ФІЗИЧНІ, ХІМІЧНІ ТА ІНШІ ЯВИЩА, НА ОСНОВІ ЯКИХ МОЖУТЬ БУТИ СТВОРЕНІ СЕНСОРИ

PHYSICAL, CHEMICAL AND OTHER PHENOMENA, AS THE BASES OF SENSORS

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NEW NUMERICAL APPROACH IN SENSING RADIATIVE TRANSITIONS PROBABILITIES IN SPECTRA OF SOME COMPLEX IONS

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NEW NUMERICAL APPROACH IN SENSING RADIATIVE TRANSITIONS PROBABILITIES IN SPECTRA OF SOME COMPLEX IONS

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Abstract. It has been carried out sensing and calculating the energies and oscillator strengths of some radiative transitions in spectra of complex ion on the basis of new numerical relativistic scheme within gauge-invariant perturbation theory.

Keywords: sensing radiative transitions, complex ions, relativistic approach

НОВИЙ ЧИСЕЛЬНИЙ ПІДХІД ДО ВИЗНАЧЕННЯ РАДІАЦІЙНИХ ПЕРЕХОДІВ У СПЕКТРАХ ДЕКОТРИХ СКЛАДНИХ ІОНІВ

Т. О. Флорко

Резюме. Виконано розрахунок енергій, імовірностей та сил осциляторів ряду радіаційних переходів у спектрі складних іонів на основі нової чисельної релятивістської схеми в межах калібровочно-інваріантної теорії збурень.

Ключові слова: детектування радіаційних переходів, складні іони, релятивістська схема

НОВЫЙ ЧИСЛЕННЫЙ ПОДХОД К ОПРЕДЕЛЕНИЮ ВЕРОЯТНОСТЕЙ РАДИАЦИОННЫХ ПЕРЕХОДОВ В СПЕКТРАХ НЕКОТОРЫХ СЛОЖНЫХ ИОНОВ

Т. А. Флорко

Резюме. Выполнен расчет вероятностей и сил осцилляторов ряда радиационных переходов в спектре сложных ионов на основе новой численной релятивистской схемы в рамках калибровочно-инвариантной теории возмущений.

Ключевые слова: детектирование радиационных переходов, сложные ионы, релятивистская схема

1. Introduction

The experimental and theoretical studying of the radiation transition characteristics of a whole number of atomic systems, which are interesting and perspective from the point of view of the quantum electronics and photoelectronics, is in last years of a great importance (c.f.[1-11]). It is also very important for search the optimal candidates and conditions for realization of the X-ray lasing. Besides, the forbidden atomic transitions are attracting from the point of view of sensing new physics behind the well known standard model.

The well known multi-configuration Dirac-Fock (MCDF) approach is widely used in calculations of the atoms and ions. It provides the most reliable version of calculation for atomic systems. The further improvement of this method is connected with using the gauge invariant procedures of generating relativistic orbitals basis's and more correct treating the nuclear, correlation, radiative effects [1-8]. In references [7-9] it has been developed a new ab initio approach to calculating spectra of atomic systems with account of relativistic, correlation, nuclear, QED effects, based on the gauge-invariant relativistic PT and new effective procedures for accounting the nuclear and radiative corrections. Here we propose a new numerical relativistic scheme for radiative transitions basing on the gauge-invariant QED perturbation theory formalism [7-9] and the ideas of the Refs. [9-11]. We study the spectrum of energy levels and the probability of E2 and M1 forbidden radiative transitions between the lowlying configurations 3s23p5, 3s3p63p43d, 3p44s singly ionized argon atom. It should be noted that the spectral information on rare gas atoms and ions, in particular, neon, and argon, is crucial, for example, for diagnostic laboratory plasma [1-5]. The unknown atoms and ions are present in a tokamak plasma, stellator. Finally, the atoms and ions of argon found in astrophysical objects (nebulae, stars, etc.) [1,2]. From a theoretical point of view, the desired atoms and ions are a class of highly complex systems due to the high sensitivity of the calculated energies and transition probabilities for the quality and completeness of both relativistic and correlation effects.

2. New relativistic approach to sensing and determination of the radiative transition probabilities

Let us describe in brief the important moment of our theoretical approach. As usually, the wave functions zeroth basis is found from the Dirac equation solution with potential, which includes the core ab initio potential, electric, polarization potentials of nucleus (the gaussian form for charge distribution in the nucleus is used). All correlation corrections of the PT second and high orders (electrons screening, particle-hole interaction etc.) are accounted

For [9]. The wave function for a particular atomic state [10]:

$$
\Psi(\Gamma P J M) = \sum_{r}^{NCF} c_r \Phi(\gamma_r P J M) \qquad (1)
$$

is obtained as the above described selfconsistent solutions of the DF type equations. Configuration mixing coefficients c_r are obtained through diagonalization of the Dirac Coulomb Hamiltonian:

$$
H_{DC}=\Sigma_i \{c\alpha_i p_i + (\beta_i-1)c^2 - Z/r + V(r|nlj)\} + \Sigma_{i>i} \exp(i\omega r_{ij})(1-\alpha_1\alpha_2)/r_{ij}.
$$
\n(2)

In this equation the potential:

$$
V(r) = V_c (r|nlj) + V_{ex} + V_{nucl} (r|R). \tag{3}
$$

This potential includes the electrical and using one of the standard nume potential increases the electrical and using one of the standard numerical
polarization potentials of the nucleus. The part V_{ex} [7] authors treated the function ρ_c $\frac{1}{2}$ accounts for exchange inter-electron interaction. analytic form with the only variable The main exchange effect are taken into account and substituted it to (6). More accurate in the equation. The rest of the exchange- requires the solution of the integral correlation effects are accounted for in first two equation for the $\rho_{\rm c}$ [2,9]. PT orders by the total inter-electron interaction In order to define the proba [9]. The effective electron core density (potential transition we have used energy V_c) is defined by iteration algorithm within gauge this approach the probability is invariant QED procedure [2,7]. with imaginary part of electron atom with imaginary part of electromagnetic potentials gauge of ϵ . $\sum_{i=1}^{\infty}$ reporting includes the electrical and points of the particles of the p $\frac{1}{\sqrt{2}}$ correlation criters are accounted for the EDPT and $\frac{1}{\sqrt{2}}$ second order of the EDPT and $\frac{1}{\sqrt{2}}$ correlation effects are accounted for in first two equation for the ρ [2.9] PT orders by the total inter-electron interaction In order to define the probability radiative contribution for the certain formulation $\frac{1}{2}$ of the photon propagator calibration is the photon propagator calibration we have used energy approximation is the effective electron core density (potential tr \overline{V} is defined by iteration algorithm within gauge this annoach the probability is directlon correlation effects, *x*₁ α *y*₁ α *i*₂, α *i*₄, α *i* (*P*). The effective electron core density (potential or transition we have used energy a *v*_c) is defined by neration algorithm within gauge this approach the probability is d

Consider the one-quasiparticle system. A system, which is defined in the α quasiparticle is a valent electron above the core perturbat of closed electron shells or a vacancy in the $\frac{1}{2}$ $\frac{2}{3}$ $\frac{1}{2}$ core. In the lowest second order of the EDPT a $Im\Delta E(B) = -\frac{e^2}{4\pi} \sum V_{\text{cm}}^{|Q_{\text{cm}}|}$, (5) non-zeroth contribution to the imaginary part
 $4\pi \frac{\Delta^{r} \text{ and } \Delta^{r}}{a > n > f}$ of electron energy Im δE (the radiation decay $[\alpha < n \le f]$ width) is provided by relativistic exchange Fock diagram. In the fourth order of the QED PT there where Σ - for electron and and the state of the SED 1 here where \sum for electron and \sum for an are diagrams, whose contribution into the ImoE $\alpha > n > f$ $\alpha < n \le f$ $\alpha > n$ t $\alpha < n \le t$
accounts for the core polarization effects. It is on $\alpha > n$ \ge $n > t$ $\alpha < n \le t$ the electromagnetic potentials gauge (the gauge vacancy. The potential V is as follows: non-invariant contribution). Let us examine the $V_{ijkl}^{|\omega|} = \iint dr_1 dr_2 \Psi_i^*(r_1) \Psi_j^*(r_2)$ multielectron atom with one quasi-particle in the $h_{ijkl} = \int a r_1 a r_2 \Psi_i(r_1) \Psi_j$ first excited state, connected with the ground state $\frac{1}{2}$ by the radiation transition [2,7]. In the zeroth $\times (1-\alpha_1\alpha_2) \Psi_k^*(r_2) \Psi_l^*(r_1)$. QED PT approximation we, as usually (c.f.[9]), 12 *n f* use the one electron bare potential $\alpha > n$ $\alpha > n$ $\alpha < n \leq t$
ization effects. It is on
ials gauge (the gauge vacancy. The potential V is as follows: *n* accounts for the core polarization effects. It is on the electromagnetic naturals gauge (the gauge QED PT approximation we, as usually (c.f.[9]),
use the one electron bare potential
the contributions of different channells and a quasinarticle is a valent electron above the core negative numerical neory as follows: $\sum_{i=1}^{n}$ order to define the probability of radiative transition we have used energy approach $\sum_{i=1}^{n}$ $\frac{d}{dx}$ is on $\frac{d}{dx}$ is on Consider the one-quasiparticle system. A system, which is defined in the quasiparticle is a valent efectron above the core perturbation theory as follows. $(0, 1)$ \mathbf{v} \mathbf{r} \mathbf{r} \mathbf{r} *n f* $\mathcal{L}_{\mathcal{A}}$ re 14,7 j. - 111-1110
See as nsually 6 \overline{a} \mathbf{u} *n f* $f(0)$ electron and $f(0)$

$$
V_N(r) + V_C(r)
$$
, (4) probability of t

with $V_N(r)$ describing the electric potential of the Γ_{α_n} = with $V_N(t)$ describing the electric potential of the
nucleus, $V_C(r)$, imitating the interaction of the quasi-particle with the core. The core potential $V(x)$ is related to the earse electron density. According to [6.7] quasi-particle with the core. The core potential
 $V_c(r)$ is related to the core electron density According to [6,7] $\rho_c(r)$ is related to the core creation density
 $\rho_c(r)$ in a standard way. The latter fully defines written as follows: the one electron representation. Moreover, all $\frac{1}{r \omega}$ $\frac{1}{$ the results of the approximate calculations are $V_{1234}^{\omega} = [(j_1)(j_2)(j_3)(j_4)]^{1/2} \sum_{\mu} (-1)^{\mu}$ the functionals of the density $p_c(r)$. In fel.[1] the
lowest order multielectron effects, in particular, $\times \text{Im}Q_\lambda(1234)$; $Q_\lambda = Q_\lambda^{\text{Qul}} + Q_\lambda^{\text{Br}}$. the gauge dependent radiative contribution for the
time is the gauge dependent radiative contribution for the the gauge dependent radiative contribution for the
certain class of the photon propagator calibration *R R R R R R R B S R C B B S C C B B S C C B B S C C B B C B C B B C B C B C B C B C B C B C B C B C B C B C C B n* Integration construction as a following to $[6,7]$, a matrix element in $[6,7]$ ated to the core electron density According $\sum_{i=1}^{n}$ 0¹ (*r*) describing the electric potential of the Γ_{α_n} *n n <i>a**n n* the results of the approximate calculations are $\frac{1234 - 101}{224}$ is $\frac{1}{204}$. i.

 $-Z/r + V(r|nlj)$ + is treated. This value is considered to be the typical representative of the electron correlation effects, whose minimization is a reasonable *i criterion* in the searching for the optimal one-
 a^{*n*}*x*^{*n*}*n*</sub>. (*r*) electron basis of the PT. The minimization of the $V(r) = V_c(r|nlj) + V_{ex} + V_{nucl}(r|R)$. (3) density functional Im δE_{min} leads to the integral $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ $\frac{1}{c}$ at the ρ_c , that can be solved the electrical and using one of the standard numerical codes. In ref. nucleus. The part V_{ex} [7] authors treated the function ρ_{c} in the simple electron interaction. analytic form with the only variable parameter *b* $\frac{1}{2}$ $\frac{1}{2}$ is the typical representation. This value is considered to $\frac{1}{2}$ in the electron correlation effects of the the the electron correlation effects, $\frac{1}{2}$ is considered to $\frac{1}{2}$ is considered to $\frac{1}{2$ of the exchange- requires the solution of the integral differential $\frac{1}{2}$ for in first two equation for the ρ_c [2,9]. of the exchange- requires the solution of the integral differential
the for in first two contribution for the e^[2] o] $V(N)$. (3) density functional inf or V_{min} reads to the integral $V_{\rm c}$, and can be solved
 $V_{\rm c}$, $V_{\rm c}$, interaction of the in the core. The core particle with the core potential *The core potential* α *relations* α *relatio* density V_{ex} [*r*] authors treated the function p_c in the simple on interaction. analytic form with the only variable parameter θ Γ into account and substituted it to (0) . More accurate calculation *V*N(*r*) + *V*C(*r*), (4) α differential describing the electric potential of the integral differential of the exchange α requires the solution of the integral differential of the exchange- requires the solution of the integral differential $\frac{d}{dx}$ and $\frac{d}{dx}$ is first two equation for the e. $\left[2, 9\right]$

electron interaction for the $P_c(z)$, the probability of radiative selectron interaction for order to define the probability of radiative $\frac{1}{2}$ in $\frac{1}{2}$ and $\frac{1}{2}$ are function $\frac{1}{2}$ and $\frac{1}{2}$ are function $\frac{1}{2}$ and $\frac{1}{2}$ parameter α and substituted α and α and α and α and β , β , β . α and β , β , β , β Friend when gauge and approach the processing is an every connected.

T]. with imaginary part of electron energy of the system. A system, which is defined in the lowest order of express tron above the core perturbation theory as follows: siparticle system. A system, which is defined in the lowest order of on interaction in order to define the probability of radiative sity (potential transition we have used energy approach [6,7]. In I within gauge this approach the probability is directly connected With imaginary part of electron energy of the r_e is a critical by ticriation argorithm within gauge and approach the probability is differently connected. $\epsilon = \frac{1}{2}$ $\epsilon = \frac{1}{2}$ exponential in this two equation for the p_c (2, 2).

Let-electron interaction in order to define the probability of radiative core density (potential transition we have used energy approach [6,7]. In lgorithm within gauge this approach the probability is directly connected invariant QED procedure $[2,7]$. with imaginary part of electron energy of the ectron above the core perturbation theory as follows: $\frac{1}{2}$ $\frac{1}{2}$

 (5) *n f n f n n ⁿ ^V ^e ^E ^B* 2 4 Im () , (5) In order to define the probability of radiative transition we have used energy approach *ⁿ ^V ^e ^E ^B* 2 differential equation for the c, that can be solved using one of the standard numerical codes. In ref. [7] authors treated the function ^c in the simple analytic form with the only variable parameter *b* and substituted it to (6). More accurate calculation requires the solution of the

where α >n> f Σ − for electron and Σ − α < $n \leq f$ Σ – for $\alpha \leq n \leq 1$ α >n>f α <n \leq f *n f n f* \mathbf{u} of the QED PT there where Σ - for electron and Σ - for electron into the Im δ E $\alpha < n \leq I$ Into the Imole $\alpha > n > f$ $\alpha < n \leq f$

vacancy. The potential V is as follows:

(6) The separated terms of the sum in (5) represent the contributions of different channells and a *^αⁿ n n n ^α ^α ^V π Г* ⁴ ¹ (7) (1) () sin () 1 2 1 12 12 1 2 2 *Ψ (r)Ψ r r r ^V dr dr ^Ψ (r)^Ψ ^r * ² ^l * ^k * ¹ ^j * i ijkl* . (6) 12 *n f n f n n* for electron and *n f* for vacancy. The potential *V* is as follows: *n f n n ⁿ ^V ^e ^E ^B* 4 Im () , (5) for electron and for vacancy. The potential *V* is as follows: Im () , (5) *ⁿ ^V ^e ^E ^B* 2 Im () , (5) for vacancy. The potential *V* is as follows: × × .

as usually (c.r. [9]), The separated terms of the sum in (5) represent and σ the contributions of different channells and a probability of the dipole transition is: probability of the dipole transition is: 1 3 $+V_c(r)$, (4) probability of the dipole transition is: (\dagger) , (\dagger) is written as follows: ri (ب)
المع*س*ميا $F(V)$ (*A*) probability of the dipole transition is: *n f f* $\ddot{}$ the contributions of different channels and a
4) probability of the dipole transition is:

describing the electric potential of the
\n
$$
\Gamma_{\alpha_n} = \frac{1}{4\pi} \cdot V_{\alpha_n \alpha_n}^{\left| \omega_{\alpha_n} \right|}
$$
\n(7)
\n
$$
\Gamma_{\alpha_n} = \frac{1}{4\pi} \cdot V_{\alpha_n \alpha_n}^{\left| \omega_{\alpha_n} \right|}
$$
\n(7)

ectron density According to [6,7], a matrix element in (7) is
expansion the expression momentum partition of follows; fully defines written as follows:

foreover, all $\begin{bmatrix} \n\zeta & \lambda \end{bmatrix}$ $\begin{bmatrix} \n\zeta & \lambda \end{bmatrix}$ Qul Br *Q Q Q* . (8) $\overline{ }$ cording to
itten er fel 1 Im 1234 \mathbf{S} .

the one electron representation. Moreover, all
the results of the approximate calculations are
the functionals of the density
$$
\rho_c(r)
$$
. In ref.[7] the
lowest order multielectron effects, in particular, $\times \text{Im } Q_{\lambda}(1234)$; $Q_{\lambda} = Q_{\lambda}^{\text{Qul}} + Q_{\lambda}^{\text{Br}}$.
The gauge dependent radiative contribution for the

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^j ^j ^V ^j ^j ^j ^j ;

where j_i are the entire single electron momentums, m_i – their projections; Q_{λ}^{Qul} is the Coulomb part of interaction, Q_{λ}^{Br} - the Breit part. The Coulomb part Q_{λ}^{Qul} is expressed in terms of radial integrals R_1 , angular coefficients S_1 [2,5]: part. The Breit part S_2 [2,5]: w_i are the entire single electronic part the ground state. On levels with $\sum_{n=1}^{\infty}$ – $\sum_{n=1}^$ m_i – their projections; Q_i Ì $\overline{1}$ í m_i – their projection m – their projections: m_i – their projections; Q_2^Q of interaction, Q_1^{Br} - the Breit part. The C

$$
Q_{\lambda}^{\text{Qu1}} = \frac{1}{Z} \{ R_i (1243) S_{\lambda} (1243) + R_{\lambda} (\tilde{1} 24\tilde{3}) S_{\lambda} (\tilde{1} 24\tilde{3}) + R_{\lambda} (1\tilde{2}43) S_{\lambda} (\tilde{1} 24\tilde{3}) \} + R_{\lambda} (1\tilde{2}43) S_{\lambda} (1\tilde{2}43) + R_{\lambda} (\tilde{1} 24\tilde{3}) S_{\lambda} (\tilde{1} 243) \} \qquad (9)
$$

where f is the large component of radial part of single electron state Dirac function; the sign « \sim » means that in (10) the large radial component f_i is \downarrow is a local procedure and \downarrow is a manufacture and f_i and \downarrow to be changed by the small *gi* one and the moment l_i is to be changed by $\tilde{\gamma} = l_i - 1$ for Dirac number $\mathfrak{E}_1 > 0$ and l_i+1 for $\mathfrak{E}_i < 0$. The Breit part of Q is defined as the sum: $\frac{1}{2}$ where f is the large component of radio where f is the large component of radial part of $\frac{1}{2}$ is the single electron state $\frac{1}{2}$ single electron state Dirac function, the small *fi* is the small *fi* is the small *fi* in the small *g*^{*i*} *g*^{*n*} *g***_{***i***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***}** *g***_{***n***} **

$$
Q_{\lambda}^{\text{Br}} = Q_{\lambda,\lambda-1}^{\text{Br}} + Q_{\lambda,\lambda}^{\text{Br}} + Q_{\lambda,\lambda+1}^{\text{Br}}, \quad (10)
$$

where the contribution of our interest is determined $\frac{d}{dx}$ and the experimental data as: as: description as: $\frac{d}{dt}$ Br Br Br Br *Q Q***,**¹ *Q***,** *Q***,**¹ , (10)

$$
Q_{\lambda}^{\text{Br}} = \frac{1}{Z} \text{Re} \{ R_{\lambda} (12\tilde{4}3) S_{\lambda} (12\tilde{4}3) + R_{\lambda} (\tilde{1}243) S_{\lambda} (1243) + \text{ most cases, more accurate than methods. However, for some methods. However, for some example, } 3s^{2}3p^{4} (1D)3d^{2}S_{1/2}^{e},
$$

$$
+ R_{\lambda} (\tilde{1}243) S_{\lambda}^{1} (\tilde{1}243) + R_{\lambda} (\tilde{1}243) S_{\lambda}^{1} (1243) \}.
$$

$$
(11)
$$
 example, $3s^{2}3p^{4} (15)3d^{2}D_{3/2}^{e}$ or $3s^{2}3p^{4} (15)3d^{2}D_{3/2}^{e}$

All calculations are performed using modified inter-configuration interaction in Superatom code developed by Ivanov et al $[6-10]$.
the ion Ar+ Apparently an adequation

3. Results and conclusions of these terms requ

We have considered the energy and transition of the secular matrix to account probabilities for the 39 low-lying levels of the configurations. We believe that in ArII: 3s23p5, 3s3p6, 3p43d, 3p44s. These states are in the PT formalism treated as $1 -$ and $3-QP$ These configurations for the state electron $(4s, 3d)$ $(3p^{-1}$ vacancy) over the core in perturb the discrete spectru of the filled electron shells $3s23p6$. The structure $\frac{100}{2}$ perfurb the discrete spectron shells $3s23p6$. The structure of the low-lying levels ArII includes two odd
noreasing the interaction configures levels with total angular momentum $J = 1/2$, $J =$ $3/2$ configuration $3s23p5$ and 37 excited levels with $J = 1/2$, $J = 3/2$ configurations 3s3p6, 3p43d, 3p44s. Among these levels of the excited states with only the levels with $J < 5/2$ chance of E1 of the low hing levels. ArII includes two edd increasing the interaction configurations. productive is the $\frac{3}{2}$ for $\frac{3}{2}$ and $\frac{3}{2}$ and $\frac{3}{2}$ and $\frac{3}{2}$ the studied ion there $\frac{1}{2}$ same participal including states with the same total including states with the same total angular momentum including states with the same total angular momentum including states with the same total angular momen BZ comparation $BZDZ$ and BZ corrections $AZ = 1/2$. In $A = 2/2$, one of $AZ = 2/2$, our the experimental data $BZ = 2/2$, or $AZ = 2/2$, or $AZ = 2/2$ Λ_{r} and Λ_{r} = 1, Λ_{r} = 1 $\frac{3}{2}$ configuration $\frac{3}{2}$. In $\frac{3}{2}$ and $\frac{3}{2}$ excited levels t_{max} being a whose block and structure of the structure of the structure of the spectrum, in most case is most called the spectrum, in most case is a spectrum, in most case in most case in most case in most case in m with $J = 1/2$, $J = 3/2$ comigurations 35 p o, $5p$ $43q$, interaction interaction interaction in the spectrum of the spectrum of the ion A $\frac{1}{4}$ and $\frac{3525p}{3}$, $\frac{355p}{3}$, $\frac{35p}{3}$, $\frac{3p}{3}$, $\frac{3p}{3}$, $\frac{3p}{3}$, $\frac{3p}{3}$ ale in the Γ 1 formalism treated as Γ - and $p_1 = \text{complex}$
sight $I = 1/2$, $I = 2/2$ and annualizes $2a^2nC$ with $y = 1/2, y = 3/2$ comiguiations $355p0,$

is, radiative transition to the ground state of the ion. $\mu_{\text{path part}}$ On levels with $J = 7/2$ chance of M2 transition to the ground state. On levels with $J = 7/2$, $9/2$ (eg, configuration 3p43d) possible inhibition of E2 and configuration 3p43d) possible inhibition of E2 and
ms of radial integrals M1 transitions to lower lying levels of the same parity. Secular matrix as usual including states with the same total angular momentum and of the $Q_{\lambda}^{\text{Qul}} = \frac{1}{Z} \{ R_i (1243) S_{\lambda} (1243) + R_{\lambda} (\tilde{1} 243) S_{\lambda} (\tilde{1} 243) + R_{\lambda} (\tilde{1} 2$ $\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), $\tilde{\tau}_{\alpha}$ ($\tilde{\tau}_{\alpha}$), \til $+ \kappa_{\lambda} (1243) \lambda_{\lambda} (1243) + \kappa_{\lambda} (1243) \lambda_{\lambda} (1243)$ (9) self-consistent field. The effects of polarization where f is the large component of radial part of interaction QPs through polarizable core and radial part of interaction Q1 s unough potanzable core and
i the sign $\alpha \sim$ screening (antiscreening in case of an electronvacancy interactions) were taken into account as part of the procedure described above [2,7- 9,12,13]. Table 1 shows the theoretical values of the excitation energies (in cm-1) for some levels with $J = 5/2$, calculated in various approximations: MCDF theory, MCDF theory plus accounting $Q_{\lambda}^{\text{Br}} = Q_{\lambda,\lambda-1}^{\text{Br}} + Q_{\lambda,\lambda}^{\text{Br}} + Q_{\lambda,\lambda+1}^{\text{Br}}$, (10) for the Breit corrections (MCDF+Breit), our theory and the experimental data [14]. In general, our theory provides a perfectly acceptable as: description of the structure of the spectrum, in $R_{\lambda}^{\text{Br}} = \frac{1}{6} \text{Re} \{ R_{\lambda} (12\tilde{4}3) S_{\lambda}^{\prime} (12\tilde{4}3) + R_{\lambda} (1243) S_{\lambda}^{\prime} (1243) + \dots \}$ most cases, more accurate than alternative MCDF $Q_{\lambda}^{\text{Br}} = \frac{1}{Z} \text{Re} \{ R_{\lambda} (12\tilde{4}\tilde{3}) S_{\lambda} (12\tilde{4}\tilde{3}) + R_{\lambda} (\tilde{1}\tilde{2}43) S_{\lambda} (1243) + \dots$ methods. However, for some of the terms (for example, $3s^23p^4(^1D)3d^2S^e_{1/2}$, $3s^23p^4(^1S)3d^2D^e_{5/2}$, $+R_1(1\,243)S'_2(1\,243)+R_1(1\,243)S'_2(1\,243)$. $3s^23p^4(^1S)3d^2D^e_{3/2}$ computation error is large enough and far beyond the standard spectroscopic, which is evidence of very strong inter-configuration interaction in the spectrum of superation code developed by Ivanov et at $[0-10]$. the ion Ar+. Apparently, an adequate description a Decrets and conclusions of these terms requires a significant expansion \mathbf{v}_k being a secular matrix to account also high-lying \mathbf{v}_k being \mathbf{v}_k and the exception of the secular matrix to account also high-lying configurations. We believe that in the spectrum of the studied ion there is an effect of the so-called $\frac{1}{2}$ same particle 3p4p4d and others. Secure matrix $\frac{1}{2}$ configurations of 3p4p4d and others. These configurations for the corresponding ion perturb the discrete spectrum, significantly description of the description of the description of the description of the description of the description of the description of the description of the description of the description of the description of the description o $\frac{m}{2}$ = 1.1, $\frac{1}{2}$, $\frac{1}{2}$ = 3.323 **3. Results and conclusions**

Level	MCDF	MCDF	$MCDF+$	Our data	Experiment
		4l(SD)	Breit		
$3s3p^6{}^2S^e_{1/2}$	112307	110781	108772	108754	108721
$3s^23p^4(^3P)3d^4D^e_{1/2}$	137892	135584	133154	132965	132737
	139843	138088	135756	135673	135601
$3s^{2}3p^{4}(^{3}P)4s^{4}P^{e}_{1/2}$					
	157482	151676	148453	147441	147228
$3s^{2}3p^{4}(^{3}P)3d^{4}P^{e}_{1/2}$					

Table 2. Probability of M1 (s⁻¹) of the forbidden transitions in the spectrum AgII calculated in the method MCDF+ Breit (a) and our approach (b) $T_{\rm{c}}$ robability of M1 (s⁻¹) of the forbidden transitions in the spectrum Δ oll calculated in $\frac{1}{\pi}$ low-ling configurations in the spectrum Again, $\frac{1}{\pi}$, calculated using the methods of the methods of the methods of the methods of the methods of the methods of the methods of the methods of the methods of $thod MCDF+ Breit (a)$ and our approach (b)

Table 2 lists the data on M1 probability of the forbidden transitions between the levels of low-lying configurations in the spectrum AgII, calculated using the methods of the MCDF+ Breit and our theory. The only available experimental value of the probability of $5.32 \times 10^{-2} = 5.32(-2)$ M1 transition. $3s^2 3p^{52}P^{\circ}_{1/2}$ - $3s^2 3p^{52}P^{\circ}_{3/2}$ is consistent with our value (error $\sim 0.4\%$), while the error in the calculation by the MCDF method is about 3%.

Analysis of the obtained data allows to make the following conclusions. Firstly, one can see that our approach provides physically reasonable agreement with experiment and significantly more advantagable in comparison with standard Dirac-Fock method. Secondly, calculation has confirmed the great role of the interelectron correlation effects of the second and higher PT orders, namely, effects of the interelectron polarization interaction and mutual screening.

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