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REZYUME

Ushbu maqolada o'lchamni qisqartirish masalasi tahlillandi. O'lchamni qisqartirish uchun alomatlar informativligidan foydalanildi. Alomatlar informativligini baholashda ishlatiladigan bir nechta usullar taqdim qilindi va natijalar solishtirildi. Alomatlarni tanlash sifatini baholash uchun Naïve Bayes klassifikatoridan foydalanildi.

РЕЗЮМЕ

В статье рассматривается проблема снижение размерности. Для снижение размерности использовались информативные признаки. Представлено несколько методов, используемых для оценки информативности признаков и проведено сравнение результатов. Для оценки качества отбора признаков использовался классификатор Naïve Bayes.

SUMMARY

This article discusses the dimensionality of reduction issue. To reduce the dimension was used the in formativeness of the features. Several methods were presented that are used to assess the in formativeness of features and the results were compared. The quality of feature selection was assessed with Naïve Bayes classifier.

EXTERNAL LIGHT INDUCED INCREASE OF SUPERCONDUCTIVITY OF CUPRATES

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Tayanch so'zlar: kupratlar, yuqori haroratli o'tao'tkazuvchanlik, bipolaron, Boze-Eynshtein kondensatsiyasi, Floke formalizmi.

Ключевые слова: купраты, высокотемпературная сверхпроводимость, биполярон, Бозе-Эйнштейновская конденсация, Флоке формализм.

Key words: cuprates, high temperature superconductivity, bipolaron, Bose-Einstein condensation, Floquet formalism.

I. **Introduction.** Though of continuing intensive theoretical and experimental efforts the high temperature superconductivity (HTSC) phenomenon in novel materials remains unclear with respect to microscopic mechanism that bounds charge bears into Cooper pairs and consequently leads to macroscopic superconducting state with relatively high superconducting transition temperature T_C. Up to date HTSC is found in many group compounds, in particular, in copper oxides (cuprates), ferro-pnictides and doped-organic molecular crystals. However, there are not an acceptable theory of superconductivity that explain all aspects of the phenomena in a general basis. Superconductivity, including critical temperature of superconducting transition, in the above materials depend on a variety of factors (doping, pressure or strain, disorder, oxygen content and et.al). Increasing a superconducting critical temperature up to the room temperatures is one of the actual problems of superconducting material science. Recently, it was reported observation of transient superconducting state of the copper oxide $YBa_2Cu_3O_{6.5}$ compound with transition temperature of the order of T_c=50 K under the influence of external light radiation [1]. Similar issue is observed for a molecular crystal K_3C_{60} (T_c=20 K) [2]. One of the possible explanation of the results of the experiment [1] is considered in Ref.[3]. The explanation is based on polaron concept. Namely, author of Ref. [3] considers tunneling of bipolarons between copper-oxygen planes of the parent compound.

Here, we do an attempt to present an another (equivalent) possible scenario for the explanation of the results of work [1]. We interpret the results of [1] on palaron idea too, but in doing that we use Floquet theory [4] combined with the results of early works [5,6]. Our model is briefly presented in the next section.

II. **The model.** We consider the system that is described by the time dependent Schrödinger equation [3]

$$i\frac{\partial\psi(\varsigma,\tau)}{\partial\tau}=\left[-\frac{1}{2}\frac{\partial^2}{\partial\varsigma^2}+U(\varsigma,\lambda,j)-\alpha_i\varsigma\sin\left(\omega\tau/\Omega\right)\right]\psi(\varsigma,\tau) \quad (1)$$

where

$$U(\varsigma,\lambda,j)=\frac{1}{2}\varsigma^2-\sqrt{j^2+2\lambda j\varsigma^2}\,, \quad (2)$$

Ω and M are the vibration frequency and mass of an apical ion, z and $\varsigma = z/z_0$ are a normal and dimensionless coordinate of the apical ion, $z_0=\sqrt{\hbar/(M\Omega)}$, $j=J/\hbar\Omega$, J is the hopping integral of a charge carrier between layers of copper oxide $YBa_2Cu_3O_{6.5}$, $\tau=\Omega t$, t is a time, $\lambda=f^2/2M\Omega^2J$ is the dimensionless electron-ion coupling constant, f is the hole-ion interaction force, $\alpha_i=(z_i|e|E/\hbar\Omega)\sqrt{\hbar/M\Omega}$ is the dimensionless ion-external field coupling constant, $z_i|e|$ is the apical ion's electric charge, E and ω are the amplitude and frequency of an external electric field. In the above expressions energy, time and length are measured in units of $\hbar\Omega$, Ω^{-1} and z_0. The Eq.(1) describes a driven electron dynamics of which is governed by the double-well potential Eq.(2). In order to get numerical data from the Eq.(1) one can apply the Floquet theory in analogy of Ref.[7] and use modified MatLab code for the considering driven system with the double-well potential [8]. The obtained results and it's analys is given in the next section.

III. **Numerical results.** According to [4] in adiabatic regime and at strong coupling limit polaron dynamics is governed by it's tunneling between wells of double-well potential that in turn determined by the displacements of the apical ions of the lattice of cuprates. Analytical and numerical calculations using Floquet theory indicate that upon influence of external light radiation polaron's quasienergy become dependable on the frequency of light radiation ω_0

(Figure 1). The difference of two low lying quasienergies ε_1, ε_2, $\Delta\varepsilon = \varepsilon_2 - \varepsilon_1$ determines the value of polaron's bandwidth, i.e., polaron's mass $m_p \simeq \hbar^2 / 2a^2\Delta E$. In turn polaron's mass is connected with bipolaron's mass $m_{Bp} = 2 \cdot m_p$ and thus with Bose-Einstein condensation temperature (T_{BEC}) of an ideal gas of bipolarons through the mass of latter [5]

$$T_{BEC} \simeq \frac{3.31 \cdot \hbar^2 \cdot n_{Bp}^{2/3}}{2k_B \cdot m_{Bp}}$$

Our calculation shows that bipolaron's mass decreases up two times at certain values of driving external light frequency. This might lead to the corresponding increase of T_{BEC} up two times too. Within the bipolaron scenario of superconductivity we associate superconductivity of cuprates with the Bose-Einstein condensation of an ideal gas of bipolarons i.e. the critical temperature of superconductivity is equal to the temperature of Bose-Einstein condensation of the ideal gas of bipolarons $T_C = T_{BEC}$ Then, according to the above model, under light radiation superconductivity in $YBa_2Cu_3O_{6.5}$ compound (which has T_C of the order of 91 K) might be increased and observed up to 180 K! In case of $HgBa_2Ca_2Cu_3O_{8+x}$ cuprate which has T_C=133 K observation of transient superconductivity might rich up to 266 K! The obtained data qualitatively and quantitatively agree with the results of experiments [1,2].

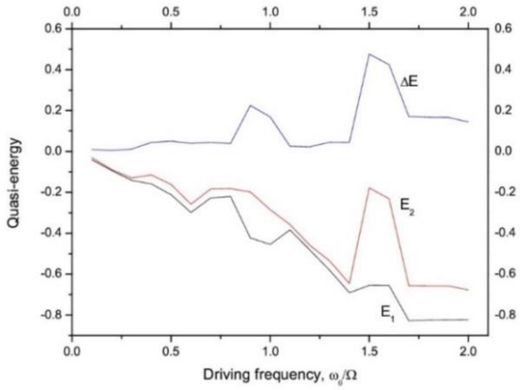

Figure 1. Dependence of polaron's two low lying quas-ienergies ε_1 and ε_2, their difference $\Delta\varepsilon = \varepsilon_2 - \varepsilon_1$ on the frequency of external laser radiation ω_0. The value of quasi-energy is given in arbitrary units, and the frequency of driving external laser radiation is given in units of phonon frequency Ω.

IV. **Conclusion.** In the paper we considered an electron in double-well potential driven by external light. In order to get an information about its dynamics, in particular about the value of quasi-energies of the driven electron, we solved the time dependent Schrödinger equation within the Floquet formalism and obtained numerical data by the use of Matlab code. Analysis of the obtained data clearly indicate that under external light radiation a transient superconducting state of the cuprates might be observed up to 266 K. The above considered scenario might be useful in material science of superconducting cuprates, in particular, in studying a dependence of T_C of cuprates on the frequency of an external laser radiation.

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REZYUME

Maqolada tashqi yorug'likning kupratlar o'tao'tkazuvchanlik kritik haroratiga ta'siri tadqiq qilingan. Shrodingerning vaqtga bog'liq tenglamasini yechish orqali qo'sh-o'rada joylashgan elektronning eng kichik kvazienergiya sathlari ayirmasi topilgan. Bu ayirma tashqi yorug'lik chastotasiga bog'liq bo'lishi sabab bipolaron gaz Boze-Eynashtein kondensatsiyasi harorati ortib ketishi ko'rsatilgan. O'rganilgan yondoshuv asosida tajribada kuzatilgan tashqi yorug'likning kupratlar o'tao'tkazuvchanlik kritik haroratiga ta'siri tahlillanadi.

РЕЗЮМЕ

В статье рассмотрено влияние внешнего светового излучения на критическую температуру сверхпроводимости купратов. Путём решения нестационарного уравнения Шрёдингера найдено разница между двумя наи-низшими уровнями квази-энергии электрона находящего в двух-ямном потенциале. Показано, увеличение температуры Бозе-Эйнштейновской конденсации газа биполяронов из-за зависимости разниц квази-энергии электрона от частоты внешнего светового излучения. В рамках рассмотренного подхода удовлетворительно объяснено наблюдаемое в эксперименте влияние внешнего светового излучения на критическую температуру сверхпроводимости купратов.

SUMMARY

In this article the effect of external light radiation on the critical temperature of superconductivity of cuprates is considered. By solving the time dependent Schodinger equation it is found that the difference of two low lying quasi-energies of the electron which is located in the double-well potential. It is shown that the temperature Bose-Einstein condensation of gas of bipolarons increases due to dependence of the difference of quasi-energies of the electron upon the frequency of external light radiation. Within the considered scenario it is satisfactorily explained observed in the experiment the effect of external light radiation on the superconducting critical temperature of cuprates.