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Experimental confirmation of left-right asymmetry in photoionization

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Synopsis Double differential cross sections for photoelectron emission from the outer s-shells of noble gas atoms He, Ne, Ar and Xe were measured using linearly polarized synchrotron radiation. A non-zero left-right asymmetry was observed relative to the photon propagation direction.

Recently, a left-right asymmetry has been observed in the double differential cross sections for outer s-shell photoionization by linearly polarized synchrotron radiation from the MAX-II light source [1]. In order to verify this observation, new measurements were carried out at beam line BW3 of the DORIS III synchrotron light source (HASYLAB, Hamburg, Germany). At DORIS III, left-right asymmetry parameters were determined for the photoionization of the He 1s, Ne 2s, Ar 3s and Xe 5s shells using linearly polarized synchrotron radiation. The photon energy was chosen such that the photoelectrons were ejected at 203.3 eV for all targets. The emitted electrons were analyzed with a newly built ESA-22 type electrostatic electron spectrometer [2].

Figure 1 compares the present experimental left-right asymmetry parameters (solid circles) with the earlier experimental results (open circles) [1] and with theoretical values (dashed line and right hand scale) [1] as a function of the atomic mass. The theoretical calculation has been performed within the framework of the Standard Model (SM). It is based on parity violation mediated by the weak interaction between the atomic nucleons and electrons [1].

The two experimental data sets are in fair agreement with one another. Both sets significantly differ from zero. Currently, there is no explanation for the non-zero asymmetry parameter. In both experiments care has been taken to exclude or quantify all possible sources of systematic errors. Although the two photon sources have different time structures the experimental outcome is the same. This rules out that the asymmetry may be caused by the finite duration of the photon wave packets as has been discussed for much shorter laser pulse durations [3].

If the non-zero asymmetry is a real physical effect, it strongly hints to the breakdown of space inversion symmetry in photoionization. Contrary to the prediction by the weak-interaction parity-violation treatment the experimental left-right asymmetry parameter decreases with increasing nuclear mass. Moreover, the experimental asymmetry parameters are orders of magnitude larger than the calculated values. Thus, the present measurement confirms the statement in Ref. [1] that the observed left-right asymmetry cannot originate from the weak interaction.

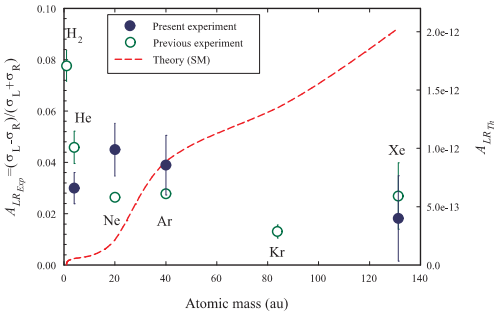

Fig. 1. The experimental ($A_{LR_{Exp}}$) and theoretical ($A_{LR_{Th}}$) s-shell left-right asymmetry parameters for H_2 molecule and for the noble gases from He to Xe as a function of the atomic mass.

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