Parity nonconservation effects in the dielectronic recombination of polarized electrons with heavy He-like ions *

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Parity nonconservation (PNC) experiments with heavy few-electron ions can provide new possibilities for tests of the Standard Model in the low-energy regime [1, 2]. In contrast to neutral atoms, the atomic structure of heavy few-electron ions can be calculated to a high accuracy. To date, various schemes [3, 4, 5, 6, 7, 8, 9] for PNC measurements in highly-charged ions were suggested. Here we report on recent studies of the PNC effect in the dielectronic recombination of polarized electrons with He-like ions.

The enhancement of PNC-effect in atomic systems takes place for close-lying opposite-parity levels. As such levels, we consider the $((1s2s)_0\, ns)_{1/2}$ and $\left(\left(1s2p_{1/2}\right)_0 ns\right)_{1/2}$ states, which are found to be close for $4 \le n \le 7$, $Z \sim 60$, and $Z \sim 90$, where n is the principal quantum number of the third electron and Z is the nuclear charge number. The related energy differences are listed in Table 1.

Table 1: The energy difference $E_{\left(\left(1s2p_{1/2}\right)_0 ns\right)_{1/2}} - E_{\left((1s2s)_0 ns\right)_{1/2}}$, in eV, for the values of Z and n, which seem to be the most promising for enhancement of the PNC effect.

Z	$n=4$	$n=5$	$n=6$	$n=7$
54	-0.489(35)	-0.787(34)	-1.21(4)	-1.47(4)
60	3.49(6)	1.42(6)	-0.222(56)	-0.376(56)
62	3.90(6)	1.66(6)	0.818(64)	-0.103(64)
64	4.40(7)	2.06(7)	1.14(7)	0.699(74)
88	9.17(30)	5.34(29)	3.86(29)	3.17(29)
90	8.27(47)	4.13(47)	2.51(47)	1.75(47)
92	6.69(27)	2.97(28)	-1.07(28)	-1.60(28)

We consider the process of the dielectronic recombination of a polarized electron with a heavy He-like ion, being originally in the ground state, into the doubly-excited $d_1 = \left(\left(1s2p_{1/2}\right)_0 ns\right)_{1/2}$ and $d_2 = ((1s2s)_0\, ns)_{1/2}$ states. In order to evaluate the PNC effect, we consider the cross section without the PNC effect, $\sigma_0 = \left(\sigma_{1/2} + \sigma_{-1/2}\right)/2$, and the P-violating contribution, $\sigma_{\rm PNC} = \left(\sigma_{1/2} - \sigma_{-1/2}\right)/2$, where $\sigma_{\pm 1/2}$ are the cross sections for the $\pm 1/2$ helicity (spin projection onto the electron momentum direction) of the incident electron, respectively.

In the process under investigation, the most pronounced PNC effect is expected in the uranium ($Z = 92$) ion, when the energy of the incident electron tuned in resonance with $\left(\left(1s2p_{1/2}\right)_0 6s\right)_{1/2}$ state. The corresponding behaviour of $\sigma_{\rm PNC}$ as a function of the energy of the incident electron is presented in Fig. 1. In this case the PNC asymmetry, $|\sigma_{\rm PNC}|/\sigma_0$, reaches a value of about 1.5×10^{-5}. The analogous process of the dielectronic recombination of polarized electrons with the H-like ions at $Z < 60$ was studied by Gribakin *et al.* in Ref. [10]. The PNC asymmetry of that process was found to amount of about 5×10^{-9}, which is by several orders of magnitude smaller than the effect as we have reported here.

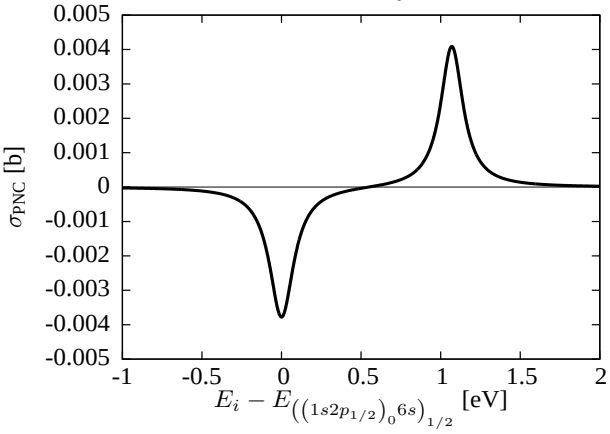

Figure 1: PNC cross section of the dielectronic recombination process into the states $\left(\left(1s2p_{1/2}\right)_0 6s\right)_{1/2}$ and $((1s2s)_0\, 6s)_{1/2}$ for $Z = 92$. The difference $E_i - E_{\left(\left(1s2p_{1/2}\right)_0 6s\right)_{1/2}}$ determines uniquely the energy of the incident electron.

* Work supported by GSI and DFG

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