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Maxime Brasseur , Patrick Palmeri , Pascal Quinet *

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*Article*

# Calculated Transition Probabilities for Os VI Spectral Lines of Interest to Nuclear Fusion Research

**Maxime Brasseur [1], Patrick Palmeri [1] and Pascal Quinet [1,2,*]**

[1] Physique Atomique et Astrophysique, Université de Mons, B-7000 Mons, Belgium

[2] IPNAS, Université de Liège, B-4000 Liège

* Correspondence: Pascal.Quinet@umons.ac.be; Tel.: +32-6537-3629

**Abstract:** In this work, we present a new set of transition probabilities for experimentally classified spectral lines in the Os VI spectrum. To do this, two independent computational approaches based on the pseudo-relativistic Hartree-Fock including core-polarization effects (HFR+CPOL) and fully relativistic Multiconfiguration Dirac-Hartree-Fock (MCDHF) methods were used, the detailed comparison of the results obtained with these two approaches allowing us to estimate the quality of the calculated radiative parameters. These atomic data, corresponding to 367 lines of five times ionized osmium between 438.720 and 1486.275 Å, are expected to be useful for the analysis of the spectra emitted by fusion plasmas in which osmium could appear as a result of transmutation by neutron bombardment of tungsten used as component of the reactor wall, such as the ITER divertor.

**Keywords:** atomic data; transition probabilities; fusion plasma diagnostics

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## 1. Introduction

It is now well established that tungsten (W) will be widely used in nuclear fusion reactors as a plasma-facing material due to its high melting point, low sputtering yield, and resistance to neutron irradiation. In particular, tungsten will be a key material for the divertor of the International Thermonuclear Experimental Reactor (ITER), the component designed to manage heat and particle flux from the plasma [1–3]. During nuclear fusion operations, the divertor will endure some of the harshest conditions in the reactor. Thus, under neutron bombardment, tungsten will undergo nuclear transmutation, forming other elements, including osmium [4].

As a transmutation product of tungsten, osmium atoms will also be sprayed into the plasma, altering its composition. Monitoring osmium's spectroscopic signals will help in understanding the dynamics of plasma-wall interactions, which are crucial for predicting material erosion and plasma contamination. The high ionization potential of neutral osmium (8.4 eV) means its ionic species may survive in high-temperature plasmas, providing diagnostic data about plasma conditions. Spectral lines of Os ions will therefore be particularly useful for identifying impurity influx from plasma-facing components and the corresponding radiative decay rates will also be used to calculate essential plasma properties, such as electron temperature and density.

The main goal of the present work is to make a new contribution to this field by determining the transition probabilities for spectral lines of five times ionized osmium (Os VI) which is characterized by a moderately complex atomic structure with 71 electrons giving $5d^3$ $^4F_{3/2}$ as the ground level. Spectroscopic studies have already been carried out previously for this ion. Indeed, nearly 30 years ago, Raassen *et al*. [5] classified 290 lines belonging to the $5d^3$ – $5d^26p$ transition array in the 435 – 765 Å region and 87 lines belonging to the $5d^26s$ – $5d^26p$ transition array in the 940 – 1510 Å region from the analysis of spectrograms made by means of the 3.0 m and 10.6 m normal incidence spectrographs installed at that time in Antigonish (Canada) and Meudon (France). This resulted in the determination of all levels (19) in the $5d^3$ ground configuration, 14 levels (out of 16 possible) in the $5d^26s$ configuration and all levels (45) in the $5d^26p$ configuration. The analysis was guided by

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predicted energy level values and transition probabilities calculated by means of a complete set of orthogonal operators. Calculated energy values, *LS*-compositions and *gA*-values, obtained from the fitted parameters using a rather limited configuration interaction model were also reported. More recently, Azarov [6] critically reviewed the data available on the $5d^3$, $5d^26s$ and $5d^26p$ configurations in the Lu I isoelectronic sequence, including Os VI, by means of calculations with orthogonal operators. This study allowed the determination of two new levels in the $5d^26s$ configuration of Os VI, namely $(^3P)^2P_{1/2}$ and $(^3P)^4P_{5/2}$.

If the electronic structure of the first three configurations of Os VI is now well known, the same cannot be said for the radiative parameters which have only been calculated by means of the pseudo-relativistic Hartree-Fock method (HFR) including the configuration interaction in a very limited way [5]. This motivated the present work, the objective of which is to provide a new set of reliable transition probabilities for experimentally observed spectral lines of Os VI. To do this, two independent methods were used, namely the pseudo-relativistic Hartree-Fock approach including core-polarization corrections (HFR+CPOL) and the fully relativistic Multiconfiguration Dirac-Hartree-Fock approach (MCDHF), the cross-comparison of the results obtained with these two methods allowing us to estimate the accuracy of the new calculated radiative data.

## 2. Computational Approaches

### *2.1. Pseudo-Relativistic Hartree-Fock Method with Core-Polarization Corrections*

The first method used for computing the radiative rates in Os VI was the pseudo-relativistic Hartree-Fock (HFR) method, originally introduced by Cowan [7], modified for taking core-polarization effects into account, giving rise to the so-called HFR+CPOL method, as described e.g. in [8–10].

The physical model was chosen as consisting of three valence electrons surrounding an Os IX-type ionic core with 76 electrons. This led us to consider the valence-valence interactions by explicitly introducing the following configurations into the calculations : $5d^3$ + $5d^26s$ + $5d6s^2$ + $5d^26d$ + $5d6p^2$ + $5d6d^2$ + $5d5f^2$ + $5d6f^2$ + 5d6s6d + 5d6p5f + 5d6p6f + 5d5f6f + $6s^26d$ + $6s6p^2$ + $6p^26d$ + $6s6d^2$ + $6d^3$ + $6s5f^2$ + $6d5f^2$ + $6s6f^2$ + $6d6f^2$ for the even parity, and $5d^26p$ + $5d^25f$ + $5d^26f$ + 5d6s6p + 5d6s5f + 5d6s6f + 5d6p6d + 5d6d5f + 5d6d6f + $6s^26p$ + $6s^25f$ + $6s^26f$ + $6p^25f$ + $6p^26f$ + $6p^3$ + $6p6d^2$ + $6d^25f$ + $6d^26f$ + $6p5f^2$ + $6p6f^2$ + $5f^26f$ + $5f6f^2$ for the odd parity. This list of configurations is similar to the one considered for our recent HFR+CPOL calculations of radiative parameters in the isoelectronic ion Re V [11]. Core-valence interactions were then estimated using a core-polarization potential and a correction to the electric dipole operator, as described in [8–10], with a dipole polarizability $\alpha_d$ = 1.50 $a_0^3$ and a cut-off radius $r_c$ = 1.12 $a_0$, the former parameter being found by extrapolating the $\alpha_d$-values published by Fraga *et al*. [12] for the first ions of the erbium isoelectronic sequence, i.e. Tm II, Yb III, Lu IV, and Hf V, while the latter parameter corresponds to the mean radius of the outermost orbital of the Os IX ionic core (5p), as obtained in the HFR calculations.

The HFR+CPOL calculations were then refined using a well-known least-squares fitting procedure of the computed energy levels to the experimental values available in the literature. More precisely, the experimental energy levels belonging to the $5d^3$, $5d^26s$ even configurations and the $5d^26p$ odd configuration published by Raassen et al. [5] were used to optimize the radial parameters corresponding to the average energies ($E_{av}$), the Slater integrals ($F^k$, $G^k$, $R^k$), the spin-orbit parameters ($\zeta_{nl}$), and the effective interaction parameters *a*, *b* characterizing these three configurations. This led to average deviations between calculated and experimental energies of 46 cm$^{-1}$ and 150 cm$^{-1}$ for the odd and even parities, respectively. These deviations are slightly higher than those obtained in the fits made by Raaseen *et al*. [5] (i.e. 11 and 107 cm$^{-1}$) and Azarov [6] (14 and 95 cm$^{-1}$) for the same configurations, but it should be noted that our calculations include a much larger number of interacting configurations, which often leads to slightly more complicated adjustment procedures, because of the more numerous mixtures in the eigenvector compositions. A detailed comparison between the HFR+CPOL levels and the available experimental values reported in [5,6] is given in

Table 1 in which the first two *LS*-components obtained in our calculations for each level are also listed. These eigenvector compositions are in excellent agreement with those published in [6].

**Table 1.** Comparison of the energy levels computed in the present work using the HFR+CPOL and MCDHF methods with the available experimental values for the 5d$^3$, 5d$^2$6s and 5d$^2$6p configurations of Os VI. All values are given in cm$^{-1}$.

| Conf. | Composition[1] | J | $E_{EXP}$[2] | $E_{HFR+CPOL}$ | $DE_{HFR+CPOL}$ | $E_{MCDHF}$ | $DE_{MCDHF}$ |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 5d$^3$ | 81% $^4$F + 10% $^2$D | 1.5 | 0.0 | 0 | 0 | 0 | 0 |
| | 94% $^4$F + 4% $^2$D | 2.5 | 6397.4 | 6422 | 25 | 5912 | -485 |
| | 84% $^4$F + 13% $^2$G | 3.5 | 11444.1 | 11450 | 6 | 11045 | -399 |
| | 46% $^4$P + 35% $^2$P | 1.5 | 14430.2 | 14390 | -40 | 15525 | 1095 |
| | 56% $^4$F + 33% $^2$G | 4.5 | 14678.3 | 14651 | -27 | 14901 | 223 |
| | 68% $^4$P + 32% $^2$P | 0.5 | 16772.4 | 16806 | 34 | 17878 | 1106 |
| | 81% $^2$G + 15% $^4$F | 3.5 | 22919.6 | 22950 | 30 | 24181 | 1261 |
| | 56% $^2$H + 34% $^4$F | 4.5 | 24028.4 | 24054 | 26 | 25420 | 1392 |
| | 89% $^4$P + 7% $^2$D | 2.5 | 24828.5 | 24808 | -20 | 25636 | 808 |
| | 42% $^4$P + 34% $^2$D | 1.5 | 27894.0 | 27944 | 50 | 28591 | 697 |
| | 67% $^2$P + 32% $^4$P | 0.5 | 28859.8 | 28876 | 16 | 29696 | 836 |
| | 100% $^2$H | 5.5 | 32155.8 | 32159 | 3 | 34620 | 2464 |
| | 84% $^2$D + 6% $^2$D | 2.5 | 34417.8 | 34433 | 15 | 35784 | 1366 |
| | 57% $^2$G + 32% $^2$H | 4.5 | 37019.4 | 37011 | -8 | 38308 | 1289 |
| | 85% $^2$F + 8% $^2$D | 2.5 | 39600.8 | 39572 | -29 | 43286 | 3685 |
| | 55% $^2$P + 17% $^2$D | 1.5 | 40202.6 | 40186 | -17 | 40607 | 404 |
| | 94% $^2$F + 5% $^2$G | 3.5 | 40447.0 | 40455 | 8 | 43864 | 3417 |
| | 66% $^2$D + 33% $^2$D | 1.5 | 59910.8 | 59972 | 61 | 63816 | 4005 |
| | 77% $^2$D + 12% $^2$F | 2.5 | 61005.3 | 60968 | -37 | 64058 | 3053 |
| 5d$^2$6s | 91% ($^3$F)$^4$F + 8% ($^1$D)$^2$D | 1.5 | 97940.4 | 97929 | -11 | 101568 | 3628 |
| | 78% ($^3$F)$^4$F + 12% ($^3$F)$^2$F | 2.5 | 100973.9 | 101053 | 79 | 104606 | 3632 |
| | 95% ($^3$F)$^4$F + 5% ($^3$F)$^2$F | 3.5 | 108538.4 | 108578 | 40 | 111778 | 3240 |
| | 53% ($^3$F)$^2$F + 21% ($^3$F)$^4$F | 2.5 | 114140.1 | 114133 | -7 | 118083 | 3943 |
| | 90% ($^3$P)$^4$P + 7% ($^1$S)$^2$S | 0.5 | 114363.2 | 114318 | -45 | 119157 | 4794 |
| | 90% ($^3$F)$^4$F + 10% ($^1$G)$^2$G | 4.5 | 115173.8 | 115184 | 10 | 118469 | 3295 |
| | 85% ($^3$P)$^4$P + 12% ($^1$D)$^2$D | 1.5 | 118499.8 | 118478 | -22 | 123014 | 4514 |
| | 51% ($^3$P)$^4$P + 29% ($^3$F)$^2$F | 2.5 | 119205.3 | 119259 | 54 | 123539 | 4334 |
| | 59% ($^1$D)$^2$D + 21% ($^3$P)$^2$P | 1.5 | 123318.6 | 123334 | 15 | 128060 | 4741 |
| | 61% ($^3$F)$^2$F + 36% ($^1$G)$^2$G | 3.5 | 123600.5 | 123520 | -80 | 128038 | 4438 |
| | 90% ($^3$P)$^2$P + 5% ($^3$P)$^4$P | 0.5 | 129179.2 | 129417 | 238 | 134405 | 5226 |
| | 89% ($^1$G)$^2$G + 10% ($^3$F)$^4$F | 4.5 | 130849.6 | 130957 | 107 | 136556 | 5706 |
| | 55% ($^1$D)$^2$D + 39% ($^3$P)$^4$P | 2.5 | 131676.2 | 131632 | -44 | 135923 | 4247 |
| | 63% ($^1$G)$^2$G + 33% ($^3$F)$^2$F | 3.5 | 132989.9 | 132897 | -93 | 138231 | 5241 |
| | 77% ($^3$P)$^2$P + 19% ($^1$D)$^2$D | 1.5 | 138441.2 | 138555 | 114 | 143272 | 4831 |
| | 89% ($^1$S)$^2$S + 5% ($^3$P)$^2$P | 0.5 | 157388.9 | 157398 | 8 | 162297 | 4907 |
| 5d$^2$6p | 62% ($^3$F)$^4$G + 19% ($^3$F)$^2$F | 2.5 | 170473.6 | 170724 | 250 | 194287 | 23813 |
| | 48% ($^3$F)$^4$F + 31% ($^3$F)$^2$D | 1.5 | 175839.8 | 175579 | -261 | 199974 | 24134 |
| | 72% ($^3$F)$^4$G + 11% ($^3$F)$^2$F | 3.5 | 182479.5 | 182524 | 44 | 205881 | 23401 |
| | 44% ($^3$F)$^4$F + 20% ($^3$F)$^2$D | 2.5 | 184033.0 | 184198 | 165 | 207833 | 23800 |
| | 50% ($^3$P)$^4$D + 16% ($^3$P)$^2$S | 0.5 | 186854.0 | 186757 | -97 | 211679 | 24825 |
| | 36% ($^3$F)$^4$G + 21% ($^3$F)$^4$F | 4.5 | 190882.5 | 190866 | -17 | 214816 | 23933 |
| | 27% ($^3$P)$^4$D + 21% ($^1$D)$^2$P | 1.5 | 190987.8 | 191141 | 153 | 215754 | 24766 |
| | 20% ($^3$F)$^4$G + 13% ($^3$P)$^4$D | 2.5 | 191516.9 | 191381 | -136 | 215489 | 23972 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 39% (³P)²S + 33% (³P)⁴P | 0.5 | 192087.9 | 192468 | 380 | 216865 | 24777 |
| | 33% (³F)⁴D + 31% (³F)⁴F | 3.5 | 192575.6 | 192473 | -103 | 216520 | 23944 |
| | 35% (³F)⁴F + 18% (³F)²D | 1.5 | 194263.2 | 194306 | 43 | 217644 | 23381 |
| | 39% (³P)⁴D + 21% (³P)⁴S | 1.5 | 195716.1 | 195276 | -440 | 220433 | 24717 |
| | 24% (³F)²F + 20% (³F)⁴D | 2.5 | 196152.8 | 196100 | -53 | 219905 | 23752 |
| | 33% (³F)²G + 17% (³F)⁴G | 3.5 | 197134.0 | 197161 | 27 | 220461 | 23327 |
| | 70% (³F)⁴D + 13% (¹D)²P | 0.5 | 198144.3 | 198214 | 70 | 222234 | 24090 |
| | 57% (³F)⁴G + 18% (¹G)²G | 4.5 | 202263.2 | 202190 | -73 | 225816 | 23553 |
| | 46% (¹G)²G + 29% (³F)⁴F | 3.5 | 203069.9 | 203306 | 236 | 227580 | 24510 |
| | 18% (³F)²F + 18% (¹D)²F | 2.5 | 204720.9 | 204779 | 58 | 228186 | 23465 |
| | 38% (³P)⁴S + 20% (¹D)²P | 1.5 | 205711.8 | 205702 | -10 | 230358 | 24646 |
| | 20% (³F)²G + 18% (³F)²F | 3.5 | 206193.4 | 206188 | -5 | 230443 | 24250 |
| | 41% (³F)⁴F + 34% (¹G)²H | 4.5 | 206555.3 | 206346 | -209 | 231212 | 24657 |
| | 29% (³F)²F + 28% (¹D)²F | 2.5 | 207333.9 | 207247 | -87 | 231344 | 24010 |
| | 55% (³F)⁴D + 20% (³F)²D | 1.5 | 207349.5 | 207473 | 123 | 230967 | 23617 |
| | 25% (³F)⁴D + 17% (³P)⁴D | 3.5 | 209856.0 | 209916 | 60 | 233316 | 23460 |
| | 90% (³F)⁴G + 10% (¹G)²H | 5.5 | 210146.1 | 209870 | -276 | 232910 | 22764 |
| | 60% (³P)⁴P + 14% (³P)⁴S | 1.5 | 211634.7 | 211444 | -191 | 236166 | 24531 |
| | 39% (³P)⁴P + 28% (¹D)²P | 0.5 | 212086.5 | 212047 | -40 | 236322 | 24235 |
| | 25% (³P)⁴D + 25% (³F)²D | 2.5 | 214387.4 | 214508 | 121 | 238266 | 23879 |
| | 55% (³F)²G + 21% (³F)⁴F | 4.5 | 215369.6 | 215554 | 214 | 238802 | 23432 |
| | 42% (³P)⁴P + 27% (¹D)²D | 2.5 | 216397.1 | 216259 | -138 | 240712 | 24315 |
| | 33% (³P)⁴D + 16% (³F)⁴D | 3.5 | 216704.6 | 216785 | 80 | 240859 | 24154 |
| | 30% (¹D)²D + 27% (³P)²P | 1.5 | 217361.9 | 217482 | 120 | 241850 | 24488 |
| | 53% (³P)²D + 14% (³F)²D | 1.5 | 219500.4 | 219622 | 122 | 244276 | 24776 |
| | 36% (¹D)²P + 20% (³P)⁴P | 0.5 | 219979.0 | 219971 | -8 | 244249 | 24270 |
| | 24% (¹D)²D + 23% (³F)²D | 2.5 | 220744.9 | 220682 | -63 | 245292 | 24547 |
| | 42% (¹G)²G + 33% (¹G)²H | 4.5 | 221932.2 | 221965 | 33 | 246907 | 24975 |
| | 42% (³P)²P + 30% (¹S)²P | 0.5 | 224004.9 | 224156 | 151 | 248952 | 24947 |
| | 41% (¹D)²F + 33% (³P)⁴D | 3.5 | 225818.9 | 225920 | 101 | 249663 | 23844 |
| | 89% (¹G)²H + 10% (³F)⁴G | 5.5 | 226320.5 | 226170 | -150 | 251706 | 25386 |
| | 33% (¹G)²F + 18% (³P)²D | 2.5 | 227935.6 | 228019 | 83 | 252758 | 24822 |
| | 47% (¹G)²F + 20% (¹G)²G | 3.5 | 228256.2 | 228274 | 18 | 253798 | 25542 |
| | 48% (³P)²P + 16% (¹D)²D | 1.5 | 231998.6 | 231890 | -109 | 256680 | 24681 |
| | 55% (¹G)²F + 15% (³F)²D | 2.5 | 233168.5 | 233242 | 74 | 258815 | 25647 |
| | 53% (¹S)²P + 26% (³P)²P | 0.5 | 236614.5 | 236645 | 31 | 262090 | 25476 |
| | 87% (¹S)²P + 3% (³P)²D | 1.5 | 252203.4 | 252163 | -40 | 277153 | 24950 |

[1] Only the first two components, as computed in our HFR+CPOL model, are given. [2] Experimental energy level values taken from [5,6].

### 2.2. *Fully Relativistic Multiconfiguration Dirac-Hartree-Fock Method*

The second computational approach used in the present work was the fully-relativistic Multiconfiguration Dirac-Hartree-Fock (MCDHF) method, as described in [13,14] and implemented in the latest version of the General Relativistic Atomic Structure Package, namely GRASP2018 [15].

We started our calculations by considering the $5d^3$, $5d^26s$ even- and the $5d^26p$ odd-parity configurations as the multireference (MR) with all the orbitals optimized on the $5d^3$ $^4F_{3/2}$ ground state, in a first step, and then optimizing separately only the 5d and 6s orbitals on all the levels of the MR even configurations ($5d^3$+$5d^26s$) and only the 5d and 6p orbitals on all the levels of the MR odd configuration $5d^26p$. Thereafter, correlation orbitals were introduced and optimized layer by layer on all the levels of the MR in two steps in valence-valence (VV) expansions of the atomic state functions (ASFs) where all single and double (SD) excitations were allowed from the 5d, 6s and 6p spectroscopic

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orbitals to the following orbital active sets (AS) where the set of $n_{max}$ stands for the maximum value of the orbital principal quantum number for each azimuthal quantum number *l*: {7s,6p,6d,5f} and {6s,7p,6d,5f} for the even- and odd-parities, respectively, in a first step (VV1 model), and {8s,7p,7d,6f} and {7s,8p,7d,6f} for the even- and odd-parities, respectively, in a second step (VV2 model). Finally, core-valence (CV) and core-core (CC) correlations were considered in a relativistic configuration interaction (RCI) calculation using the orbitals optimized previously. Here, the ASF expansions were further extended by adding SD excitations from the 4f core orbital of the MR configurations to the AS of the last step of the orbital optimizations. This gave rise to 515 057 and 900 402 configuration state functions (CSFs) in the even- and odd-parities, respectively.

The final MCDHF energy levels are compared to the available experimental values in Table 1, where it can be seen that a fairly good agreement has been reached, the average deviation being equal to 8% for the whole set of energy levels belonging to the $5d^3$, $5d^26s$ and $5d^26p$ configurations, with a lower value for even-parity levels (4%) compared to the value obtained for odd-parity levels (10%).

## 3. Radiative Decay Rates

Transition probabilities ($gA$ in $10^{10}$ $s^{-1}$) obtained in the present work with the HFR+CPOL and MCDHF methods are reported in Table 2. They are given for the lines experimentally identified by Raassen *et al*. [5] in the Os VI spectrum between 438.720 and 1486.275 Å. In this table, the transitions are classified by the numerical values of the lower and upper energy levels, with the spectroscopic designations of these levels given in Table 1. Transition probabilities published in [5] are also given for comparison in Table 2.

**Table 2.** Transition probabilities for experimentally observed lines in the Os VI emission spectrum.

| *l* (Å)[1] | Lower level[2] | | Upper level[2] | | *gA* ($10^{10}$ $s^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | *E* (cm⁻¹) | *J* | *E* (cm⁻¹) | *J* | Previous[3] | HFR+CPOL[4] | MCDHF[4] |
| 438.720 | 0.0 | 1.5 | 227935.6 | 2.5 | 0.006 | 0.006* | 0.004 |
| 455.577 | 0.0 | 1.5 | 219500.4 | 1.5 | 0.068 | 0.061* | 0.042 |
| 459.160 | 34417.8 | 2.5 | 252203.4 | 1.5 | 0.150 | 0.151 | 0.220 |
| 461.913 | 11444.1 | 3.5 | 227935.6 | 2.5 | 0.022 | 0.024* | 0.022 |
| 466.531 | 6397.4 | 2.5 | 220744.9 | 2.5 | 0.092 | 0.087 | 0.053 |
| 469.251 | 6397.4 | 2.5 | 219500.4 | 1.5 | 0.017 | 0.025* | 0.024 |
| 471.499 | 0.0 | 1.5 | 212086.5 | 0.5 | 0.025 | 0.023* | 0.022 |
| 471.694 | 40202.6 | 1.5 | 252203.4 | 1.5 | 0.185 | 0.305 | 0.275 |
| 472.510 | 0.0 | 1.5 | 211634.7 | 1.5 | 0.069 | 0.070 | 0.044 |
| 473.616 | 14678.3 | 4.5 | 225818.9 | 3.5 | 0.061 | 0.071* | 0.148 |
| 474.010 | 6397.4 | 2.5 | 217361.9 | 1.5 | 0.052 | 0.059* | 0.041 |
| 475.490 | 6397.4 | 2.5 | 216704.6 | 3.5 | 0.007 | 0.011* | 0.012** |
| 475.625 | 22919.6 | 3.5 | 233168.5 | 2.5 | 0.104 | 0.095* | 0.126 |
| 476.191 | 6397.4 | 2.5 | 216397.1 | 2.5 | 0.085 | 0.086* | 0.084 |
| 477.151 | 14430.2 | 1.5 | 224004.9 | 0.5 | 0.041 | 0.044* | 0.051 |
| 477.779 | 11444.1 | 3.5 | 220744.9 | 2.5 | 0.211 | 0.247 | 0.166 |
| 479.981 | 24828.5 | 2.5 | 233168.5 | 2.5 | 0.049 | 0.051* | 0.030** |
| 482.493 | 14678.3 | 4.5 | 221932.2 | 4.5 | 0.012 | 0.020* | 0.009** |
| 486.120 | 0.0 | 1.5 | 205711.8 | 1.5 | 0.038 | 0.037* | 0.043 |
| 487.005 | 22919.6 | 3.5 | 228256.2 | 3.5 | 0.127 | 0.116* | 0.101 |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 487.180 | 11444.1 | 3.5 | 216704.6 | 3.5 | 0.247 | 0.234 | 0.196 |
| 487.241 | 6397.4 | 2.5 | 211634.7 | 1.5 | 0.054 | 0.068 | 0.035 |
| 487.643 | 14430.2 | 1.5 | 219500.4 | 1.5 | 0.049 | 0.065* | 0.042 |
| 487.767 | 22919.6 | 3.5 | 227935.6 | 2.5 | 0.309 | 0.283 | 0.225 |
| 487.916 | 11444.1 | 3.5 | 216397.1 | 2.5 | 0.163 | 0.164 | 0.170 |
| 488.470 | 0.0 | 1.5 | 204720.9 | 2.5 | 0.023 | 0.027* | 0.028** |
| 489.648 | 24028.4 | 4.5 | 228256.2 | 3.5 | 0.459 | 0.429 | 0.215 |
| 490.375 | 11444.1 | 3.5 | 215369.6 | 4.5 | 0.206 | 0.193 | 0.153 |
| 491.577 | 24828.5 | 2.5 | 228256.2 | 3.5 | 0.174 | 0.176 | 0.125** |
| 492.275 | 28859.8 | 0.5 | 231998.6 | 1.5 | 0.095 | 0.096* | 0.074 |
| 492.355 | 24828.5 | 2.5 | 227935.6 | 2.5 | 0.096 | 0.097* | 0.113 |
| 492.775 | 14430.2 | 1.5 | 217361.9 | 1.5 | 0.029 | 0.056* | 0.027 |
| 492.857 | 22919.6 | 3.5 | 225818.9 | 3.5 | 0.096 | 0.127* | 0.071 |
| 494.335 | 24028.4 | 4.5 | 226320.5 | 5.5 | 0.289 | 0.246 | 0.228 |
| 494.985 | 14678.3 | 4.5 | 216704.6 | 3.5 | 0.547 | 0.566* | 0.527 |
| 495.131 | 14430.2 | 1.5 | 216397.1 | 2.5 | 0.129 | 0.139 | 0.137 |
| 495.562 | 24028.4 | 4.5 | 225818.9 | 3.5 | 0.116 | 0.191* | 0.341 |
| 497.635 | 6397.4 | 2.5 | 207349.5 | 1.5 | 0.162 | 0.151* | 0.057 |
| 497.671 | 6397.4 | 2.5 | 207333.9 | 2.5 | 0.114 | 0.112 | 0.135 |
| 498.279 | 14678.3 | 4.5 | 215369.6 | 4.5 | 0.496 | 0.567 | 0.660 |
| 498.536 | 16772.4 | 0.5 | 217361.9 | 1.5 | 0.083 | 0.094 | 0.064 |
| 499.892 | 27894.0 | 1.5 | 227935.6 | 2.5 | 0.116 | 0.128* | 0.137 |
| 500.108 | 14430.2 | 1.5 | 214387.4 | 2.5 | 0.103 | 0.062* | 0.090 |
| 500.511 | 6397.4 | 2.5 | 206193.4 | 3.5 | 0.141 | 0.167 | 0.027 |
| 502.478 | 22919.6 | 3.5 | 221932.2 | 4.5 | 0.078 | 0.108 | 0.047 |
| 503.144 | 34417.8 | 2.5 | 233168.5 | 2.5 | 0.187 | 0.210* | 0.090 |
| 504.230 | 6397.4 | 2.5 | 204720.9 | 2.5 | 0.029 | 0.050* | 0.025 |
| 504.684 | 0.0 | 1.5 | 198144.3 | 0.5 | 0.262 | 0.253 | 0.099** |
| 505.302 | 24028.4 | 4.5 | 221932.2 | 4.5 | 0.162 | 0.180* | 0.094 |
| 505.501 | 22919.6 | 3.5 | 220744.9 | 2.5 | 0.056 | 0.082* | 0.056 |
| 506.123 | 34417.8 | 2.5 | 231998.6 | 1.5 | 0.157 | 0.190* | 0.147 |
| 508.462 | 6397.4 | 2.5 | 203069.9 | 3.5 | 0.188 | 0.147 | 0.228 |
| 509.134 | 40202.6 | 1.5 | 236614.5 | 0.5 | 0.038 | 0.084* | 0.033 |
| 509.800 | 0.0 | 1.5 | 196152.8 | 2.5 | 0.050 | 0.050* | 0.010 |
| 509.914 | 27894.0 | 1.5 | 224004.9 | 0.5 | 0.507 | 0.538 | 0.524 |
| 510.425 | 24828.5 | 2.5 | 220744.9 | 2.5 | 0.123 | 0.168 | 0.137 |
| 510.492 | 11444.1 | 3.5 | 207333.9 | 2.5 | 0.312 | 0.382 | 0.423 |
| 510.947 | 0.0 | 1.5 | 195716.1 | 1.5 | 0.130 | 0.131 | 0.184 |
| 511.593 | 14678.3 | 4.5 | 210146.1 | 5.5 | 0.758 | 0.667 | 0.749 |
| 512.354 | 14678.3 | 4.5 | 209856.0 | 3.5 | 0.414 | 0.462* | 0.805 |
| 512.442 | 28859.8 | 0.5 | 224004.9 | 0.5 | 0.061 | 0.062 | 0.108 |

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|---|---|---|---|---|---|---|---|
| 512.534 | 11444.1 | 3.5 | 206555.3 | 4.5 | 0.035 | 0.031* | 0.074 |
| 513.482 | 11444.1 | 3.5 | 206193.4 | 3.5 | 0.588 | 0.683 | 0.319 |
| 513.684 | 24828.5 | 2.5 | 219500.4 | 1.5 | 0.137 | 0.123 | 0.135 |
| 514.766 | 0.0 | 1.5 | 194263.2 | 1.5 | 0.071 | 0.087* | 0.104** |
| 515.025 | 32155.8 | 5.5 | 226320.5 | 5.5 | 3.680 | 3.780 | 3.759 |
| 516.033 | 22919.6 | 3.5 | 216704.6 | 3.5 | 0.081 | 0.083* | 0.053 |
| 516.617 | 39600.8 | 2.5 | 233168.5 | 2.5 | 0.978 | 0.998 | 1.224 |
| 516.749 | 34417.8 | 2.5 | 227935.6 | 2.5 | 0.503 | 0.532 | 0.666 |
| 516.858 | 22919.6 | 3.5 | 216397.1 | 2.5 | 0.078 | 0.119 | 0.093 |
| 517.396 | 11444.1 | 3.5 | 204720.9 | 2.5 | 0.082 | 0.039* | 0.146** |
| 518.539 | 27894.0 | 1.5 | 220744.9 | 2.5 | 0.183 | 0.152* | 0.141 |
| 518.885 | 40447.0 | 3.5 | 233168.5 | 2.5 | 0.105 | 0.113* | 0.031 |
| 519.756 | 39600.8 | 2.5 | 231998.6 | 1.5 | 0.299 | 0.339 | 0.289 |
| 520.051 | 59910.8 | 1.5 | 252203.4 | 1.5 | 0.294 | 0.265 | 0.227 |
| 520.597 | 0.0 | 1.5 | 192087.9 | 0.5 | 0.239 | 0.227 | 0.282 |
| 521.169 | 14678.3 | 4.5 | 206555.3 | 4.5 | 0.925 | 0.848 | 0.580 |
| 521.386 | 40202.6 | 1.5 | 231998.6 | 1.5 | 0.933 | 0.756 | 0.746 |
| 521.858 | 11444.1 | 3.5 | 203069.9 | 3.5 | 0.343 | 0.250 | 0.593 |
| 522.008 | 24828.5 | 2.5 | 216397.1 | 2.5 | 1.520 | 1.590 | 1.560 |
| 522.152 | 0.0 | 1.5 | 191516.9 | 2.5 | 0.158 | 0.147 | 0.156 |
| 522.282 | 22919.6 | 3.5 | 214387.4 | 2.5 | 0.268 | 0.246 | 0.239 |
| 522.466 | 34417.8 | 2.5 | 225818.9 | 3.5 | 0.244 | 0.248 | 0.263 |
| 522.631 | 24028.4 | 4.5 | 215369.6 | 4.5 | 0.424 | 0.524 | 0.297** |
| 522.911 | 37019.4 | 4.5 | 228256.2 | 3.5 | 0.876 | 1.360 | 1.264 |
| 523.020 | 61005.3 | 2.5 | 252203.4 | 1.5 | 1.960 | 1.880 | 1.819 |
| 523.232 | 28859.8 | 0.5 | 219979.0 | 0.5 | 0.099 | 0.071* | 0.048 |
| 523.595 | 0.0 | 1.5 | 190987.8 | 1.5 | 0.099 | 0.071* | 0.126 |
| 524.721 | 16772.4 | 0.5 | 207349.5 | 1.5 | 0.072 | 0.059* | 0.090 |
| 525.512 | 14430.2 | 1.5 | 204720.9 | 2.5 | 0.262 | 0.252 | 0.279 |
| 526.939 | 32155.8 | 5.5 | 221932.2 | 4.5 | 0.841 | 0.559 | 1.437 |
| 526.999 | 6397.4 | 2.5 | 196152.8 | 2.5 | 0.038 | 0.101* | 0.0003 |
| 528.211 | 6397.4 | 2.5 | 195716.1 | 1.5 | 1.060 | 1.280 | 0.907 |
| 529.270 | 16772.4 | 0.5 | 205711.8 | 1.5 | 0.132 | 0.117 | 0.120 |
| 529.661 | 37019.4 | 4.5 | 225818.9 | 3.5 | 7.410 | 6.770 | 6.104 |
| 530.070 | 39600.8 | 2.5 | 228256.2 | 3.5 | 0.074 | 0.087* | 0.078 |
| 530.507 | 28859.8 | 0.5 | 217361.9 | 1.5 | 0.024 | 0.015* | 0.017** |
| 530.811 | 14678.3 | 4.5 | 203069.9 | 3.5 | 0.501 | 0.339 | 0.241 |
| 530.969 | 39600.8 | 2.5 | 227935.6 | 2.5 | 0.472 | 0.476 | 0.230 |
| 532.296 | 6397.4 | 2.5 | 194263.2 | 1.5 | 1.060 | 0.858 | 1.045 |
| 532.456 | 40447.0 | 3.5 | 228256.2 | 3.5 | 1.630 | 1.490 | 1.794 |
| 532.675 | 40202.6 | 1.5 | 227935.6 | 2.5 | 0.254 | 0.259 | 0.179** |

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|---|---|---|---|---|---|---|---|
| 533.093 | 14678.3 | 4.5 | 202263.2 | 4.5 | 1.920 | 1.830 | 2.568 |
| 533.367 | 40447.0 | 3.5 | 227935.6 | 2.5 | 0.654 | 0.710 | 0.849 |
| 535.179 | 0.0 | 1.5 | 186854.0 | 0.5 | 1.240 | 1.210 | 1.448 |
| 535.318 | 24828.5 | 2.5 | 211634.7 | 1.5 | 1.950 | 1.800 | 1.887 |
| 536.215 | 27894.0 | 1.5 | 214387.4 | 2.5 | 0.236 | 0.269 | 0.289** |
| 536.691 | 34417.8 | 2.5 | 220744.9 | 2.5 | 0.098 | 0.050* | 0.143 |
| 537.011 | 39600.8 | 2.5 | 225818.9 | 3.5 | 0.023 | 0.019* | 0.018 |
| 537.119 | 6397.4 | 2.5 | 192575.6 | 3.5 | 0.151 | 0.159 | 0.203 |
| 537.294 | 24028.4 | 4.5 | 210146.1 | 5.5 | 0.217 | 0.197 | 0.140** |
| 538.138 | 24028.4 | 4.5 | 209856.0 | 3.5 | 6.290 | 6.080 | 6.008 |
| 538.532 | 11444.1 | 3.5 | 197134.0 | 3.5 | 0.459 | 0.570 | 0.406 |
| 539.465 | 40447.0 | 3.5 | 225818.9 | 3.5 | 0.093 | 0.210 | 0.123 |
| 540.191 | 6397.4 | 2.5 | 191516.9 | 2.5 | 1.560 | 1.330 | 1.583 |
| 540.457 | 24828.5 | 2.5 | 209856.0 | 3.5 | 0.280 | 0.205 | 0.271 |
| 540.795 | 37019.4 | 4.5 | 221932.2 | 4.5 | 4.350 | 4.350 | 3.921 |
| 541.393 | 11444.1 | 3.5 | 196152.8 | 2.5 | 4.690 | 4.280 | 4.746 |
| 541.741 | 6397.4 | 2.5 | 190987.8 | 1.5 | 1.170 | 1.010 | 1.529 |
| 542.260 | 22919.6 | 3.5 | 207333.9 | 2.5 | 4.840 | 4.810 | 4.262 |
| 542.911 | 27894.0 | 1.5 | 212086.5 | 0.5 | 0.486 | 0.480 | 0.544 |
| 543.383 | 0.0 | 1.5 | 184033.0 | 2.5 | 0.211 | 0.195 | 0.256 |
| 544.063 | 40202.6 | 1.5 | 224004.9 | 0.5 | 0.427 | 0.502 | 0.242 |
| 544.249 | 27894.0 | 1.5 | 211634.7 | 1.5 | 0.028 | 0.047* | 0.008 |
| 544.324 | 14430.2 | 1.5 | 198144.3 | 0.5 | 0.172 | 0.153 | 0.117 |
| 544.555 | 22919.6 | 3.5 | 206555.3 | 4.5 | 0.160 | 0.088* | 0.198 |
| 545.629 | 22919.6 | 3.5 | 206193.4 | 3.5 | 0.147 | 0.265 | 0.138 |
| 545.771 | 28859.8 | 0.5 | 212086.5 | 0.5 | 0.859 | 0.812 | 0.781 |
| 545.809 | 32155.8 | 5.5 | 215369.6 | 4.5 | 11.100 | 10.030 | 10.048 |
| 546.616 | 34417.8 | 2.5 | 217361.9 | 1.5 | 2.110 | 2.140 | 1.978 |
| 547.126 | 28859.8 | 0.5 | 211634.7 | 1.5 | 0.112 | 0.124 | 0.104 |
| 547.863 | 24028.4 | 4.5 | 206555.3 | 4.5 | 3.710 | 3.340 | 3.974 |
| 548.078 | 14678.3 | 4.5 | 197134.0 | 3.5 | 5.150 | 4.870 | 4.651 |
| 548.589 | 34417.8 | 2.5 | 216704.6 | 3.5 | 0.346 | 0.318 | 0.229 |
| 548.954 | 24028.4 | 4.5 | 206193.4 | 3.5 | 2.290 | 1.820 | 1.889 |
| 549.515 | 34417.8 | 2.5 | 216397.1 | 2.5 | 0.189 | 0.274 | 0.276 |
| 550.051 | 22919.6 | 3.5 | 204720.9 | 2.5 | 0.410 | 0.113* | 0.827 |
| 550.291 | 14430.2 | 1.5 | 196152.8 | 2.5 | 0.160 | 0.112* | 0.058 |
| 551.011 | 40447.0 | 3.5 | 221932.2 | 4.5 | 0.604 | 0.448 | 0.470 |
| 551.358 | 16772.4 | 0.5 | 198144.3 | 0.5 | 0.675 | 0.638 | 0.632 |
| 551.616 | 14430.2 | 1.5 | 195716.1 | 1.5 | 0.801 | 0.530 | 1.020 |
| 552.086 | 11444.1 | 3.5 | 192575.6 | 3.5 | 3.200 | 2.870 | 3.444 |
| 552.843 | 24828.5 | 2.5 | 205711.8 | 1.5 | 0.396 | 0.271 | 0.316 |

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|---|---|---|---|---|---|---|---|
| 553.893 | 40202.6 | 1.5 | 220744.9 | 2.5 | 0.635 | 0.569 | 0.484 |
| 554.642 | 40447.0 | 3.5 | 220744.9 | 2.5 | 6.130 | 2.860 | 3.099 |
| 555.091 | 22919.6 | 3.5 | 203069.9 | 3.5 | 3.530 | 3.270 | 3.614 |
| 555.333 | 11444.1 | 3.5 | 191516.9 | 2.5 | 0.117 | 0.242 | 0.014** |
| 555.652 | 34417.8 | 2.5 | 214387.4 | 2.5 | 1.820 | 1.410 | 1.336 |
| 555.870 | 39600.8 | 2.5 | 219500.4 | 1.5 | 2.580 | 2.450 | 2.650 |
| 556.072 | 14430.2 | 1.5 | 194263.2 | 1.5 | 1.150 | 1.160 | 0.785 |
| 556.247 | 40202.6 | 1.5 | 219979.0 | 0.5 | 1.240 | 1.070 | 1.429 |
| 556.528 | 37019.4 | 4.5 | 216704.6 | 3.5 | 1.100 | 0.961 | 1.503 |
| 557.245 | 27894.0 | 1.5 | 207349.5 | 1.5 | 1.340 | 1.240 | 1.061 |
| 557.294 | 11444.1 | 3.5 | 190882.5 | 4.5 | 0.900 | 0.808 | 0.954 |
| 557.590 | 22919.6 | 3.5 | 202263.2 | 4.5 | 0.303 | 0.261 | 0.165 |
| 557.732 | 40202.6 | 1.5 | 219500.4 | 1.5 | 0.254 | 0.268 | 0.206 |
| 558.528 | 24028.4 | 4.5 | 203069.9 | 3.5 | 0.094 | 0.261* | 0.095 |
| 558.833 | 16772.4 | 0.5 | 195716.1 | 1.5 | 0.608 | 0.468 | 0.523 |
| 560.257 | 28859.8 | 0.5 | 207349.5 | 1.5 | 0.513 | 0.455 | 0.537 |
| 560.695 | 37019.4 | 4.5 | 215369.6 | 4.5 | 0.698 | 0.487 | 0.885 |
| 561.057 | 24028.4 | 4.5 | 202263.2 | 4.5 | 0.179 | 0.254 | 0.080 |
| 561.828 | 32155.8 | 5.5 | 210146.1 | 5.5 | 0.310 | 0.322 | 0.249 |
| 562.123 | 14678.3 | 4.5 | 192575.6 | 3.5 | 0.652 | 0.808 | 0.682 |
| 562.374 | 27894.0 | 1.5 | 205711.8 | 1.5 | 1.400 | 1.160 | 1.523 |
| 562.550 | 39600.8 | 2.5 | 217361.9 | 1.5 | 0.877 | 0.761 | 0.641 |
| 562.880 | 14430.2 | 1.5 | 192087.9 | 0.5 | 0.752 | 0.762 | 0.866 |
| 562.950 | 6397.4 | 2.5 | 184033.0 | 2.5 | 2.000 | 1.900 | 2.145 |
| 563.407 | 16772.4 | 0.5 | 194263.2 | 1.5 | 0.293 | 0.222 | 0.408 |
| 564.282 | 34417.8 | 2.5 | 211634.7 | 1.5 | 0.068 | 0.055 | 0.112 |
| 564.465 | 40202.6 | 1.5 | 217361.9 | 1.5 | 0.397 | 0.343 | 0.425 |
| 564.695 | 14430.2 | 1.5 | 191516.9 | 2.5 | 0.209 | 0.230 | 0.303 |
| 565.448 | 28859.8 | 0.5 | 205711.8 | 1.5 | 0.696 | 0.667 | 0.628 |
| 565.524 | 27894.0 | 1.5 | 204720.9 | 2.5 | 0.881 | 0.764 | 0.782 |
| 565.625 | 39600.8 | 2.5 | 216397.1 | 2.5 | 0.021 | 0.014* | 0.012** |
| 565.919 | 59910.8 | 1.5 | 236614.5 | 0.5 | 1.780 | 1.660 | 1.729 |
| 566.387 | 14430.2 | 1.5 | 190987.8 | 1.5 | 0.343 | 0.301 | 0.367 |
| 567.352 | 40447.0 | 3.5 | 216704.6 | 3.5 | 1.920 | 1.930 | 1.631 |
| 567.522 | 14678.3 | 4.5 | 190882.5 | 4.5 | 2.580 | 2.360 | 2.380 |
| 567.916 | 6397.4 | 2.5 | 182479.5 | 3.5 | 0.853 | 0.757 | 0.858 |
| 568.343 | 40447.0 | 3.5 | 216397.1 | 2.5 | 0.127 | 0.203 | 0.173 |
| 568.698 | 0.0 | 1.5 | 175839.8 | 1.5 | 2.420 | 2.230 | 2.477 |
| 570.000 | 34417.8 | 2.5 | 209856.0 | 3.5 | 0.550 | 0.449 | 0.443 |
| 570.398 | 16772.4 | 0.5 | 192087.9 | 0.5 | 0.077 | 0.092 | 0.076 |
| 571.674 | 40447.0 | 3.5 | 215369.6 | 4.5 | 0.221 | 0.105* | 0.071 |

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|---|---|---|---|---|---|---|---|
| 572.123 | 39600.8 | 2.5 | 214387.4 | 2.5 | 0.127 | 0.138 | 0.064 |
| 573.395 | 32155.8 | 5.5 | 206555.3 | 4.5 | 1.590 | 1.900 | 1.534 |
| 574.005 | 16772.4 | 0.5 | 190987.8 | 1.5 | 0.567 | 0.628 | 0.510 |
| 574.102 | 40202.6 | 1.5 | 214387.4 | 2.5 | 0.648 | 0.668 | 0.743 |
| 574.909 | 40447.0 | 3.5 | 214387.4 | 2.5 | 0.743 | 0.614 | 0.423 |
| 577.176 | 59910.8 | 1.5 | 233168.5 | 2.5 | 0.611 | 0.514 | 0.701 |
| 577.256 | 22919.6 | 3.5 | 196152.8 | 2.5 | 0.532 | 0.548 | 0.768 |
| 577.615 | 37019.4 | 4.5 | 210146.1 | 5.5 | 0.060 | 0.061 | 0.050** |
| 577.679 | 24028.4 | 4.5 | 197134.0 | 3.5 | 0.505 | 0.591 | 1.002 |
| 578.313 | 34417.8 | 2.5 | 207333.9 | 2.5 | 0.300 | 0.220 | 0.404 |
| 578.587 | 37019.4 | 4.5 | 209856.0 | 3.5 | 0.038 | 0.067* | 0.125 |
| 579.963 | 14430.2 | 1.5 | 186854.0 | 0.5 | 0.029 | 0.040* | 0.036 |
| 580.367 | 24828.5 | 2.5 | 197134.0 | 3.5 | 0.437 | 0.267 | 0.387 |
| 580.846 | 61005.3 | 2.5 | 233168.5 | 2.5 | 1.640 | 1.590 | 1.346 |
| 581.097 | 59910.8 | 1.5 | 231998.6 | 1.5 | 0.548 | 0.469 | 0.475 |
| 581.288 | 39600.8 | 2.5 | 211634.7 | 1.5 | 0.050 | 0.050* | 0.040 |
| 582.154 | 34417.8 | 2.5 | 206193.4 | 3.5 | 0.565 | 0.513 | 0.657 |
| 583.320 | 40202.6 | 1.5 | 211634.7 | 1.5 | 0.042 | 0.038* | 0.051 |
| 583.687 | 24828.5 | 2.5 | 196152.8 | 2.5 | 0.291 | 0.234 | 0.286 |
| 583.789 | 34417.8 | 2.5 | 205711.8 | 1.5 | 0.584 | 0.548 | 0.670 |
| 584.673 | 11444.1 | 3.5 | 182479.5 | 3.5 | 0.231 | 0.176 | 0.190 |
| 584.818 | 61005.3 | 2.5 | 231998.6 | 1.5 | 1.500 | 1.270 | 1.351 |
| 585.178 | 24828.5 | 2.5 | 195716.1 | 1.5 | 0.620 | 0.452 | 0.581 |
| 586.602 | 0.0 | 1.5 | 170473.6 | 2.5 | 0.549 | 0.506 | 0.554 |
| 587.188 | 34417.8 | 2.5 | 204720.9 | 2.5 | 0.152 | 0.165 | 0.072 |
| 587.361 | 39600.8 | 2.5 | 209856.0 | 3.5 | 0.121 | 0.055* | 0.113 |
| 587.866 | 32155.8 | 5.5 | 202263.2 | 4.5 | 0.022 | 0.046* | 0.038 |
| 587.954 | 16772.4 | 0.5 | 186854.0 | 0.5 | 0.122 | 0.091 | 0.140 |
| 589.432 | 22919.6 | 3.5 | 192575.6 | 3.5 | 0.037 | 0.044* | 0.056 |
| 589.611 | 14430.2 | 1.5 | 184033.0 | 2.5 | 0.925 | 0.867 | 0.923 |
| 590.172 | 6397.4 | 2.5 | 175839.8 | 1.5 | 0.014 | 0.008* | 0.015** |
| 590.286 | 40447.0 | 3.5 | 209856.0 | 3.5 | 0.111 | 0.065* | 0.094 |
| 591.104 | 37019.4 | 4.5 | 206193.4 | 3.5 | 0.368 | 0.305* | 0.503 |
| 593.126 | 22919.6 | 3.5 | 191516.9 | 2.5 | 0.049 | 0.093* | 0.021 |
| 595.148 | 59910.8 | 1.5 | 227935.6 | 2.5 | 0.705 | 0.620 | 0.498 |
| 595.942 | 14678.3 | 4.5 | 182479.5 | 3.5 | 0.343 | 0.373 | 0.320 |
| 596.136 | 24828.5 | 2.5 | 192575.6 | 3.5 | 1.090 | 1.010 | 1.056 |
| 596.188 | 39600.8 | 2.5 | 207333.9 | 2.5 | 0.575 | 0.577 | 0.473 |
| 597.903 | 61005.3 | 2.5 | 228256.2 | 3.5 | 1.260 | 1.140 | 1.182 |
| 599.206 | 40447.0 | 3.5 | 207333.9 | 2.5 | 0.192 | 0.163 | 0.275 |
| 599.325 | 24028.4 | 4.5 | 190882.5 | 4.5 | 0.028 | 0.037* | 0.100 |

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|---|---|---|---|---|---|---|---|
| 599.927 | 24828.5 | 2.5 | 191516.9 | 2.5 | 0.031 | 0.040 | 0.013 |
| 600.264 | 39600.8 | 2.5 | 206193.4 | 3.5 | 0.249 | 0.114 | 0.477 |
| 601.066 | 27894.0 | 1.5 | 194263.2 | 1.5 | 0.047 | 0.042* | 0.050 |
| 601.826 | 24828.5 | 2.5 | 190987.8 | 1.5 | 0.045 | 0.042* | 0.033 |
| 602.006 | 39600.8 | 2.5 | 205711.8 | 1.5 | 0.060 | 0.059 | 0.042 |
| 602.225 | 37019.4 | 4.5 | 203069.9 | 3.5 | 0.027 | 0.056* | 0.014 |
| 603.331 | 40447.0 | 3.5 | 206193.4 | 3.5 | 0.317 | 0.318 | 0.309 |
| 604.200 | 40202.6 | 1.5 | 205711.8 | 1.5 | 0.031 | 0.023* | 0.031 |
| 604.580 | 28859.8 | 0.5 | 194263.2 | 1.5 | 0.051 | 0.058 | 0.071 |
| 605.160 | 37019.4 | 4.5 | 202263.2 | 4.5 | 0.035 | 0.024* | 0.059 |
| 606.743 | 61005.3 | 2.5 | 225818.9 | 3.5 | 0.229 | 0.077* | 0.072 |
| 607.834 | 40202.6 | 1.5 | 204720.9 | 2.5 | 0.345 | 0.342 | 0.354 |
| 608.738 | 40447.0 | 3.5 | 204720.9 | 2.5 | 0.318 | 0.376 | 0.254 |
| 609.409 | 59910.8 | 1.5 | 224004.9 | 0.5 | 0.114 | 0.082* | 0.171 |
| 611.164 | 27894.0 | 1.5 | 191516.9 | 2.5 | 0.083 | 0.081 | 0.090 |
| 611.734 | 39600.8 | 2.5 | 203069.9 | 3.5 | 0.721 | 0.696 | 0.377 |
| 612.637 | 28859.8 | 0.5 | 192087.9 | 0.5 | 0.076 | 0.066 | 0.102 |
| 614.914 | 40447.0 | 3.5 | 203069.9 | 3.5 | 0.022 | 0.020* | 0.014** |
| 616.793 | 28859.8 | 0.5 | 190987.8 | 1.5 | 0.114 | 0.102 | 0.138 |
| 617.982 | 40447.0 | 3.5 | 202263.2 | 4.5 | 0.161 | 0.145 | 0.121** |
| 619.542 | 14430.2 | 1.5 | 175839.8 | 1.5 | 0.150 | 0.141 | 0.174 |
| 621.766 | 59910.8 | 1.5 | 220744.9 | 2.5 | 0.173 | 0.140 | 0.090 |
| 624.732 | 59910.8 | 1.5 | 219979.0 | 0.5 | 0.151 | 0.154 | 0.090 |
| 626.020 | 61005.3 | 2.5 | 220744.9 | 2.5 | 0.299 | 0.249 | 0.278 |
| 626.604 | 59910.8 | 1.5 | 219500.4 | 1.5 | 0.190 | 0.162 | 0.140 |
| 626.728 | 22919.6 | 3.5 | 182479.5 | 3.5 | 0.057 | 0.051 | 0.063 |
| 628.126 | 24828.5 | 2.5 | 184033.0 | 2.5 | 0.096 | 0.094 | 0.103 |
| 628.665 | 16772.4 | 0.5 | 175839.8 | 1.5 | 0.049 | 0.043 | 0.060 |
| 628.813 | 11444.1 | 3.5 | 170473.6 | 2.5 | 0.018 | 0.017* | 0.019 |
| 630.014 | 32155.8 | 5.5 | 190882.5 | 4.5 | 0.199 | 0.261 | 0.325 |
| 630.939 | 61005.3 | 2.5 | 219500.4 | 1.5 | 0.089 | 0.074* | 0.096 |
| 631.109 | 24028.4 | 4.5 | 182479.5 | 3.5 | 0.087 | 0.111 | 0.165 |
| 632.927 | 28859.8 | 0.5 | 186854.0 | 0.5 | 0.027 | 0.027 | 0.033 |
| 634.307 | 24828.5 | 2.5 | 182479.5 | 3.5 | 0.009 | 0.012 | 0.011 |
| 634.787 | 39600.8 | 2.5 | 197134.0 | 3.5 | 0.043 | 0.046 | 0.050** |
| 635.136 | 59910.8 | 1.5 | 217361.9 | 1.5 | 0.024 | 0.031* | 0.038 |
| 636.534 | 34417.8 | 2.5 | 191516.9 | 2.5 | 0.043 | 0.034* | 0.047 |
| 638.219 | 40447.0 | 3.5 | 197134.0 | 3.5 | 0.100 | 0.074 | 0.114 |
| 638.698 | 34417.8 | 2.5 | 190987.8 | 1.5 | 0.070 | 0.066 | 0.087 |
| 638.764 | 39600.8 | 2.5 | 196152.8 | 2.5 | 0.175 | 0.167 | 0.170 |
| 639.568 | 61005.3 | 2.5 | 217361.9 | 1.5 | 0.034 | 0.032* | 0.039 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 640.549 | 39600.8 | 2.5 | 195716.1 | 1.5 | 0.124 | 0.138 | 0.156 |
| 640.848 | 14430.2 | 1.5 | 170473.6 | 2.5 | 0.052 | 0.052 | 0.063 |
| 646.570 | 39600.8 | 2.5 | 194263.2 | 1.5 | 0.023 | 0.029* | 0.016 |
| 647.344 | 59910.8 | 1.5 | 214387.4 | 2.5 | 0.016 | 0.012* | 0.012 |
| 649.097 | 40202.6 | 1.5 | 194263.2 | 1.5 | 0.006 | 0.004* | 0.004 |
| 649.931 | 37019.4 | 4.5 | 190882.5 | 4.5 | 0.078 | 0.074* | 0.085 |
| 658.393 | 40202.6 | 1.5 | 192087.9 | 0.5 | 0.040 | 0.039 | 0.055 |
| 661.943 | 40447.0 | 3.5 | 191516.9 | 2.5 | 0.009 | 0.014* | 0.008 |
| 664.738 | 40447.0 | 3.5 | 190882.5 | 4.5 | 0.048 | 0.041 | 0.043** |
| 668.385 | 34417.8 | 2.5 | 184033.0 | 2.5 | 0.046 | 0.040* | 0.058 |
| 675.399 | 34417.8 | 2.5 | 182479.5 | 3.5 | 0.019 | 0.015* | 0.017** |
| 686.606 | 24828.5 | 2.5 | 170473.6 | 2.5 | 0.005 | 0.005* | 0.005 |
| 695.257 | 40202.6 | 1.5 | 184033.0 | 2.5 | 0.011 | 0.011* | 0.015 |
| 696.443 | 40447.0 | 3.5 | 184033.0 | 2.5 | 0.016 | 0.011* | 0.016 |
| 701.360 | 27894.0 | 1.5 | 170473.6 | 2.5 | 0.029 | 0.026 | 0.032 |
| 704.066 | 40447.0 | 3.5 | 182479.5 | 3.5 | 0.031 | 0.031 | 0.037 |
| 764.104 | 39600.8 | 2.5 | 170473.6 | 2.5 | 0.025 | 0.023 | 0.028 |
| 823.207 | 61005.3 | 2.5 | 182479.5 | 3.5 | 0.007 | 0.007* | 0.006 |
| 940.059 | 100973.9 | 2.5 | 207349.5 | 1.5 | 0.342 | 0.262 | 0.337 |
| 944.741 | 108538.4 | 3.5 | 214387.4 | 2.5 | 0.258 | 0.194 | 0.259 |
| 958.446 | 123600.5 | 3.5 | 227935.6 | 2.5 | 0.500 | 0.302 | 0.420 |
| 975.001 | 114140.1 | 2.5 | 216704.6 | 3.5 | 0.192 | 0.134 | 0.129 |
| 977.922 | 114140.1 | 2.5 | 216397.1 | 2.5 | 0.236 | 0.175 | 0.190 |
| 984.931 | 115173.8 | 4.5 | 216704.6 | 3.5 | 0.512 | 0.354 | 0.426 |
| 986.987 | 108538.4 | 3.5 | 209856.0 | 3.5 | 0.389 | 0.362 | 0.388 |
| 997.955 | 97940.4 | 1.5 | 198144.3 | 0.5 | 0.585 | 0.423 | 0.515 |
| 998.040 | 115173.8 | 4.5 | 215369.6 | 4.5 | 1.040 | 0.870 | 1.066 |
| 998.213 | 132989.9 | 3.5 | 233168.5 | 2.5 | 1.580 | 1.030 | 1.661 |
| 1012.199 | 108538.4 | 3.5 | 207333.9 | 2.5 | 0.143 | 0.157 | 0.113 |
| 1018.199 | 97940.4 | 1.5 | 196152.8 | 2.5 | 0.457 | 0.388 | 0.343 |
| 1018.614 | 138441.2 | 1.5 | 236614.5 | 0.5 | 0.166 | 0.119 | 0.141 |
| 1020.229 | 108538.4 | 3.5 | 206555.3 | 4.5 | 0.759 | 0.632 | 0.324 |
| 1021.475 | 118499.8 | 1.5 | 216397.1 | 2.5 | 1.360 | 0.894 | 1.236 |
| 1024.015 | 108538.4 | 3.5 | 206193.4 | 3.5 | 0.306 | 0.282 | 0.053 |
| 1026.422 | 123318.6 | 1.5 | 220744.9 | 2.5 | 0.583 | 0.392 | 0.589 |
| 1026.617 | 130849.6 | 4.5 | 228256.2 | 3.5 | 1.120 | 0.729 | 1.187 |
| 1028.050 | 114363.2 | 0.5 | 211634.7 | 1.5 | 0.792 | 0.561 | 0.769 |
| 1029.397 | 123600.5 | 3.5 | 220744.9 | 2.5 | 0.714 | 0.394 | 0.478 |
| 1034.565 | 123318.6 | 1.5 | 219979.0 | 0.5 | 0.253 | 0.179 | 0.237 |
| 1035.410 | 131676.2 | 2.5 | 228256.2 | 3.5 | 0.573 | 0.268 | 0.333 |
| 1038.184 | 97940.4 | 1.5 | 194263.2 | 1.5 | 0.838 | 0.617 | 0.833 |

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|---|---|---|---|---|---|---|---|
| 1038.864 | 131676.2 | 2.5 | 227935.6 | 2.5 | 0.662 | 0.419 | 0.630 |
| 1039.709 | 123318.6 | 1.5 | 219500.0 | 1.5 | 0.203 | 0.076 | 0.051 |
| 1039.943 | 100973.9 | 2.5 | 197134.0 | 3.5 | 1.500 | 1.140 | 1.435** |
| 1047.439 | 130849.6 | 4.5 | 226320.5 | 5.5 | 3.760 | 2.580 | 3.576** |
| 1049.695 | 132989.9 | 3.5 | 228256.2 | 3.5 | 0.833 | 0.688 | 0.945 |
| 1050.652 | 100973.9 | 2.5 | 196152.8 | 2.5 | 0.568 | 0.469 | 0.507 |
| 1052.939 | 115173.8 | 4.5 | 210146.1 | 5.5 | 3.670 | 2.670 | 3.612** |
| 1053.231 | 132989.9 | 3.5 | 227935.6 | 2.5 | 0.276 | 0.188 | 0.167 |
| 1054.694 | 157388.9 | 0.5 | 252203.4 | 1.5 | 1.190 | 0.801 | 1.177 |
| 1055.665 | 138441.2 | 1.5 | 233168.5 | 2.5 | 0.327 | 0.180 | 0.200 |
| 1056.151 | 115173.8 | 4.5 | 209856.0 | 3.5 | 0.345 | 0.247 | 0.403 |
| 1057.849 | 108538.4 | 3.5 | 203069.9 | 3.5 | 0.483 | 0.264 | 0.726 |
| 1062.219 | 131676.2 | 2.5 | 225818.9 | 3.5 | 1.730 | 1.390 | 1.944** |
| 1063.333 | 123318.6 | 1.5 | 217361.9 | 1.5 | 0.733 | 0.461 | 0.742 |
| 1066.956 | 108538.4 | 3.5 | 202263.2 | 4.5 | 1.890 | 1.310 | 2.232** |
| 1068.531 | 118499.8 | 1.5 | 212086.5 | 0.5 | 0.335 | 0.240 | 0.333 |
| 1068.647 | 97940.4 | 1.5 | 191516.9 | 2.5 | 0.382 | 0.230 | 0.477** |
| 1068.864 | 138441.2 | 1.5 | 231998.6 | 1.5 | 1.140 | 0.655 | 1.028 |
| 1071.936 | 100973.9 | 2.5 | 194263.2 | 1.5 | 0.138 | 0.085 | 0.126 |
| 1072.848 | 114140.1 | 2.5 | 207349.5 | 1.5 | 0.603 | 0.406 | 0.569 |
| 1074.069 | 123600.5 | 3.5 | 216704.6 | 3.5 | 0.471 | 0.388 | 0.436 |
| 1075.424 | 114363.2 | 0.5 | 207349.5 | 1.5 | 0.102 | 0.084 | 0.102 |
| 1077.246 | 132989.9 | 3.5 | 225818.9 | 3.5 | 0.501 | 0.279 | 0.341 |
| 1086.336 | 114140.1 | 2.5 | 206193.4 | 3.5 | 1.030 | 0.742 | 0.605** |
| 1089.694 | 123600.5 | 3.5 | 215369.6 | 4.5 | 1.510 | 1.030 | 1.418** |
| 1094.314 | 115173.8 | 4.5 | 206555.3 | 4.5 | 0.490 | 0.329 | 0.482 |
| 1098.083 | 123318.6 | 1.5 | 214387.4 | 2.5 | 0.276 | 0.202 | 0.231 |
| 1098.651 | 115173.8 | 4.5 | 206193.4 | 3.5 | 0.012 | 0.011* | 0.019 |
| 1101.487 | 123600.5 | 3.5 | 214387.4 | 2.5 | 0.517 | 0.352 | 0.578 |
| 1103.982 | 114140.1 | 2.5 | 204720.9 | 2.5 | 0.366 | 0.186 | 0.482 |
| 1104.445 | 100973.9 | 2.5 | 191516.9 | 2.5 | 0.237 | 0.126 | 0.316 |
| 1117.393 | 138441.2 | 1.5 | 227935.6 | 2.5 | 0.387 | 0.267 | 0.478 |
| 1122.731 | 131676.2 | 2.5 | 220744.9 | 2.5 | 0.343 | 0.235 | 0.414 |
| 1124.334 | 132989.9 | 3.5 | 221932.2 | 4.5 | 1.320 | 0.942 | 1.365** |
| 1124.487 | 114140.1 | 2.5 | 203069.9 | 3.5 | 0.146 | 0.069 | 0.532** |
| 1126.533 | 123318.6 | 1.5 | 212086.5 | 0.5 | 0.119 | 0.091 | 0.126 |
| 1141.380 | 108538.4 | 3.5 | 196152.8 | 2.5 | 0.103 | 0.052 | 0.140 |
| 1183.150 | 130849.6 | 4.5 | 215369.6 | 4.5 | 0.146 | 0.107 | 0.132 |
| 1213.899 | 132989.9 | 3.5 | 215369.6 | 4.5 | 0.218 | 0.082 | 0.192** |
| 1214.431 | 108538.4 | 3.5 | 190882.5 | 4.5 | 0.242 | 0.195 | 0.330** |
| 1226.917 | 100973.9 | 2.5 | 182479.5 | 3.5 | 0.416 | 0.325 | 0.487** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1262.213 | 157388.9 | 0.5 | 236614.5 | 0.5 | 0.239 | 0.153 | 0.255** |
| 1283.719 | 97940.4 | 1.5 | 175839.8 | 1.5 | 0.181 | 0.126 | 0.197 |
| 1291.962 | 115173.8 | 4.5 | 192575.6 | 3.5 | 0.747 | 0.569 | 0.818 |
| 1292.383 | 114140.1 | 2.5 | 191516.9 | 2.5 | 0.117 | 0.082 | 0.133 |
| 1320.854 | 115173.8 | 4.5 | 190882.5 | 4.5 | 0.774 | 0.572 | 0.861 |
| 1324.610 | 108538.4 | 3.5 | 184033.0 | 2.5 | 0.516 | 0.391 | 0.565 |
| 1350.694 | 131676.2 | 2.5 | 205711.8 | 1.5 | 0.416 | 0.323 | 0.471 |
| 1352.428 | 108538.4 | 3.5 | 182479.5 | 3.5 | 0.472 | 0.342 | 0.501 |
| 1366.055 | 132989.9 | 3.5 | 206193.4 | 3.5 | 0.162 | 0.088 | 0.315 |
| 1378.678 | 97940.4 | 1.5 | 170473.6 | 2.5 | 0.451 | 0.345 | 0.501** |
| 1381.265 | 123318.6 | 1.5 | 195716.1 | 1.5 | 0.100 | 0.070 | 0.088 |
| 1426.942 | 132989.9 | 3.5 | 203069.9 | 3.5 | 0.205 | 0.215 | 0.148 |
| 1430.758 | 114140.1 | 2.5 | 184033.0 | 2.5 | 0.180 | 0.128 | 0.193 |
| 1443.568 | 132989.9 | 3.5 | 202263.2 | 4.5 | 0.085 | 0.073 | 0.028** |
| 1449.783 | 123600.5 | 3.5 | 192575.6 | 3.5 | 0.253 | 0.196 | 0.262 |
| 1451.520 | 138441.2 | 1.5 | 207333.9 | 2.5 | 0.111 | 0.060 | 0.162** |
| 1463.294 | 114140.1 | 2.5 | 182479.5 | 3.5 | 0.216 | 0.157 | 0.216** |
| 1466.297 | 123318.6 | 1.5 | 191516.9 | 2.5 | 0.114 | 0.097 | 0.113** |
| 1486.275 | 123600.5 | 3.5 | 190882.5 | 4.5 | 0.357 | 0.252 | 0.346** |

[1] Experimental wavelengths from [5]. [2] Experimental energy levels from [5,6]. [3] Calculated transition probabilities from [5]. [4] Calculated transition probabilities obtained in the present work. *gA*-values with * symbol correspond to transitions for which *CF* < 0.05 in HFR+CPOL calculations while *gA*-values with ** symbol correspond to transitions for which *dT* > 0.25 in MCDHF calculations (see text).

A first observation that can be made when looking at this table is that our HFR+CPOL transition probabilities are in good agreement with the results previously published by Raassen *et al*. [5], with a mean ratio $gA_{HFR+CPOL}/gA_{Raassen}$ equal to 0.95 ± 0.21 (where the number after ± represents the standard deviation from the mean), which is quite comparable to the ratio we get when comparing our HFR calculations with and without core polarization corrections, i.e. $gA_{HFR+CPOL}/gA_{HFR}$ = 0.98 ± 0.10.

It is also interesting to note that the agreement between the HFR+CPOL and MCDHF results obtained in the present work is generally good, the mean ratio between both sets of data, $gA_{HFR+CPOL}/gA_{MCDHF}$, being equal to 1.08 ± 0.48, if we exclude the two transitions at 526.999 and 555.333 Å for which the *gA*-values differ from each other by one or two orders of magnitude. This means that the majority of our *gA*-values calculated using the two methods agree within a few tens of percent. Such a comparison is shown in Figure 1 where transition probabilities obtained using the HFR+CPOL approach are plotted against those deduced from MCDHF calculations.

The quality of the transition probabilities obtained in our work can also be estimated from parameters such as the cancellation factor (*CF*) and the uncertainty parameter (*dT*) for HFR+CPOL and MCDHF calculations, respectively. As a reminder, the former parameter is defined by [7]:

$$CF = \left[\frac{\left|\sum\sum y^{\gamma}_{\beta J}\langle\beta J\|P^{(1)}\|\beta' J'\rangle y^{\gamma'}_{\beta' J'}\right|}{\sum\sum\left|y^{\gamma}_{\beta J}\langle\beta J\|P^{(1)}\|\beta' J'\rangle\right| y^{\gamma'}_{\beta' J'}}\right]^2 \quad (1)$$

where $P^{(1)}$ is the dipole operator for the transition between two atomic states |*γJ*> and |*γ'J'*> developed in terms of pure basis states |*βJ*> and |*β'J'*>, with $y^{\gamma}_{\beta J}$ and $y^{\gamma'}_{\beta' J'}$ as mixing coefficients, respectively. According to Cowan [7], very small values of this parameter (typically *CF* < 0.05) may be expected to show significant errors in the computed line strengths. In our work, it was verified that the *CF*-values

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were larger than 0.05 for most of the lines listed in Table 2, the only exceptions occurring for 91 transitions (among 367) generally characterized by rather weak *gA*-values (typically smaller than $10^9$ $s^{-1}$). This is illustrated in Figure 2 where the *CF* parameter is plotted as a function of HFR+CPOL transition probabilities for all Os VI lines considered in the present work.

As for the *dT* parameter, it is expressed by [16]:

$$dT = \frac{|A_B - A_C|}{\max\,(A_B, A_C)} \tag{2}$$

where $A_B$ and $A_C$ are transition probabilities in Babushkin (length) and Coulomb (velocity) gauges, the electric dipole transition moment having the same value in both formalisms for exact solutions of the Dirac equation [17]. The *dT* parameter thus provides a statistical estimate of the uncertainty of MCDHF transition rates for approximate solutions for which the transition moment differs from one gauge to another. For transitions listed in Table 2, the average value of *dT* was found to be equal to 0.17 ± 0.06, which means that the uncertainties affecting most or our MCDHF *gA*-values do not exceed 25%. The few exceptions for which the *dT* parameter was found to be greater than 25% concern only 42 transitions out of the 367 listed in Table 2. This is illustrated in Figure 3 where *dT* is plotted as a function of $gA_{MCDHF}$.

Finally, it should be noted that, if we set aside the transitions listed in Table 2 for which, both *CF* < 0.05 (in the HFR+CPOL calculations) and *dT* > 0.25 (in the MCDHF calculations), there remain 250 transitions whose differences between the *gA*-values obtained using the two methods do not exceed 30%, the mean relative deviation D*gA*/<*gA*> (where D*gA* = $|gA_{HFR+CPOL} - gA_{MCDHF}|$ and <*gA*> = $(gA_{HFR+CPOL} + gA_{MCDHF})/2$) being equal to 0.29. Consequently, at least for these 250 lines, the uncertainty on the HFR+CPOL and MCDHF transition probabilities obtained in our work can be estimated at most 30%, the *gA*-values of other transitions can be affected by slightly larger uncertainties up to a factor of two.

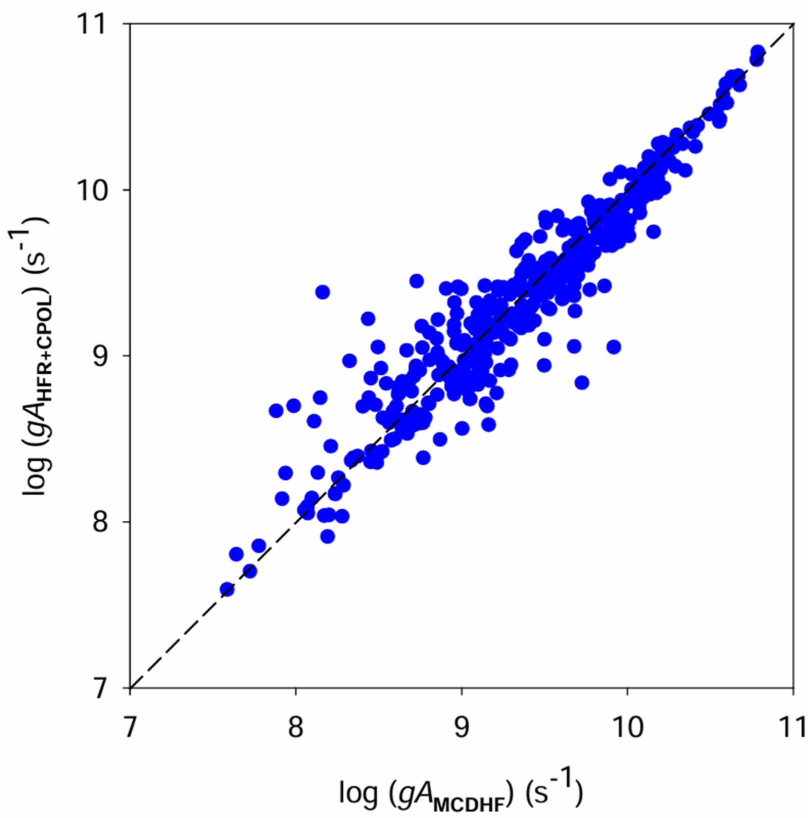


**Figure 1.** Comparison between transition probabilities (*gA*) obtained using the HFR+CPOL method and those deduced from MCDHF calculations.

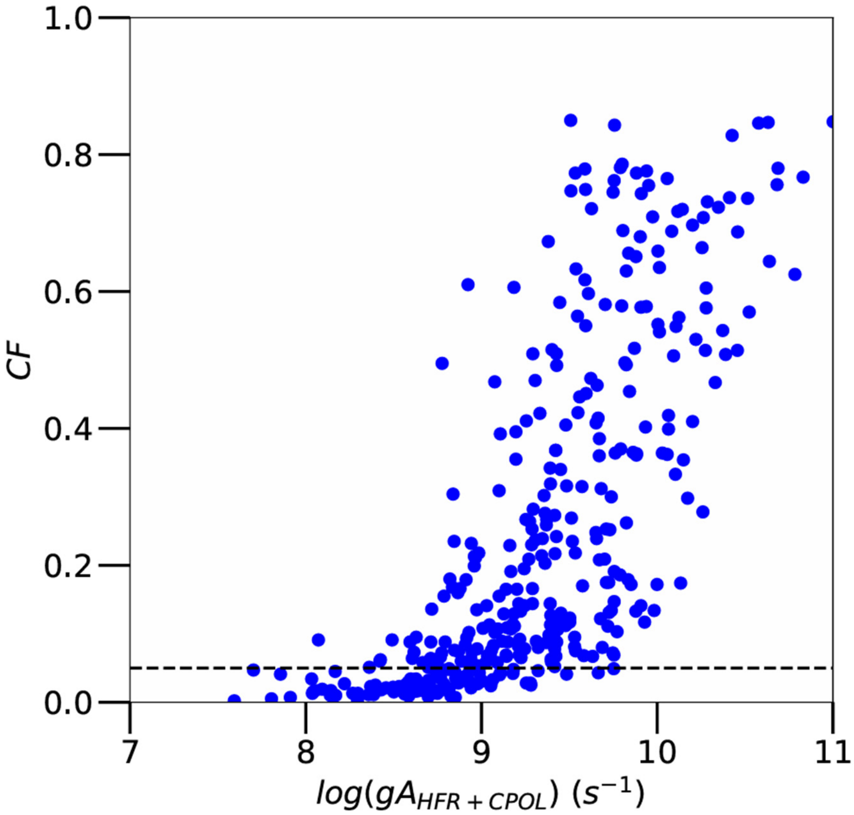


**Figure 2.** Cancellation factors (*CF*) as a function of *gA*-values obtained using the HFR+CPOL method for Os VI transitions. The dotted line corresponds to *CF* = 0.05.

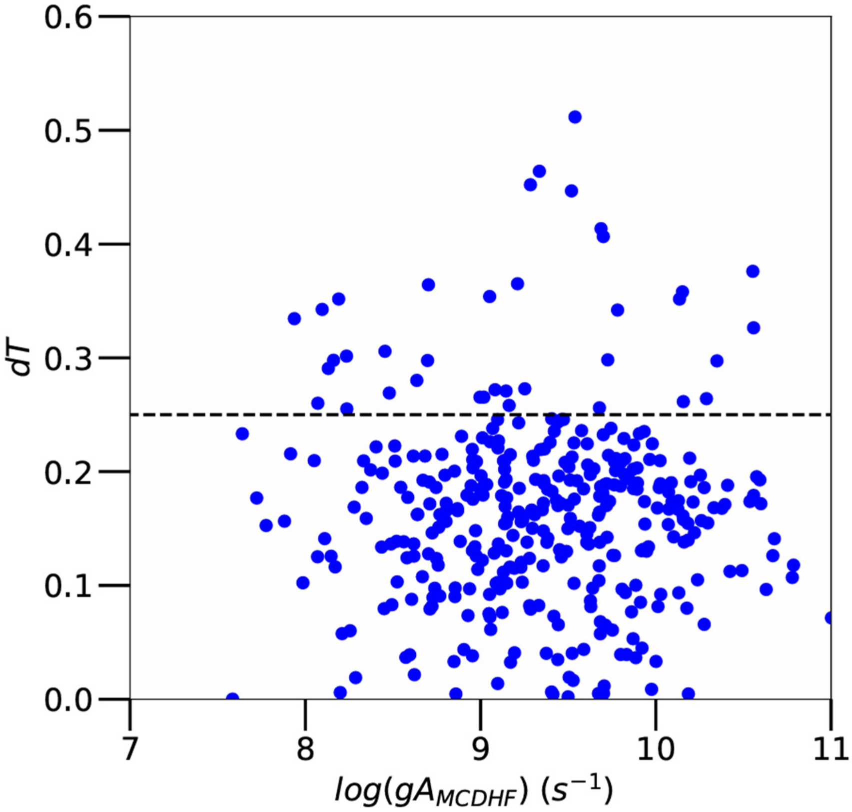


**Figure 3.** Uncertainty parameter (*dT*) as a function of *gA*-values obtained using the MCDHF method for Os VI transitions. The dotted line corresponds to *dT* = 0.25.

## 4. Conclusions

New transition probabilities for experimentally observed lines in the Os VI spectrum are reported in the present work. They were obtained using two different computational approaches based on the pseudo-relativistic Hartree-Fock method including core-polarization corrections (HFR+CPOL) and the fully relativistic Multiconfiguration Dirac-Hartree-Fock method (MCDHF). Based on the detailed comparison showing a good agreement between the two sets of results (within a few tens of percent for most transitions), it can be concluded that the $gA$-values reported in this paper are the most reliable currently available for the Os VI ion. These new atomic data will be useful for the analysis of the spectra emitted by fusion plasmas produced in Tokamaks such as ITER.

**Author Contributions:** Conceptualization, M.B. and P.Q.; methodology, M.B., P.P. and and P.Q.; software, M.B.; validation, M.B., P.P. and P.Q.; formal analysis, M.B.; investigation, M.B.; resources, M.B. and P.Q.; data curation, M.B. and and P.Q.; writing—original draft preparation, P.Q.; writing—review and editing, M.B., P.P. and P.Q.; visualization, P.Q.; supervision, P.Q.; project administration, P.Q.; funding acquisition, P.P. and P.Q. All authors have read and agreed to the published version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

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