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Search for axioelectric effect on Kr atoms for solar axions

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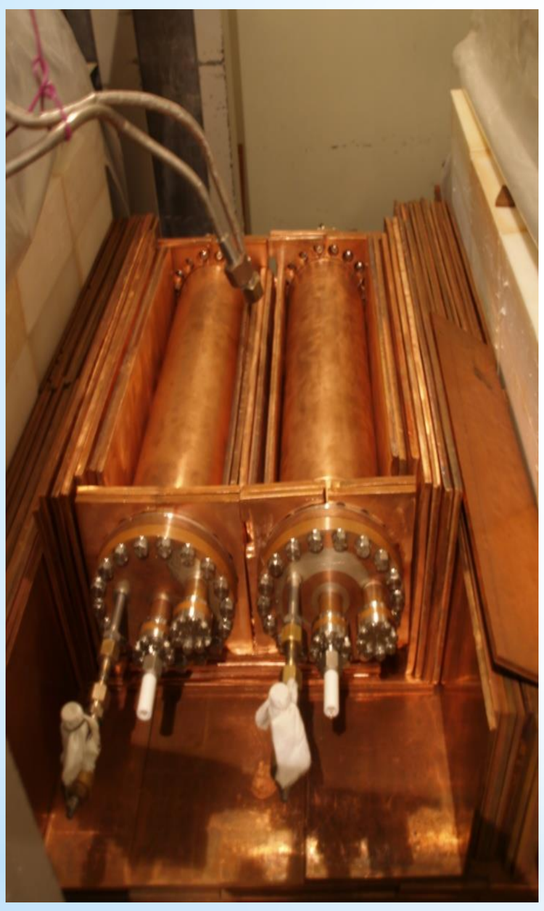
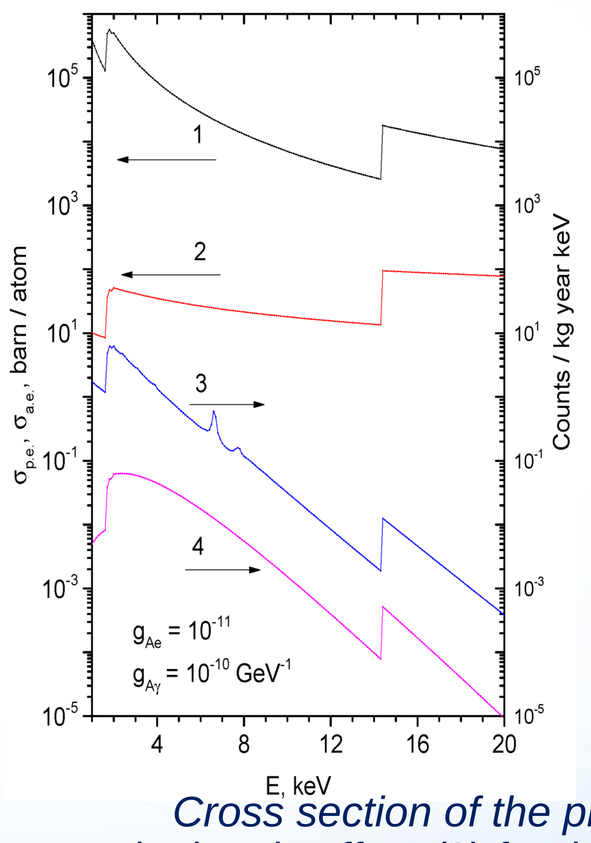
A search for solar axions with continuous spectra and 14.4 keV axions have been performed The data of large krypton proportional counter located in a low-background setup in the underground laboratory of the BNO INR RAS have been analyzed. Nnew limits on the axion-electron coupling $|g_{Ae}| \leq 4.9\times10^{-11}$*, on the product of coupling constants of axion with electron and photon* $|g_{Ae}\, g_{A\gamma}| \leq 1.6\times10^{-19}$ *GeV*$^{-1}$ *and with a nucleons* $|g_{Ae}\, g_{AN}{}^{eff}| \leq 3.2\times10^{-16}$ *have been obtained for 90% c.l.*

Kr-counter in the Baksan



A large proportional counter (LPC) with a casing of copper is used. The LPC is a cylinder with inner and outer diameters of 137 and 150 mm, respectively. A gold-plated tungsten wire of 10 μm in diameter is stretched along the LPC axis and is used as an anode. The fiducial volume is 8.77 L. The LPC is surrounded by passive shield made of copper (20 cm), lead (20 cm) and polyethylene (8 cm). The setup is located at the depth of 4700 m w.e., where the cosmic ray flux is reduced by ~10^7 times and evaluated as 2.6 muons m^{-2} d^{-1}.

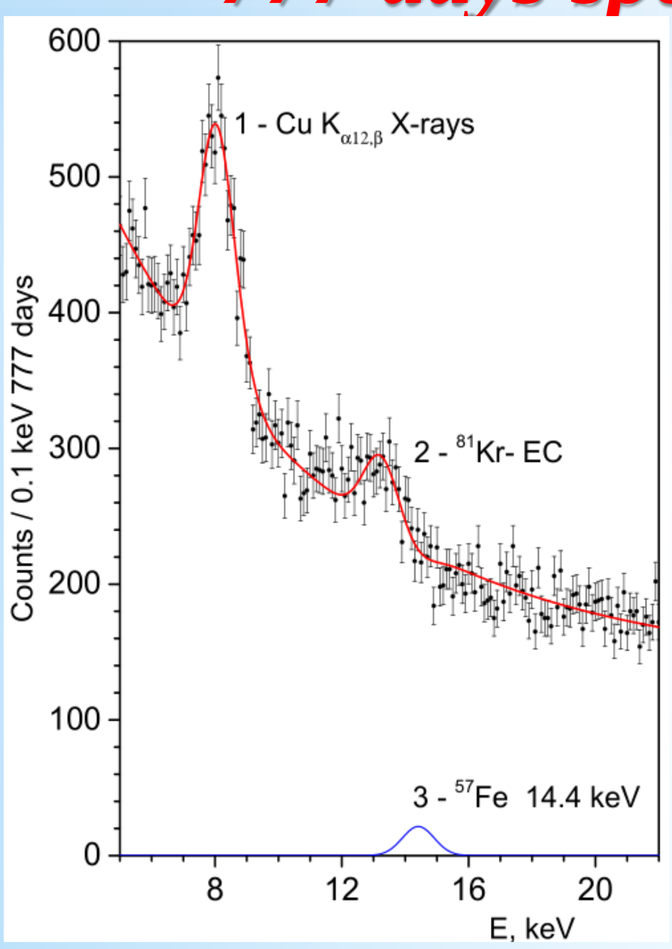
Detection via axioelectric effect



Cross section of the photoelectric effect (1) and axioelectric effect (2) for the Kr atom for $g_{Ae}=1$ *and* $m_A=0$ *(left scale). Expected spectra of the Kr-detector at* $g_{Ae}=10^{-11}$*(3) and* $g_{A\gamma}=10^{-11}$ *GeV*$^{-1}$ *(4) (right scale).*

The axioelectric effect (AEe) is an analogue of the photoelectric effect – the axion disappears while a free electron and the subsequent characteristic X-rays of the atom appears. The cross section of AE effect σ_{ae} *is directly proportional to the photoelectric effect cross section* σ_{pe} *and the constant* $g_{Ae}{}^2$*, the number of AE events depends on the flux and spectrum of axions* $d\Phi_{Ae}/dE_A$ *and* $d\Phi_{A\gamma}/dE_{A\gamma}$

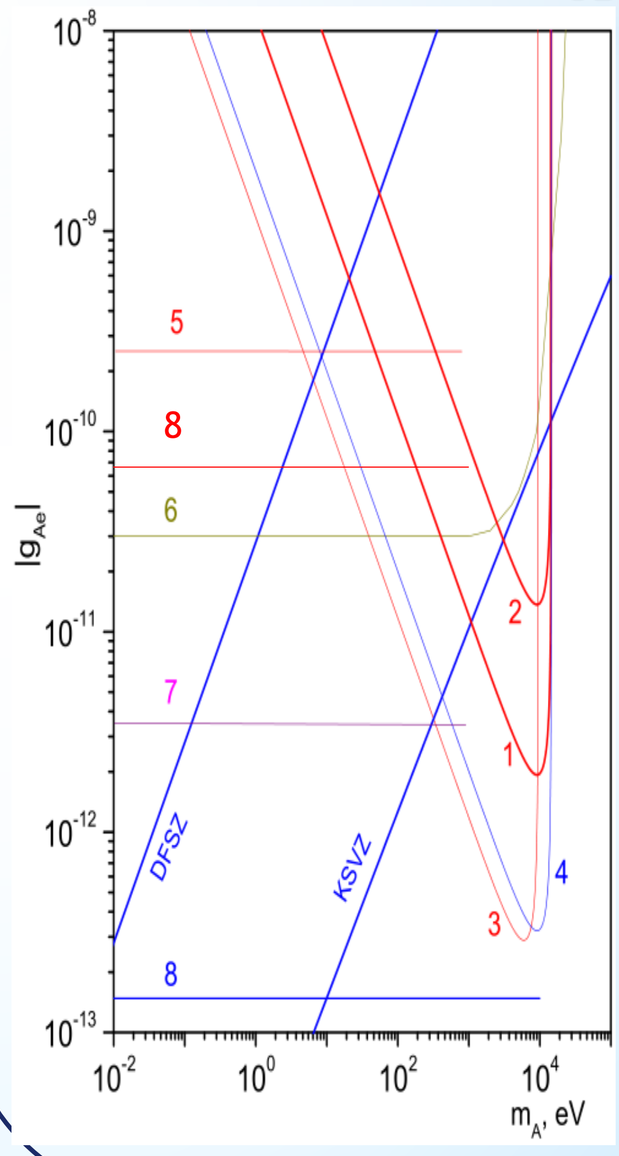
777 days spectrum



The measured spectrum in the range (4–20) keV was fitted with a function for a flat background and three Gaussian peaks. Since the cross section of axioelectric effect is proportional to $g_{Ae}{}^2$*, the number of registered axions will be proportional to* $g_{Ae}{}^4$ *and* $g_{A\gamma}{}^2 g_{Ae}{}^2$*, for the first and second cases, respectively.*

Kr-counter spectrum and results of fitting by the theoretical form. 1 – Cu X-ray peaks; 2 – peak associated with decay of ^{81}*Kr and X-rays of Kr and Br atoms; 3 – expected 14.4 keV axion peak containing 3Slim events..*

Limits on g_{Ae} coupling



1.8 -Upper limits on $|g_{Ae}|$ *obtained in works [1,2], in comparison with the results of other experiments: 2 - Si(Li) detector, 3 - from solar neutrino data, 4 - LUX experiment, 5, 6 - resonant absorption of axions by* ^{169}*Tm and* ^{83}*Kr nuclei, 7 - astrophysical restrictions. The range of possible values of the parameters* g_{Ae} *and* m_A *in the DFSZ and KSVZ axion models is shown.*

The obtained limits are valid for the axion mass region (0-4) keV; at large masses it is necessary to take into account the modification of the axion spectrum. The obtained limits are model-independent limits particle.

1. E.F. Bubnov, Yu.M. Gavrilyuk, A.N. Gangapshev, A.V. Derbin, I.S. Drachnev, V.V. Kazalov, V.V. Kuzminov, V.N. Muratova, D.A. Tekueva, E.V. Unzhakov, S.P. Yakimenko, Letters to ZhTF, 2024, T.50, V.6, P.37.

2. A.B. Derbin, I.S. Drachnev, Yu.M. Gavrilyuk, A.N. Gangapshev, V.V. Kazalov, V.V. Kuzminov, V.N. Muratova, D.A. Semenov, D.A. Tekueva, M.V. Trushin, E.V. Unzhakov, S.P. Yakimenko, Letters to ZhTF, 2024, T.50, V.23, P.7.