$m_0^{GF} = \frac{3}{2} e \frac{\exp(b)}{a} \frac{\sqrt{M}}{f(\sqrt{2M})}; \qquad m^{GF} = m_0^{GF} - \Delta m^{GF}$$

$$\Delta m^{GF} = 3e \frac{\exp(b)}{a} \cdot \frac{\sqrt{M}}{f(\sqrt{2M})} \sin^2\left[\frac{1}{6} a b N_0(b)\sqrt{M} \cdot f(\sqrt{2M})\right]. \qquad (18)$$

$$(w = 0; \quad \Gamma^{GF}_{0rel}(b) << b^{-1} << 1)$$

sadac: N-polaronebis koncentraciaa.

naTelia, rom Δm^{GF} _sidide, romelic warmoadgens temperaturul Sesworebas polaronis Δm_0^{GF} _dabaltemperaturul Zvradobaze, warmoadgens mcire sidides TviT am ZvradobasTan SedarebiT.

amave §3.4_Si agreTve ganxilulia da gaanalizebulia sakiTxi polaronis dabaltemperaturuli Zvradobis yofaqcevis Sesaxeb eleqtron-fononuri bmis α_mudmivas zRvruli (susti da Zlieri) mniSvnelobebis dros. dadgenilia, rom: 1. susti eleqtron-fononuri bmis zRvrul SemTxvevaSi: (α<1, M_{GF}<<1, $M_{GF} \to 0$), rodesac polaronis fgm

gadadis polaronis frolixis modelSi, polaronis dabal temperaturuli ZvradobisTvis gvaqvs:

$$m_0^{GF} \Rightarrow m_0 = \frac{3e}{2a} e^b; \quad \Delta m^{GF} \Rightarrow \Delta m = \frac{1}{3} e a b^2 e^{-b}; (a < 1, b >> 1) \qquad (19)$$

romelic emTxveva dabal temperaturuli Zvradobis mniSvnelobas polaronis frolixis modelSi.

2. Zlieri eleqtron-fononuri bmis zRvrul SemTxvevaSi: (α>>1, M_{GF}>>1, $M_{GF} \to 8$), rodesac fgm aRadgens pekaris Teorias, polaronis dabal temperaturuli Zvradobis yofaqceva aRiwereba Tanafardobit:

$$m_{o\Pi}^{GF} \sim \frac{3e}{2} \exp(b) a^{13}; \quad (a >> 1, b >> 1) \qquad (20)$$

sadisertacio naSromSi avtoris mier ganviTarebuli formalizmi da meTodebi, miRebuli ganzogadoebuli kvanturi kinetikuri gantolebebi wonasworuli korelaciuri funqciebisTvis da mesame Tavis $3.1_$3.4_ebSi ganxilul modelebze dayrdnobiT miRebuli Sedegebi (gamoyvanili formulebi: rogorc zogadi, aseve miaxloebiTi) SesaZleblobas iZleva gadaugvarebel, farTozonian, erTgvarovan (polarul) naxevargamtarebSi, ionur da kovalentur kristalebSi_eleqtronuli da polaronuli gamtarobisa da dabal temperaturuli dreifuli Zvradobis wrfivi kvanturi Teoriis agebas_kvanturi dinamiuri sistemebis sxva modelTaTvisac, romlebic urTierTqmedeben fononebTan (eleqtronebis gabneva arapolarul optikur fononebze, piezoeleqtuli gabneva, polaronis fm. da sxva)._eleqtronebisTvis erTi zonis miaxloebaSi, dispersiis rogorc zogadi, aseve paraboluri kanonis dros da fononebis dispersiis izotropuli kanonis SemTxvevaSi.

daskvnebi

1. sxvadasxva midgomebis-mowesrigebul operatorTa da liuvilis superoperatoruli formalizmisa da proeqciuli operatoris meTodis gamoyenebiT, sawyisi korelaciebis gaTvaliswinebiT_gamoyvanilia axali, zusti, ganzogadoebuli kvanturi evoluciuri (kinetikuri) gantolebebi drois ormomentiani wonasworuli korelaciuri funqciebisTvis, dinamiuri qvesistemisTvis romelic urTierTqmedebs bozonur velTan (TermostatTan). miRebul gantolebaTa dajaxebiTi integralebi

Seicaven rogorc wevrebs, romlebic aRweren namdvili korelaciebis evolucias droSi, aseve sawyisi korelaciebis evoluciur wevrebs, romlebic ganpirobebulia qvesistemis urTierTqmedebiT bozonur TermostatTan drois sawyis momentSi.

2. SeSfoTebis Teoriis meore miaxloebaSi – qvesistemis TermostatTan urTierTqmedebis hamiltonianis mixedviT – napovnia ganzogadoebuli kvanturi kinetikuri gantolebebi gamoricxuli bozonuri amplitudebiT korelaciuri funqciebisTvis, rogorc markoviseuli, ise aramarkoviseuli saxiT, romlebic Seicaven cxadad gamoyofil sawyisi korelaciebis evoluciur wevrebs.

3. eleqtron-fononuri sistemisTvis, frolixisa da akustikuri polaronis modelTaTvis, SeSfoTebis Teoriis meore miaxloebaSi, susti eleqtron-fononuri urTierTqmedebis SemTxvevaSi da erTi zonis miaxloebaSi eleqtronisaTvis gamoyvanilia da gamokvleulia markovis saxis kinetikuri gantolebebi eleqtronis siCqaris operatoris komponentebis saSualo mniSvnelobebis diagonaluri matriculi elementebisaTvis, romlebic warmoadgenen bolcmanis tipis gantolebebs, saidanac gamoricxulia fononuri amplitudebi. Gganxilulia eleqtronis aradrekadi gabnevis procesebi fononebze da dadgenilia, rom ganxilul modelebSi adgili aqvs relaqsaciur process korelaciuri funqciebis oscilaciebiT. Nnapovnia eleqtronis impulsis (siCqaris) relaqsaciis sixSireebis analizuri gamosaxulebebi kristalis dabali temperaturebis SemTxvevaSi. gamoTvlilia eleqtronis “siCqaresiCqareze” korelaciuri funqciebis milevis dekrementebi da oscilirebadi faqtorebi.

4. gamokvleulia da dadgenilia, rom eleqtronis siCqaris (impulsis) mcire mniSvnelobebisaTvis, siCqaris relaqsaciis droebi (sixSireebi) ganxilul modelebSi ar aris damokidebuli impulsis sidideze. mcire siCqareebiTYmoZravi eleqtronebisTvis Zalian dabali temperaturebis dros napovnia dabalsixSiruli eleqtrogamtarobisa da eleqtronis dreifuli Zvradobis gamosaTvleli formulebi.

5. frolixis polaronis modelSi miRebuli gamosaxulebebi eleqtronis dabaltemperaturuli dreifuli Zvradobisa da dinamiuri gamtarobiTvis warmoadgens osakas mier napovni Sedegis ganzogadoebas mcire intensivobis mqone dabalsixSirul gareSe eleqtrul velSi, rac faqtiurad SesaZlebelia ganxiluli iqnas, rogorc drudes formula kuTri eleqtrogamtarobisTvis. napovnia agreTve statikuri ($w=0$) eleqtrogamtarobisa da dabaltemperaturuli dreifuli Zvradobis analizuri gamosaxulebebi, rogorc frolixis, aseve akustikuri polaronis modelebSi.

6. rogorc gamoTvlebi gviCvenebs, eleqtronebis gabnevisas polarul optikur fononebze, dabaltemperaturuli dreifuli ZvradobisTvis (dcmobility; $w=0$) miRebuli mniSvneloba 3-jer aRemateba Zvradobis im mniSvnelobas, romelic miiReba bolcmanis kinetikuri gantolebis gamoyenebiT da amoxsniT relaqsaciis drois miaxloebaSi.

miRebuli Sedegi warmoadgens – “$\frac{3}{2}\frac{K_B T}{\hbar w_0}$ problemis” – nawilobriv gadawyvetas frolixis polaronis dabal temperaturuli Zvradobis TeoriaSi.

7. eleqtronebis gabnevisas akustikur fononebze (akustikuri polaronis modeli) miRebuli dabal temperaturuli dreifuli Zvradobis $(w=0)$ mniSvneloba 2-jer naklebia Zvradobis im mniSvneloba-ze, romelic aseve miiReba bolcmanis kinetikuri gantolebis amoxsnisas relaqsaciis drois miaxloebaSi.

8. ganxilul modelebSi napovnia agreTve eleqtronis dreiful Zvradobaze temperaturuli Seswo-rebebi, romlebic ganpirobebulia sawyisi korelaciebis evoluciuri wevrebis arsebobiT gamoyvanili kinetikuri gantolebebis dajaxebiT integralebSi da naCvenebia, rom es Seswo-rebebi warmoadgenen mcire sidideebs ganxiluli Teoriis farglebSi.

9. polaronis fgm-sTvis miRebuli kvanturi kinetikuri gantolebebi eleqtruli denis operatoris komponentebis (polaronis impulsis) drois ormomentiani wonasworuli korelaciuri funqciebisTvis gamoyenebulia polaronis dreifuli Zvradobisa da eleqtrogamtarobis tenzoris gamosaTvlelad. Gganxilul erTzonian izotropul SemTxvevaSi, markoviseul miaxloebaSi polaronis dinamikisTvis, napovnia miaxloebiTi gamosaxulebebi korelaciuri funqciebisTvis.

10. kristalis Zalian dabali temperaturebis SemTxvevaSi gamoyvanilia bolcmanis tipis kinetikuri gantoleba korelaciuri funqciis diagonaluri matriculi elementisTvis, romelic Seesabameba polaronis ZiriTad mdgomareobas. gamokvleulia polaronis aradrekadi gabnevis procesebi fononebze. napovnia impulsis relaqsaciis sixSiris (drois) analizuri gamosaxuleba da dadgenilia, rom mcire siCqariT moZravi polaronisTvis impulsis relaqsaciis sixSire (dro) ar aris damokidebuli impulsis sidideze.

11. kubos wrfivi reaqciis Teoriis gamoyenebiT miRebulia dabalsixSiruli eleqtrogamtarobis tenzoris analizuri gamosaxuleba eleqtron-fononuri sistemisaTvis erTzonian miaxloebaSi da fononebis dispersiis zogadi (izotropuli) kanonis SemTxvevaSi. gamoTvlilia polaronis dabal temperaturuli dreifuli Zvradoba fgm-Si. am modelSi napovnia agreTve temperaturuli Seswo-reba polaronis dreiful Zvradobaze, romelic ganpirobebulia sawyisi korelaciebis evoluciuri wevrebis arsebobiT miRebuli kinetikuri gantolebebis dajaxebiT integralebSi, da dasabuTebulia, rom es temperaturuli Seswo-reba warmoadgens mcire sidides.

12. ganxilulia da gaanalizebulia polaronis dabal temperaturuli dreifuli Zvradobis yofaqceva susti $(a<1)$ da Zlieri $(a>>1)$ eleqtron-fononuri urTierTqmedebis zRvrul SemTxvevebSi. susti eleqtron-fononuri urTierTqmedebis SemTxvevaSi $(M_{GF}\to 0)$, rodesac polaronis fgm gadadis polaronis frolixis modelSi, pola-

ronis dabal temperaturuli dreifuli ZvradobisTvis ($g >> 1$; $w = 0$) vRebulobT iseTive miSvnelobas, rogoric napovnia polaronis frolixis modelSi. Zlieri eleqtron-fononuri urTierTqmedebis SemTxvevaSi ($M_{GF} \to \infty$), rodesac polaronis fgm aRadgens polaronis pekaris naxevradklasikur Teorias, dabal temperaturuli dreifuli Zvradobis yofaqceva moicema Semdegi Tanafardobit: $m_{GF} \sim \frac{3}{2} e.\exp(g) a^{13}$; ($\hbar = m = w_0 = 1$; $g = b >> 1$; $w = 0$); anu polaronis dabal temperaturuli Zvradoba Zlieri eleqtron-fononuri urTierTqmedebis SemTxvevaSi ($a >> 1$) izrdeba a-bmis mudmivas mecamete rigis proporciulad am mudmivas didi mniSvnelobebis dros, maSin rodesac polaronis pekaris TeoriaSi dabal temperaturuli Zvradoba izrdeba misi mexuTe rigis proporciulad: $m_{\Pi} \sim a^5$; rodesac $a >> 1$; ($\hbar = m = w_0 = 1$; $b >> 1; w = 0$).

13. sadisertacio naSromSi Catarebuli gamokvlevebi gviCvenebs, rom ganviTarebul meTodebs, romlebic dafuZnebulia kinetikuri gantolebebis miRebaze wonasworuli korelaciuri funqciebisTvis da maT gamoTvlaze, gansxvavebiT sxva midgomebisgan, ar mivyavarT ganSladi wevrebisagan Sedgenili usasrulo mwkrivebis ajamvis aucileblobasTan kvazinawilakis (eleqtronis, polaronis) urTierTqmedebis mixedviT fononebTan, kristalze modebuli gareSe eleqtruli velis dabali ($w \to 0$) sixSireebis SemTxvevaSi.

naSromSi dasabuTebulia, rom arsebuli sawyisi korelaciebis evolucia da korelaciuri funqciebis oscilaciebi drois mixedviT, romlebic ganpirobebulia kvazinawilakis (zogad SemTxvevaSi kvanturi dinamiuri qvesistemis) urTierTqmedebiT fononur (bozonur) velTan drois sawyis momentSi, gavlenas ar axdenen relaqsaciur procesebze da isini warmoadgenen Zvradobebze temperaturuli Seswor ebebis ZiriTad mizezs (wyaros) ganxilul modelebSi.

SUMMARY

In modern conditions a subject to research is a subject of electron and polaron transport phenomena study in solid states and condensed matter physics. Making electron and polaron mobility and electrical conductivity quantum theory and quasi-particle kinetic features calculation remains one of the actual problem in modern theory of electron and polaron. In the latest years a tendency of making materials of difficult molecular building and studying polaron features gave stimuli to implement a lot of theoretical research for describing autolocalized (polaron) matter. Polaron concepts, which represents a simple example of nonlinear quasi-particle, has great importance and is highly used in solid states and condensed matter physics and especially it is closely connected to the fundamental problems of quantum dynamical systems theory and to the subjects of quantum theory of a field. In the latest period it became actual to research subjects of electron-phonon system and polaron kinetic on the base of Kubo linear response theory and to build correct quantum theory of electron and polaron transfer phenomena and calculation of mechanical coefficients (mobility, electrical conductivity) in semiconductors and ionic crystals.

The aim of thesis work is to receive and research new, exact generalized quantum kinetic equations for time correlation functions for some quantum dynamical systems of solid physics, which interacts with phonon field (electron-phonon system, Frohlich and acoustical polaron models, polaron generalized model of Feynman) and on the base of such models building of consecutive, correct electron and polaron low- frequency conductivity and low-temperature drift mobility quantum theory for non degenerated wide-band semiconductors and ionic crystals based on Kubo linear response and perturbation theory and calculation of mechanical coefficients transport (mobility, electrical conductivity) for above mentioned quantum subsystems models.

The thesis work discusses two method of approach for new, exact generalized quantum kinetic equations for double-time equilibrium correlation functions for quantum dynamical systems, which interacts with boson (phonon) field (thermostat).

The first method of approach is based on ordered operators formalism and chronological and antichronological T-product method; and the second method of approach which is based on Liouville superoperative formalism and projection operator method.

The first chapter of the work generally gives a short brief. In the first paragraph of this chapter deals with model Hamiltonian kind of dynamical systems, which interact with boson (phonon) thermostat and there are discussed some actual examples of quantum dissipative and open nonequilibrium modeling systems and from different fields of modern physics, which became the subject of intensive research and learn in the latest 30-40 years. The spectrum of the wide research contained subjects of metals' electrical conductivity and superconductivity theories, subjects of metal alloy and cold "metal glasses" electronic theory; subjects of week and strong localization and strong inhomogeneous substances electrical conductivity theory in disordered systems physics; aspects of laser radiation and superradiation theory aspects in quantum radiophysics; subjects of magnetic polaron and fluctuon (phason) and etc in magnetic substances (environment) and others. The second paragraph deals with dynamically disordered system - electron-phonon system and electron interaction with acoustical and polar optical phonons and gives general introduction of Hamiltonian of electron-phonon system (Frohlich - Pekar type Hamiltonian), Hamiltonians of electron acoustical and polar optical phonons interaction and short brief of deformation potential method. The third part of the work deals with large radius polaron models. There are reviewed polaron Frohlich and Pekary models and polaron Feynman oscillator and generalized Feynman models there. The same paragraph deals with a new approach for polaron systems thermodynamics and kinetic subjects, developed in latest years – ordered operators formalism, T-product method and phonon operators elimination method from equilibrium and nonequilibrium average value – physical quantity characteristic for electron-phonon system. The advantage of a new method of approach in some occasions to at studying kinetic subjects of electron-phonon system. The fourth paragraph deals with several principal subjects of physical kinetics of dynamical systems, which interact with phonon (boson) field. There is given review of very important and principal subject such as opportunity of shorten description at evolution (kinetic) equation for K-type dynamical systems (for classic and quantum as well), which is not based of a hypothesis about usage of initial correlations weakness and random phase approximation (RPA). There is described those basic schedules and methods, which lead us to Boltzmann type kinetic equation and master equation there. The chapter deals with such basic principal difficulties, which are arisen at calculation of drift mobilities for above mentioned models, as according to Boltzmann kinetic equation and Kubo linear response theory and also at using some methods of linear and nonlinear conductivity theories (nonequilibrium density matrix and balance equation methods).

The second chapter of thesis work deals with general question – to receive exact, generalized, quantum evolutionary equations for equilibrium correlation and Green functions of dynamical subsystems, which interacts with boson (phonon) thermostat. The first paragraph deals with ordered operators formalism and T-product method. The second paragraph deals with new and exact quantum evolutional (kinetic) initial correlations weakness principles equations for without random phase approximation usage and double-time equilibrium correlation and Green retarded functions, with eliminated boson amplitudes. The fourth paragraph deals with new and exact generalized quantum kinetic equations for double-time equilibrium correlation and Green functions been found by using Liouville superoperative formalism and projection operator method. Unlike kinetic equations for correlation functions, received by different authors in scientific literature, integrals of evolutional equations presented in this work contain additional members, which describe initial correlations evolution in the period of time and which are caused by subsystem interaction with boson thermostat in initial moment of time. The third and fifth paragraphs discuss Markov method of approach for subsystem dynamics and accordingly by the help of both formalism and methods there has been found approximately quantum kinetic equations for correlation functions with eliminated boson amplitudes and initial correlation description and additional members in collission integrals. Researches and results have been conducted in this chapter of the work give opportunity for better and wider studying of kinetic phenomena, which take place in dynamical systems and which interact with boson field.

Subjects of electron and polaron transport phenomena quantum theories in solid states – in semiconductors and ionic crystals – have been researched in the third chapter of thesis work. All four paragraphs of the same work are dedicated to electron and polaron low-frequency conductivity and low-temperature drift mobility quantum theory, which is based on the above mentioned models of quantum dynamical systems, Kubo linear response and perturbation theory and on quantum kinetic equations for equilibrium correlation functions presented in the second chapter. The first paragraph researches Markovian type kinetic equations for correlation functions of electron "velocity – on velocity" in relaxation time approximation and there has been found decrements of damping correlation functions and oscillation factors; for electron-phonon systems in the case of weak electron-phonon interaction in one band approximation there has been received analyze image of low-frequency electrical conductivity tensor and low-temperature drift mobility of electron in the case of anisotropy has been calculated there – conductivity band is of electron velocity. The second and third paragraphs deals with several subjects of electronic transport phenomena in Frohlich and acoustical polaron models. There have been found formulas for calculating drift mobility and low-frequency conductivity at low-temperatures for electron in such models. Generalization of Osaka result for electron low-temperature mobility and low-frequency conductivity in electric field are received in polaron Frohlich model. There is given partial decision for "$\frac{3}{2}\frac{K_B \mathrm{T}}{\hbar\omega_0}$ problem" in Frohlich polaron low-temperature mobility theory and is shown, that meaning of mobility given in this work excels three times those meaning of mobility which is received by Boltzmann kinetic equation in relaxation time approximation. In acoustical polaron model (at scattered electron on acoustical phonons) meaning of low-temperature mobility is two times less than the meaning of mobility, which is also received by Boltzmann equation in relaxation time approximation. The fourth paragraph of the same chapter deals researches several subjects of polaron kinetic in generalized Feynman model and kinetic equations are solved for polaron "momentum-on momentum" equilibrium

correlation functions; there is calculated frequency of polaron momentum relaxation (relaxation time) at low temperature crystal and analyze image of low-frequency electrical conductivity tensor (dissipative part) is received; there is found polaron low-temperature drift mobility meaning there. There is analyzed polaron low-temperature mobility behavior in the event of electron phonon interaction there and there is found mobility dependence on coupling constant in the case of strong electron-phonon interaction and different behavior of low-temperature mobility according to the degree of coupling constant by polaron Pekar model is established. The work also calculates temperature corrections on electron and polaron low-temperature mobilitys in the discussed models and there is shown, that these corrections represent small quantities within discussed theory and approaches has been used there.

disertaciis ZiriTadi Sedegebi gamoqveynebulia

Semdeg SromebSi:

1. ???? ?.?., ????? ?.?. ?????????? ???????? ? ????? ????? ?????? ???????? ??? ?????? ???????????. 24-? ?????????? ????????? ?? ?????? ?????? ??????????. ?????? ????????: ????? II: ?????????? ??????? ??? ?????? ???????????. ???????, 8-10 ????????, 1986 ?., ???. 201-202.

2. ????? ?.?., ???? ?.?. ? ?????? ???????? ????????. ?????????? ?????????: ???-???????? ???????? ????????????? ??????. ???????, 14-17 ??? 1991 ?. ??????? ?????????, ???. 1-140. ?????? ????????, ???. 83.

3. Kotiya B.A., Los' V.F. Exact equations for subsystem correlation functions and density matrix. The 18th IUPAP International Conference on Statistical Physics. Berlin, 2-8 August, 1992, Programme and Abstracts. Exact and Rigorous Results, p. 133.

4. Kotiya B.A., Los' V.F. Exact equations for subsystem correlation functions and density matrix. Application in Polaron mobility. International Workshop "Polarons and Applications", May 23-31, 1992, Puschino, Russia. Abstracts, p. 18.

5. Kotiya B.A., Los' V.F. Exact equations for subsystem correlation functions and density matrix. Application in Polaron mobility. Proceedings in Nonlinear Science. Polarons and Applications. Ed. Lakhno V.D. (John Wiley and Sons, Chichester, 1994), pp. 407-418 (impaqt. datvirTvis mqone).

6. Kotiya B.A., Los' V.F. To the theory of transport Phenomena in open systems. The Norwegian Academy of Technological Sciences. The Lars Onsager Symposium. Coupled Transport Processes and Phase Transitions. June 2-4, 1993,Trondheim, Norwey. Abstracts, p. 89.

7. Kotiya B.A., Los' V.F. Exact Equations for Correlation Functions and Density Matrix of a Subsystem Interacting with a Heat Bath and their Application in the Polaron Mobility. European physical Society. Eps9. Trends in Physics. Firenze. Italy. September 14-17, 1993. Abstracts. Symposium 29. Statistical Machanics: Rigorous Results. ED. Systems, p. 130.

8. kotia b. gadatanis movlenebis Teoria eleqtron-fononuri sistemisaTvis. saqarTvelos teqnikuri universitetis profesor-maswavlebelTa samecniero-teqnikuri konferencia. programa, 16-19 noemberi, Tbilisi, 1993 w. I-Teoriuli fizika, gv. 32.

9. kotia b., losi v. polaronis Zvradobis TeoriisTvis. saqarTvelos mecnierebaTa akademiis moambe. t. 149, #1, 1994 w., Tbilisi, fizika, gv. 61-68.

10. ????? ?.?., ???? ?.?. ? ?????? ???????????????? ?????????? ????????? ? ?????? ???????????? ????????. ?????????? ???????? ????. ???????? ???????? ????. ????? ??????????, ?. 59, ? 8, 1995 ?.: ? ???????? ?????????? ???????? ????????? «???????????????? ????????? ? ???????????? ? ????????????? ????????». ??????. ?????? 1995 ?., ???.133-138 (impaqt. datvirTvis mqone).

11. Kotiya B.A., Los' V.F. Low-Temperature Electron Mobility of Acoustical Polaron. In Perspectives of Polarons. Editors: G.N. Chuev and V.D. Lakhno. Russian Academy of Sciences. World Scientific. Singapore. New Jersey. London. Hong Kong. 1996, p. 216-222 (impaqt. datvirTvis mqone).

12. Kotiya B.A., Los' V.F. On the theory on Transport phenomena in the Polaron's Systems. The 19th IUPAP International Conference on Statistical Physics. Xiamen 31 July-4 August, 1995. Programme and Abstracts. Transport and Relaxation, p. 42.

13. Kotiya B.A., Los' V.F. Gigilashvili T.G. On the theory of transport phenomena in. electron-phonons'systems. The 20th IUPAP International Conference on Statistical Physics. Paris, UNESCO, Sorbonne. July 20-25, 1998. Book of Abstracts, Nonequlibrium systems, p. 7.

14. Kotiya B.A. On the theory of exact equations for correlation functions of the system Interacting with a thermostat. Georgian Engineering News, 2005, ? 1, pp. 7-13.

15. Kotiya B.A. On the theory of low-temperature electron mobility in the electron-phonon system and Frohlich's model of the Polaron. Georgian Engineering News, 2005, ? 2, pp. 11-21.

16. ????? ?.?. ? ???????? ????????? ???????????? ??????, ???????????????? ? ???????? ?????. ???? I. ????????? ???????????? ?????????? ? ???????? ?????????? ???????? ????????. Georgian Engineering News, 2005, ? 4, ???. 7-17

17. ????? ?.?. ? ???????? ????????? ???????????? ??????, ???????????????? ? ???????? ?????. ????? II. ???????????? ????????? ??? ????????????? ??????? ? ??????? ?????. Georgian Engineering News, 2006, ? 1, ???. 7-17.